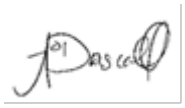
SCEPTREPLUS

Final Trial Report

Trial code:	SP43
Title:	Evaluation of new products for control of rust in leeks
Crop	Group: Field vegetables - alliums (leeks)
Target	Rust (*Puccinia allii*), PUCCAL
Lead researcher:	Dr Aoife O' Driscoll
Organisation:	RSK ADAS Ltd.
Period:	May 2019 to October 2019
Report date:	18th December 2019
Report author:	Dr Aoife O' Driscoll
ORETO Number: (certificate should be attached)	409

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



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Date Authors signature

Trial Summary

Introduction

Leek rust caused by the fungus *Puccinia allii* is the most important foliar disease of leeks in the UK. While severe attacks can reduce yield directly, the main economic impact is from its importance as a leaf blemish that downgrades crop quality. Leek rust is active for most of the year and remains a challenge for control as numerous fungicide treatments may be required on overwintered crops. Current control relies on a limited number of active substances from the azole and strobilurin fungicide families and with the common approach of fortnightly applications of alternating fungicides to prevent rust development, resistance could become a real problem. This provides the impetus to identify new active substances which could contribute to both disease control and resistance management strategies against rust in leeks. An inoculated pot trial carried out at ADAS Boxworth identified potential new products to effectively manage leek rust.

Methods

The trial was laid out as a randomised complete block design with four replicates of nine treatments and eight replicates of the untreated control. Each plot comprised ten plants. Plant protection products comprising six conventional chemical fungicides and one biopesticide were tested alongside an untreated control and an industry 'standard' which was a programme of Amistar Top, Rudis, Nativo and Rudis, in an inoculated pot trial using the open pollinated variety Jolant. The trial was inoculated using a spreader plant method; plants were potted into 5L pots containing John Innes No 3 compost, then placed amongst a set of diseased leek plants to encourage infection. The first treatments were applied on to plants which had approximately five true leaves on 1st August 2019, three days after planting. This was just as the crop was being exposed to infection by *P. allii* from diseased spreader plants (i.e. products were applied as protectant treatments). All tested products were applied every two to three weeks with a total of four applications of each product made. Products were applied using an Oxford Precision Sprayer at a water volume of 300 L/ha. Rust was first seen in the untreated plots 17 days after spreader plants were placed within the trial and two weeks after the first application of treatment. Infection was then assessed fortnightly until twelve weeks after planting, with five full assessments in total. Disease assessments were performed by visual estimation of the presence of leek rust pustules on the adaxial side of the leaf surface, using a scale in increments of 5% to record the % disease on each plant.

Results

Rust incidence and severity was assessed on a % scale where incidence was measured as the proportion of plants affected and severity was measured as the total % leaf area of each plant affected. Mean values and results of analyses at the five assessment timings are presented in Tables 1 and 2. The efficacy of each tested product against rust (presented as the percentage reduction in rust levels compared to the untreated control) at the final assessment date, is presented in Figure 1.

Table 1: Effect of plant protection products on mean % leek rust incidence at five assessment dates.

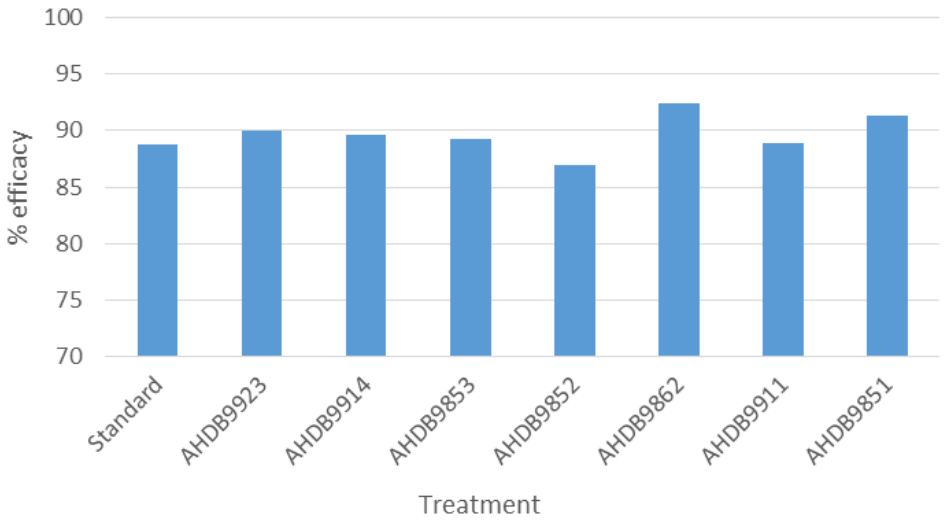
	Mean % disease incidence				
Date	**25/08/19**	**03/09/19**	**24/09/19**	**9/10/19**	**23/10/19**
Treatment					
Untreated	52.5	100	100	100	100

Standard	30	50	60	65	62.5
AHDB9923	30	57.5	65	70	70
AHDB9914	46.67	52.5	55	60	62.5
AHDB9853	47.5	52.5	57.5	62.5	62.5
AHDB9852	46.67	50	55	57.5	60
AHDB9862	47.5	52.5	55	60	62.5
AHDB9911	23.75	46.67	50	56.67	56.67
AHDB9851	23.75	47.5	66.67	66.67	70
P value	0.025	>0.001	>0.001	>0.001	>0.001
d.f.	37	37	37	37	37
l.s.d.	18.74	17.19	16.94	16.57	16.58
	Not significantly different from untreated control (p>0.05)				
	Significantly different from untreated control (p>0.05)				

Table 2: Effect of plant protection products on mean % leek rust severity at five assessment dates

	Mean % disease severity				
Date	**25/08/19**	**03/09/19**	**24/09/19**	**9/10/19**	**23/10/19**
Treatment					
Untreated	2.1	14.14	24.81	35.93	52.31
Standard	2.2	2.68	3.18	5.41	5.85
AHDB9923	1.75	2.33	2.83	4.83	5.25
AHDB9914	1.8	2.25	3	4.5	5.43
AHDB9853	1.65	2.4	2.85	4.35	5.63
AHDB9852	1.93	2.5	2.75	4.875	6.8
AHDB9862	1.5	1.88	2.38	3.925	4
AHDB9911	2.33	2.23	2.98	4.475	5.825
AHDB9851	1.7	2.63	2.63	4.73	4.53
P value	0.014	>0.001	>0.001	>0.001	>0.001
d.f.	37	37	37	37	37
l.s.d.	0.86	1.68	1.87	2.45	2.93
	Not significantly different from untreated control (p>0.05)				
	Significantly different from untreated control (p>0.05)				

Figure 1: Effect of plant protection products, on percentage reduction in leek rust severity at the final assessment date.



Conclusions

Moderate to high leek rust levels were observed in untreated plots by the end of the trial. The industry standard programme of sprays performed well, reducing disease by approximately 89% compared with the untreated control; thus the trial had sufficient disease levels for evaluation of products and the standard treatment performed as expected. By the final disease assessment, all of the products tested resulted in over 87% control of leek rust compared to the untreated control, with two products providing greater than 90% control; AHDB9862 and AHDB9851. These products could provide important new control options which, if taken forward for registration, could help with pathogen resistance management strategies in the future. The least best performing product in the trial was AHDB9852, a biopesticide product, which still had good efficacy against rust resulting in 87% control. This product therefore has the potential to provide an additional tool for organic growers who currently operate with limited options in product choice. The effect of all treatments was observed to be maintained for up to four weeks after the final application. This extended protection merits further evaluation to determine if efficacy against leek rust can be maintained with longer intervals in between treatments. This is especially important for a long season, often over wintered crop such as leek where the number of fungicide applications in a season, relative to the length of the crops life cycle, is limited. Phytotoxicity was not observed with any of the treatments and no problems were encountered with the mixing or applying of any of the products.

Take home message:

All products tested provided significant levels of leek rust control by the end of the trial. AHDB9862 and AHDB9851 were the two best performing products, providing important new product options which, if taken forward for registration could help with fungicide resistance management strategies in the future. The biopesticide AHDB9852 also performed well and has the potential to provide an additional disease management tool to growers of both conventional and organic leeks.

Objectives

1. To evaluate the effectiveness of six conventional fungicides and a biopesticide against leek rust (*Puccinia allii*) as measured by disease incidence, severity and % efficacy.
2. To monitor the treated crop for phytotoxicity.

Trial conduct

UK regulatory guidelines were followed but EPPO guideline took precedence. The following EPPO guidelines were followed:

Relevant EPPO guideline(s)		**Variation from EPPO**
PP 1/152(3)	Design and analysis of efficacy evaluation trials	None
PP 1/135(3)	Phytotoxicity assessment	None
PP 1/181(3)	Conduct and reporting of efficacy evaluation trials including GEP	Yes
PP 1/124 (2)	Rusts of vegetables	None

There were two deviations from EPPO guidance. Plot sizes were 3.13m^2 rather than 10m^2 stipulated in the guidelines. Plants were spaced closer together in a smaller plot area to ensure an even, dense canopy to encourage infection. T3 application took place on the 4th October 2019, with the exception of AHDB9911, which was applied late (6th October 2019) due to the chemical not being on site.

Test site

Item	**Details**
Location address	RSK ADAS Ltd. Boxworth, Cambs CB23 4NN
Crop	Leek
Cultivar	Jolant
Soil or substrate type	John Innes No 3 compost
Agronomic practice	Calcium nitrate application (74 kg/ha) on 25/9/19. No herbicides were applied as the trial was hand weeded. Plants were watered by hand twice daily (09:00 and 16:00). On days where rainfall occurred, no watering took place.
Prior history of site	N/A

Trial design

The trial was laid out as a randomised complete block design with four replicates of nine treatments and eight replicates of the untreated control.

Item	**Details**
Trial design:	Replicated randomised block
Number of replicates:	4
Row spacing:	60cm
Plot size: (w x l)	1.56m x 2m
Plot size: (m^2)	3.13m^2
Number of plants per plot:	10
Leaf Wall Area calculations	N/A

Treatment details

AHDB Code	Active substance	Product name or manufacturers code	Formulation batch number	Content of active substance in product	Formulation type[1]
Untreated	N/A	N/A	N/A	N/A	N/A
N/A	Azoxystrobin + difenoconazole	Amistar Top	GRA7B201E	200g/l + 125g/l	
N/A	Tebuconazole + trifloxystrobin	Nativo	EM20010927	250 g/kg + 500 g/kg	WG
N/A	Prothioconazole	Rudis	EM4LO24763	480 g/l	SC
AHDB9923	N/D	N/D	N/D	N/D	N/D
AHDB9914	N/D	N/D	N/D	N/D	N/D
AHDB9853	N/D	N/D	N/D	N/D	N/D
AHDB9852	N/D	N/D	N/D	N/D	N/D
AHDB9862	N/D	N/D	N/D	N/D	N/D
AHDB9911	N/D	N/D	N/D	N/D	N/D
AHDB9851	N/D	N/D	N/D	N/D	N/D

[1]SC; Suspension concentrate, EC; Emulsifiable concentrate, WG; Water dispersible granule

Methods, assessments and records

Inoculum production

The trial was artificially inoculated using spreader plants of infected material. Leek seedlings of cv. Pandora were raised in seed modules at Delflands Nurseries, Cambs from March to May 2019 to provide fresh material for inoculation. In tandem with this, diseased leeks were collected from a harvested organic crop in March 2019 at Allpress Farms, Norfolk then potted up at ADAS Boxworth into 5L pots containing John Innes No 3 compost and kept in an enclosed polytunnel until required for inoculation. Once the plants of cv. Pandora had reached three true leaves they were brought back to ADAS, potted up into 5L pots containing John Innes No 3 compost and dispersed in amongst the diseased plants which were collected in March. They were watered twice daily from above to encourage rain splash, with first symptoms observed three weeks after planting. This method ensured that freshly inoculated material with pathogenic spores was used for the trial.

Main trial

Leek seed of cv. Jolant; an older open pollinated variety which is rust susceptible was supplied by Elsoms Seeds and raised in seed modules at Delflands Nurseries, Cambs from May-July 2019 to ensure good starting plant material was used for the trial. The plants were brought back to ADAS Boxworth at the five leaf stage and potted into 5L pots containing John Innes compost No 3. On the 30th July 2019, ten plants per plot were spread strategically within the plot areas with a minimum of two spreader plants per plot. The trial was watered by hand twice daily to ensure effective spore splash amongst the plants and adequate leaf wetness for spore germination and infection was achieved. First treatments were applied to the trial on the 1st August 2019; three days after trial plants were first exposed to rust infection. Subsequent treatment applications took place every 2-3 weeks, taking into account the ca. three week life cycle of rust and prevailing weather patterns which dictated choice of spray dates. A shaded temperature and humidity logger was positioned within the plant canopy when marking out the trial area to record temperature (min and max) and humidity every hour for the duration of the trial. Products were applied using an Oxford Precision Sprayer at a water volume of 300 L/ha.

Application schedule

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	N/A	N/A	ABCD
2	Untreated	N/A	N/A	ABCD
3	Amistar Top	200 g/ha + 125 g/ha	1.0 l/ha	A
3	Rudis	192 ml/ha	0.4 l/ha	B D
3	Nativo	90g /ha+ 180 g/ha	0.36 kg/ha	C
4	AHDB9923	N/D	1.0 l/ha	ABCD
5	AHDB9914	N/D	0.8 l/ha	ABCD
6	AHDB9853	N/D	0.5 l/ha	ABCD
7	AHDB9852	N/D	3.2 l/ha	ABCD
8	AHDB9862	N/D	1.5 l/ha	ABCD
9	AHDB9911	N/D	1.75 l/ha	ABCD
10	AHDB9851	N/D	0.1 l/ha	ABCD

Application details

	Application A	Application B	Application C	Application D
Application date	01/08/2019	15/08/2019	04/09/2019	26/09/2019
Time of day	10:15 – 10:45	12:00 – 12:30	11:45 – 12:15	09:00 – 09:30
Crop growth stage (Max, min average BBCH)	41	43	43	43
Crop height (cm)	25	30	30	35
Crop coverage (%)	50	50	70	80
Application Method	Spray	Spray	Spray	Spray
Application Placement	Foliar	Foliar	Foliar	Foliar
Application equipment	OPS	OPS	OPS	OPS
Nozzle pressure	2 Bar	2 Bar	2 Bar	2 Bar
Nozzle type	Flat fan	Flat fan	Flat fan	Flat fan
Nozzle size	F04/110	F04/110	F04/110	F04/110
Application water volume/ha	300 l/ha	300 l/ha	300 l/ha	300 l/ha
Temperature of air - shade (°C)	22.8	20.25	22.7	20.25
Relative humidity (%)	61.6	64.65	64.45	64.65
Wind speed range (m/s)	1.1 – 1.8	7.5 – 6.5	4.2 – 4.8	7.5 – 6.5
Dew presence (Y/N)	N	N	N	N
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 (%)	80%	80%	50%	70%

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

Common name	Scientific Name	EPPO Code	Infection level pre-application	Infection level at start of assessment period	Infection level at end of assessment period
Leek rust	*Puccinia allii*	PUCCAL	0% incidence	0% incidence	100% incidence in untreated control 52% severity

Assessment details

All plants were scored for leek rust symptoms every 2-3 weeks, until twelve weeks after planting, with five full assessments in total. Disease assessments were performed by visual estimation of the presence of leek rust pustules on the adaxial side of the leaf surface, using a scale in increments of 5% to record the % disease within each plot. This score gave incidence and severity of rust within the plot.

Evaluation date	Evaluation Timing (DA)*	Crop Growth Stage (BBCH)	Evaluation type (efficacy, phytotox)	What was assessed and how (e.g. dead or live pest; disease incidence and severity; yield, marketable quality)
01/08/2019	0	41	Baseline assessment	Disease incidence (Rust)
15/08/2019	14	41	Phytotoxicity and efficacy	Phytotoxicity Disease incidence and severity (Rust)
03/09/2019	33	43	Phytotoxicity and efficacy	Phytotoxicity Disease incidence and severity (Rust)

24/09/2019	54	43	Phytotoxicity and efficacy	Phytotoxicity Disease incidence and severity (Rust)
09/10/2019	69	43	Phytotoxicity and efficacy	Phytotoxicity Disease incidence and severity (Rust)
23/10/2019	83	45	Phytotoxicity and efficacy	Phytotoxicity Disease incidence and severity (Rust)

* DA – days after first application

Statistical analysis

The trial was laid out as a randomised complete block design. Statistical analysis was carried out using a generalised ANOVA and Duncan's Multiple Range test in Genstat 12.2, using disease incidence and severity values as variables. The analysis assessed for differences between treatments compared to the untreated control as well as differences between the replicate blocks in the trial.
Using disease severity data from the final assessment on the 23rd October, % efficacy of each product was calculated using the following formula.

$$\text{Percentage control} = 1 - \frac{\text{Disease severity of treatment}}{\text{Disease severity of untreated}} \times 100$$

Results

Phytotoxicity

There were no phytotoxic symptoms observed with any of the products tested at any of the assessments.

Efficacy

The first visible symptoms of leek rust were present in untreated plots seventeen days after inoculation, with 52.5% of untreated plants infected by the first full assessment (25/08/19). As plants grew larger there was continuing disease activity that maintained severity in the untreated controls throughout the trial period. The results for mean % leek rust incidence and severity on five assessment dates are presented in Table 3 and Table 4, respectively. The efficacy of each product when compared to disease severity in the untreated controls at the final assessment is presented in Figure 2. All treatments had a significant ($p<0.05$) effect both on the incidence and severity of leek rust at the different assessment points. By the final assessment, all of the products tested gave over 87% control of the disease compared to the untreated control, with two products providing greater than 90% control; these were AHDB9862 and AHDB9851. The least best performing product in the trial was AHDB9852, a biopesticide product, which still had good efficacy against rust giving 87% control.

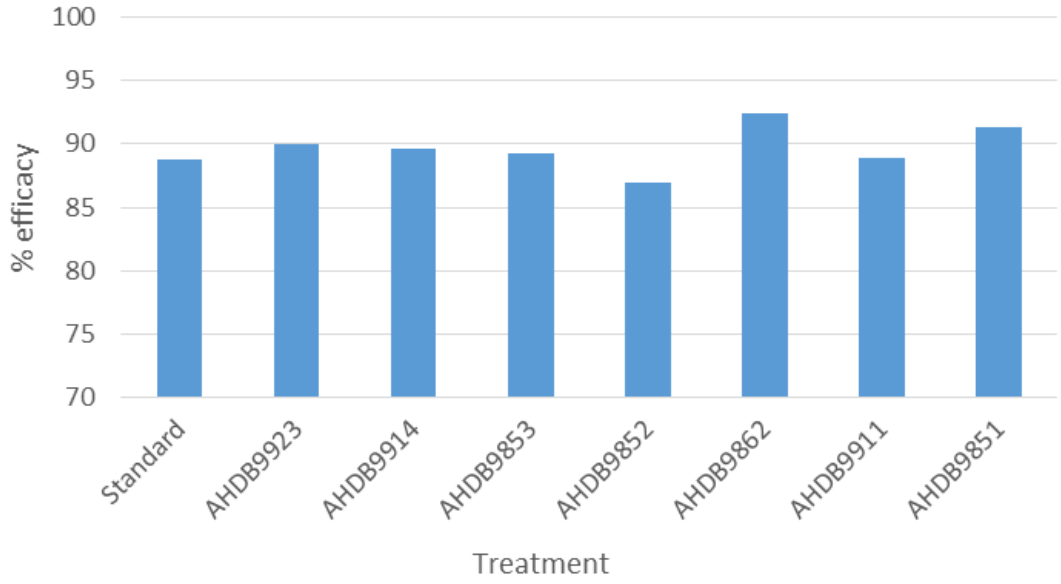
Table 3: Effect of plant protection products on mean % leek rust incidence at five assessment dates.

	Mean % disease incidence				
Date	**25/08/19**	**03/09/19**	**24/09/19**	**9/10/19**	**23/10/19**
Treatment					
Untreated	52.5	100	100	100	100
Standard	30	50	60	65	62.5
AHDB9923	30	57.5	65	70	70
AHDB9914	46.67	52.5	55	60	62.5
AHDB9853	47.5	52.5	57.5	62.5	62.5
AHDB9852	46.67	50	55	57.5	60
AHDB9862	47.5	52.5	55	60	62.5
AHDB9911	23.75	46.67	50	56.67	56.67
AHDB9851	23.75	47.5	66.67	66.67	70
P value	0.025	>0.001	>0.001	>0.001	>0.001
d.f.	37	37	37	37	37
l.s.d.	18.74	17.19	16.94	16.57	16.58
	Not significantly different from untreated control (p>0.05)				
	Significantly different from untreated control (p>0.05)				

Table 4: Effect of plant protection products on mean % leek rust severity at five assessment dates.

	Mean % disease severity				
Date	**25/08/19**	**03/09/19**	**24/09/19**	**9/10/19**	**23/10/19**
Treatment					
Untreated	2.1	14.14	24.81	35.93	52.31
Standard	2.2	2.68	3.18	5.41	5.85
AHDB9923	1.75	2.33	2.83	4.83	5.25
AHDB9914	1.8	2.25	3	4.5	5.43
AHDB9853	1.65	2.4	2.85	4.35	5.63
AHDB9852	1.93	2.5	2.75	4.875	6.8
AHDB9862	1.5	1.88	2.38	3.925	4
AHDB9911	2.33	2.23	2.98	4.475	5.825
AHDB9851	1.7	2.63	2.63	4.73	4.53
P value	0.014	>0.001	>0.001	>0.001	>0.001
d.f.	37	37	37	37	37
l.s.d.	0.86	1.68	1.87	2.45	2.93
	Not significantly different from untreated control (p>0.05)				
	Significantly different from untreated control (p>0.05)				

Figure 2: Effect of plant protection products, on percentage reduction in leek rust severity at the final assessment date.



Discussion

High leek rust levels were observed in untreated plots by the end of the trial. The industry standard fungicide programme performed well, reducing disease by approximately 88% compared to the untreated control; thus the trial had sufficient disease levels for evaluation of products and the standard treatment performed as expected.

By the final assessment, all products tested resulted in over 87% control of leek rust compared to the untreated control, with two products providing greater than 90% control; AHDB9862 and AHDB9851. These products could provide important new control options which, if taken forward for registration could help with pathogen resistance management strategies in the future. The least best performing product in the trial was AHDB9852, a biopesticide product, which nevertheless still had good efficacy against rust resulting in 87% control. This product has the potential to provide an additional tool for organic growers who currently operate with limited options in product choice. Phytotoxicity was not observed with any of the treatments and no problems were encountered with the mixing or applying of any of the products. The effect of all treatments was observed to be maintained for up to four weeks after the final application. This extended protection merits further evaluation to determine if efficacy against leek rust can be maintained with longer intervals in between treatments. This is especially important for a long season, often over wintered crop such as leek where the number of fungicide applications in a season, relative to the length of the crops life cycle, is limited.

Conclusions

- Leek rust disease levels developed to high levels in untreated plots.
- The industry standard fungicide programme resulted in good control of rust.
- All conventional fungicide treatments provided significant levels of rust control by the end of the trial.
- AHDB9862 and AHDB9851 were the two best performing products in the trial, providing important new product options which, if taken forward for registration could help with resistance management strategies in the future.

- The biopesticide product AHDB9852 performed well in the trial, providing 87% control of rust compared to the untreated control. This has the potential to provide an additional disease management tool to growers of both conventional and organic leeks.
- The effect of all treatments was observed to be maintained for up to four weeks after the final application. This extended protection merits further evaluation to determine if efficacy against leek rust can be maintained with longer intervals in between treatments.
- No product tested proved phytotoxic to the plant.

Acknowledgements

We would like to thank AHDB and the participating crop protection companies for project funding. David Norman (Fresh Produce Consultancy) for agronomic advice and review of protocols and the final report. Allpress Farms for providing the spreader plants for the trial and Delflands Nurseries for propagation facilities in growing up young leeks.

Appendix

a. Crop diary – events related to growing crop

Crop	Cultivar	Planting date
Leek	Jolant	29th July 2019

Fertilisers applied to the trial area

Date	Product	Rate	Unit
25/09/2019	YaraMila	75	Kg/ha

b. Table showing sequence of events by date – this relates to treatments and assessments.

Date	Event
18/03/2019	Collection of diseased leeks from an organic crop being harvested at Allpress Farms, Cambs. Approx. 120 leeks were potted into John Innes No2 and put in polytunnel 2.
08/04/2019	Leeks were placed on hard standing and watering by hand 3 time per week from above to encourage further disease spread.
16/05/2019	Sowed 300 seeds of cv. Jolant at Delflands Nurseries
07/06/2019	Pandora leeks (approx. 180 plants) from Delflands potted up 3L pots containing John Innes No2 with 2 plants/pot, and placed around the older leeks for infection - watering by hand 3 time per week from above to encourage further disease spread.
19/07/2019	Collection of leeks cv. Jolant from Delflands.
23/07/2019	Filled new 5L pots with John Innes No2 compost and placed in trial positions on hard standing on bread crates
29/07/2019	Potted cv. Jolant leeks into the pots on hard standing
30/07/2019	Baseline assessment of trial
01/08/2019	T1 application
15/08/2019	Assessment 2, little disease present yet
15/08/2019	T2 application
03/09/2019	Assessment 3, disease taking off in untreated plots
04/09/2019	T3 application, with the exception of AHDB9911
10/09/2019	Treatment 9 AHDB9911 applied late due to chemical not being on site
24/09/2019	Assessment 4, big differences between treated and untreated, little difference between treatments
25/09/2019	YaraMila complex 75kg/ha = 300g spread over all soil surfaces
26/09/2019	T4 application
02/10/2019	Leeks weeded, spreader plants removed
09/10/2019	Assessment 5
23/10/2019	Assessment 6

c. Table showing climatological data during study period – if outdoors then air max, air min and rainfall. If indoors air max and min and RH.

Date	Max Temp °C	Min Temp °C	Average RH %
30/07/2019	14.5	29	86.02
31/07/2019	14.5	24.5	87.75
01/08/2019	14	34	79.81
02/08/2019	12	28.5	86
03/08/2019	9	35	89.68
04/08/2019	13	30	87.12
05/08/2019	14	29	91.5
06/08/2019	12.5	30.5	89.48
07/08/2019	13	29	85.58
08/08/2019	11.5	36	90.46

09/08/2019	15.5	28	92.69
10/08/2019	14.5	25.5	89.77
11/08/2019	12.5	25	88.77
12/08/2019	10.5	26	94.52
13/08/2019	8.5	27	89.35
14/08/2019	9	21	96.94
15/08/2019	11	25	91.46
16/08/2019	9.5	18	96.08
17/08/2019	12	27.5	89.67
18/08/2019	12	26	86.98
19/08/2019	10.5	23.5	88.39
20/08/2019	9	27.5	89.71
21/08/2019	10	26	90.94
22/08/2019	10	28	84.5
23/08/2019	13	34.5	88.88
24/08/2019	8.5	37	85.63
25/08/2019	10.5	39	75.83
26/08/2019	12	38.5	73.27
27/08/2019	13.5	37	85.44
28/08/2019	16.5	33	81.27
29/08/2019	10	27	82.67
30/08/2019	11.5	29.5	81.38
31/08/2019	10	29	83
01/09/2019	8	27.5	79.62
02/09/2019	7	28.5	82.06
03/09/2019	12	29.5	81.46
04/09/2019	12.5	24	83.69
05/09/2019	7	24.5	80.75
06/09/2019	8.5	18.5	92.94
07/09/2019	6	18.5	95.31
08/09/2019	4	21.5	87.19
09/09/2019	9.5	15	94.35
10/09/2019	9	26	97.43
11/09/2019	12	27	92.89
12/09/2019	11	28.5	91.66
13/09/2019	7.5	26.5	77.3
14/09/2019	3	30.5	87.42
15/09/2019	9.5	30.5	90.33
16/09/2019	9.5	18.5	97.98
17/09/2019	5	22	92.5
18/09/2019	2	24	95.73
19/09/2019	7	26.5	87.96
20/09/2019	4.5	23.5	88.44
21/09/2019	6	26.5	88.29
22/09/2019	13	25	97.5
23/09/2019	11.5	23.5	97.04
24/09/2019	14	22	99.19
25/09/2019	13.5	22.5	99.15
26/09/2019	12	25	97.39
27/09/2019	10.5	22.5	97.56
28/09/2019	10	21	97.44
29/09/2019	10.5	21	99.31
30/09/2019	8	21.5	99.041
01/10/2019	10	22	99.91
02/10/2019	3	19	98.43
03/10/2019	2.5	13	98.52
04/10/2019	9	17.5	99.06
05/10/2019	10	18	99.74

06/10/2019	9.5	16.5	100
07/10/2019	7	15.5	100
08/10/2019	9	18	99.83
09/10/2019	7.5	18	99.18
10/10/2019	6.5	16	98.75
11/10/2019	12.5	17.5	99.79
12/10/2019	9.5	14	100
13/10/2019	8.5	16	100
14/10/2019	8	13.5	99.97
15/10/2019	8	15.5	99.85
16/10/2019	5.5	17	99.85
17/10/2019	4	17.5	99.79
18/10/2019	8.5	15.5	99.81
19/10/2019	7	15	99.43
20/10/2019	4.5	12	99.97
21/10/2019	8	12.5	99.97
22/10/2019	5	15.5	99.31
23/10/2019	2.5	14	99.85
24/10/2019	8	12.5	100
25/10/2019	7.5	15	100
26/10/2019	4	15	99.83

d. Raw data from assessments

Plot No	Assessment Date Assessment Type Treatment Name	05/09/19 Incidence (%)	05/09/19 Severity (%)	17/09/19 Incidence (%)	17/09/19 Severity (%)	30/09/19 Incidence (%)	30/09/19 Severity (%)	07/10/19 Incidence (%)	07/10/19 Severity (%)	23/10/19 Incidence (%)	23/10/19 Severity (%)
109	Untreated	20	2.3	100	15	100	26.5	100	35.5	100	49
206	Untreated	20	2.6	100	12.5	100	21	100	36	100	52.5
310	Untreated	30	1.3	100	17.5	100	24.5	100	33.5	100	54.5
404	Untreated	30	2.6	100	15.5	100	25.5	100	35.5	100	50.5
104	Untreated	10	1.3	100	20.5	100	27.5	100	33.5	100	53
205	Untreated	30	2.3	100	14.5	100	23.5	100	36.5	100	45.5
307	Untreated	30	1.6	100	14.8	100	24	100	35	100	56.5
406	Untreated	20	2.8	100	2.8	100	26	100	42	100	57
106	Standard	50	0.9	60	2.8	70	3.8	80	6.8	80	6.8
202	Standard	50	2.3	50	2.3	60	3.3	70	5.3	60	5.3
309	Standard	30	3.1	40	3.1	50	3.1	50	6.1	50	7.8
401	Standard	50	2.5	50	2.5	60	2.5	60	3.5	60	3.5
108	AHDB9923	50	0.8	50	2.6	60	3.6	70	4.6	70	4.6
203	AHDB9923	60	2.1	70	2.1	80	3.1	80	5.1	80	5.1
304	AHDB9923	50	1.5	50	2	50	2	60	5	60	5
407	AHDB9923	60	2.6	60	2.6	70	2.6	70	4.6	70	6.3
102	AHDB9914	40	1	50	1.8	50	2.8	60	3.8	60	3.8
204	AHDB9914	50	2.6	50	3.1	60	4.1	60	6.1	70	7.8
308	AHDB9914	40	2	50	2	50	3	50	4	40	4
402	AHDB9914	60	1.6	60	2.1	60	2.1	70	4.1	80	6.1
107	AHDB9853	50	1.3	50	2.6	60	3.6	60	4.6	60	6.3
209	AHDB9853	50	1.6	60	2.1	60	2.1	70	3.1	70	2.8
303	AHDB9853	60	2.6	60	2.6	70	3.6	70	5.6	70	7.3
410	AHDB9853	30	1.1	40	2.1	40	2.1	50	4.1	50	6.1
101	AHDB9852	50	0.8	50	2.3	60	2.3	60	2.8	70	6.8
210	AHDB9852	60	2.8	60	2.8	60	2.8	60	5.8	50	7.8
302	AHDB9852	40	2.3	50	2.6	50	3.6	60	5.6	70	7.3
405	AHDB9852	40	1.8	40	2.3	50	2.3	50	5.3	50	5.3
201	AHDB9862	70	1.3	70	1.8	70	2.8	80	3.8	80	3.8
103	AHDB9862	30	1.1	40	2.1	50	2.1	50	4.3	50	4.6
301	AHDB9862	50	2.1	50	2.1	50	3.1	50	4.1	50	4.1

Plot No	Assessment Date Assessment Type Treatment Name	05/09/19 Incidence (%)	05/09/19 Severity (%)	17/09/19 Incidence (%)	17/09/19 Severity (%)	30/09/19 Incidence (%)	30/09/19 Severity (%)	07/10/19 Incidence (%)	07/10/19 Severity (%)	23/10/19 Incidence (%)	23/10/19 Severity (%)
403	AHDB9862	40	1.5	50	1.5	50	1.5	60	3.5	70	3.5
110	AHDB9911	30	1.9	30	1.5	30	2.5	40	3.5	40	4.9
208	AHDB9911	60	2.3	60	2.3	70	3.3	70	5.3	70	7.3
305	AHDB9911	40	2.1	50	2.1	50	3.1	60	4.1	60	6.1
409	AHDB9911	60	3	60	3	60	3	60	5	50	5
105	AHDB9851	60	0.5	60	2.8	60	2.8	70	4.1	70	3.8
207	AHDB9851	60	1.8	70	2.3	80	2.3	80	5.3	70	5.3
306	AHDB9851	60	2.8	60	2.8	60	2.8	70	4.8	70	4.5
408	AHDB9851	30	2.6	50	3.1	60	4.1	60	7.1	70	6.8

e. photographs

Trial layout

Typical rust symptoms in the untreated control plots, at the final assessment date. 25th October 2019.

Typical untreated plot (left) versus a typical treated plot with AHDB9862 (right).

Certificate of

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

This certifies that

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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
Stored Crops
Biologicals and Semiochemicals

Date of issue: 1 June 2018
Effective date: 18 March 2018
Expiry date: 17 March 2023

Signature Alison Richardson
Authorised signatory

Certification Number
ORETO 409

HSE
Chemicals Regulation Division

Department of Agriculture and Rural Development