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Project leader:	Angela Huckle, ADAS Horticulture
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Location of project:	Balmullo and Wester Forret, Fife, Scotland
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Date project commenced:	1 April 2020

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The results and conclusions in this report are based on an investigation 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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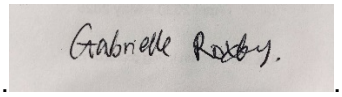
Signature .....  ..... Date ...21/12/2020.....

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GROWER SUMMARY

Headline

- Naturally occurring levels of downy mildew in both the cauliflower and broccoli trials were low.
- The programme with Revus (mandipropamid) + the adjuvant Phase II applied twice, followed by Infinito applied at heading, significantly reduced downy mildew (*Hyaloperonospora parasitica*) severity (%) in the broccoli trial at the first assessment.

Background

The objective of this trial was to compare a number of fungicides, of both experimental and commercially available products for efficacy against downy mildew (*Hyaloperonospora parasitica*) in planted crops of broccoli and cauliflower.

Downy mildew is an increasing disease issue for both edible and ornamental brassica crops and has a worldwide distribution. The disease is an increasing problem for growers in the UK, mainly in climatic zones where extended periods of leaf wetness occur, such as those found in the south-west of England and Scotland. Infection of plants with downy mildew commonly occurs through true seeds, stems, leaves, flowers and curd, as well as airborne and soil borne oospores (sexual spores) on crop residues and volunteers. The damage caused by downy mildew occurs mainly during spring and autumn, and can cause yield losses, and reduced crop quality rendering produce unmarketable. Initial development of leaf symptoms includes black speckling accompanied by pale-yellow lesions. These lesions typically stay between the leaf veins, with sporulation occurring on the underside of the affected areas. Black discolouration symptoms are not restricted to leaves, and can infect brassica heads, including the interior of curd, resulting in unmarketable product (Figure 1).

Figure 1. Broccoli head showing dark discolouration within the stem caused by downy mildew infection which may lead to rejection when cut for floretting.

Summary

Materials and methods

The trials were located at East of Scotland Growers at two locations in Fife, Scotland. The broccoli trial was situated near Balmullo, in a crop of the commercially grown cultivar, Parthenon. The cauliflower crop was located at Wester Forret in a crop of the commercially grown cultivar, Liria. The trials were dependent on naturally occurring sources of inoculum and both crops were planted with an autumn targeted harvest date. This was chosen based on the epidemiology of *H. parasitica,* the history of disease at this site and grower experience.

The trial comprised a fully randomised block design with six treatments (Table 1), including one untreated control and a commercial industry standard (Amistar), and was replicated four times. An 11 m wide band of crop was made available, giving a total area for each trial of 11.0 m x 52.0 m (572 m^2). Each plot measured 1.8 m by 7.0 m, a total area of 12.6 m^2, and comprised three rows of broccoli or cauliflower. Altogether the trial was six beds wide with additional discard beds planted either side of the trial to avoid spray drift from fungicides used in the main crop. The central row of each bed was used for all assessments, excluding the 0.5 m at each end.

Table 1. Treatment products, rates and timings for the broccoli and cauliflower downy mildew screens in Fife, Scotland, 2020

	Timing 1 – 3 to 4 weeks after planting		**Timing 2 – approx. 14 to 21 days after Timing 1**		**Timing 3 – approx. 14 to 21 days after Timing 2***	
Broccoli	**23rd August 2020**		**6th September 2020**		**19th September 2020**	
Cauliflower	**24th August 2020**		**14th September 2020**		**-**	
Treatment number	**Product**	**Rate (L or kg/ha)**	**Product**	**Rate (L or kg/ha)**	**Product**	**Rate (L or kg/ha)**
1	Untreated control	-	Untreated control	-	Untreated control	-
2	Amistar	1.0	Amistar	1.0	Infinito	1.6
3	Revus + Phase II	0.6 1.0	Revus + Phase II	0.6 1.0	Infinito	1.6
4	AHDB 9958	-	AHDB 9958	-	AHDB 9958	-
5	Taegro	0.37	Taegro	0.37	Taegro	0.37
6	Taegro	0.37	Amistar	1.0	Taegro	0.37

* Timing 3 was not applied to the cauliflower trial due to harvest intervals

Treatments were applied using a precision knapsack sprayer with a 1.5 metre boom and 02F110 nozzles at medium quality using 200 litres per hectare water volume. Treatments were applied at each timing as per Table 1. Three fungicide applications were made to the broccoli trial (Table 3) with the first application, on 23 August, three weeks after planting and

before the appearance of disease. Application 2 was made 15 days after Timing 1 on 6 September and a third application was made on 19 September.

Two fungicide applications were made to the cauliflower trial (Table 4), the third application was omitted as the crop grew too fast and the application would have been too close to harvest. Treatments were applied at each timing as per Table 1. Timing 1 was applied on 24th August 2020 at approximately three to four weeks after planting, and before the appearance of disease. If the host grower noted any mildew in the weeks before the first application was due, then the timing could have been brought forward. Timing 2 was applied approximately 21 days after Timing 1 on 14 September.

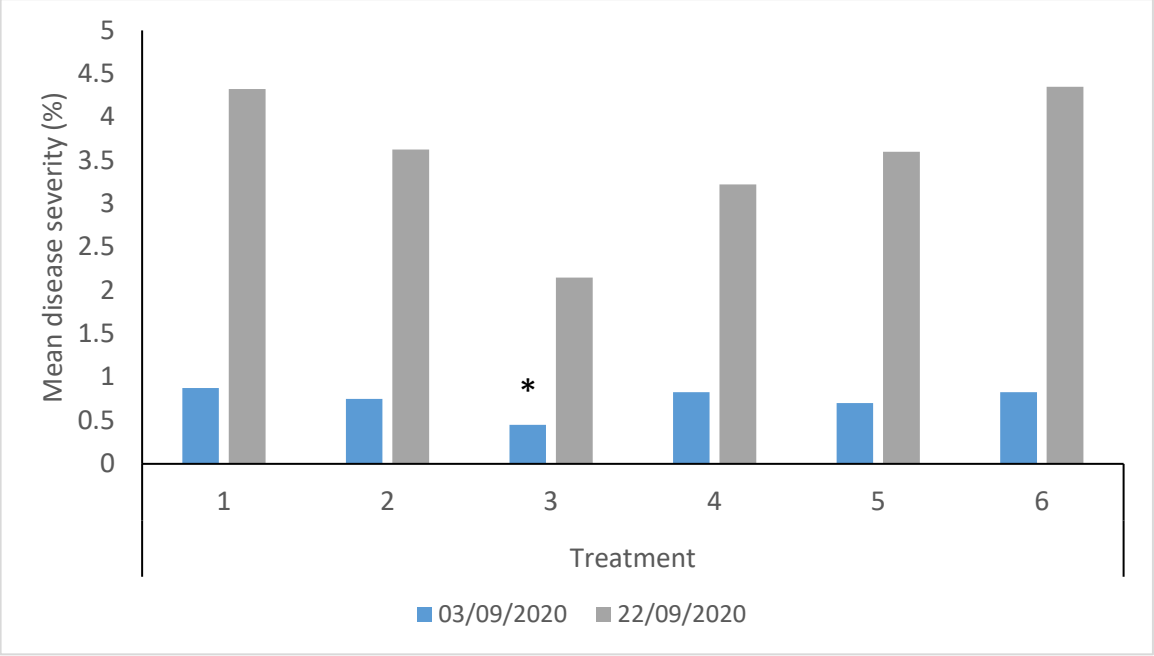
For both trials - with the exception of the fungicide treatments, all other pesticides and fertilisers were applied as per commercial practice by the host grower.

Results and discussion

There were no crop safety issues caused by any of the treatments.

In the broccoli trial, the results indicate that the Revus + Phase II and Infinito programme performed best in reducing foliar downy mildew. Overall, downy mildew levels were very low throughout the trial area and assessment, and despite the statistically significant reduction ($P<0.05$) caution should be exercised when considering the result (Figure 2).

Figure 2. Mean downy mildew severity in the broccoli trial from disease assessments carried out on 03/09/2020 and 22/09/2020 showing mean scores by date and treatment. F pr = 0.013, LSD – 0.24 (3rd September); F pr = 0.143 (not significant), LSD – 1.751 (22nd September). * indicates treatment significantly different from the untreated control.



In the cauliflower trial, no significant differences between the treatments and the untreated control were observed, and again there was low downy mildew presence until the harvest assessment. As this experiment was reliant on naturally occurring inoculum to infect the crop, there was the risk that the downy mildew may not appear if conditions were not favourable, or, if downy mildew was present, it may appear within the trial crop in an uneven or unbalanced distribution. With the former being true during the application period no data was collected until 4 September, and the data which was collected did not reach levels where differences between treatments could be determined with confidence.

At the final assessment, disease was recorded and although there was no significant difference between any of the assessments as shown through the analysis of variance, there was a trend for a difference in incidence and severity with selected treatments.

Where Amistar was included, the disease incidence remained lower than 50% of the cauliflowers assessed, unlike all other treatments which had disease presence greater than 50%. With regard to total % disease severity, Amistar treated plants were also the lowest in terms of high severity of individual plants within treatments, and clusters of adjacent plants being infected.

All other treatments showed little or no trend for noticeably effective results compared to the control, with the next best programme being the treatment of Revus + Phase II providing 50% protection for the crop.

The low disease levels may have been due to the high temperatures and low humidity experienced in the summer months, which would have discouraged long periods of leaf wetness. Despite rain showers through late August and September, the lack of leaf wetness would not have promoted favourable conditions for mildew growth for this reason. Therefore the differences between treatments were not pronounced in the cauliflower trial, and there was no statistically significant result in the second disease assessment of the broccoli trial. Although including Revus in the programme in the broccoli trial gave the only significant reduction in downy mildew, there was a trend in the cauliflower trial that indicated that Amistar reduced downy mildew by the greatest percentage, and it is important to alternate modes of action to prevent the development of fungicide resistance and not just rely on one product or active ingredient alone.

Financial Benefit

Although the disease pressure in this trial was low, Revus applied with the esterified rapeseed oil adjuvant, Phase II, did reduce disease severity significantly at one of the assessments.

Therefore in a high downy mildew disease pressure situation, if the use of an effective fungicide such as Revus applied with Phase II can reduce the incidence of systemic downy mildew appearing in the heads of broccoli or cauliflower by even as little as 5%, this could equate to an extra 500 kg/ha of marketable heads of broccoli in a typical crop which usually yields 10,000 kg/ha (10 t/ha), and therefore a financial benefit of £400/ha for broccoli. In cauliflower this equates to 1000 heads which would be a benefit of £450/ha for the grower.

Conclusions

Broccoli

- Revus + Phase 2 and Infinito used in a fungicide programme, showed significantly lower severity foliar downy mildew levels to the other treatments at the first assessment.
- There was a trend for the Revus programme to continue to give the greatest reduction in foliar downy mildew severity at the second and final assessment at heading.
- Despite disease levels being comparatively higher in the final assessment, they were still not high enough to reach a strong conclusion.
- There were no crop safety issues caused by any of the treatments.

Cauliflower

Although the trial did not show any statistically significant results, there was a trend that indicated that Amistar reduced downy mildew by the greatest percentage, with Revus + Phase II the close next best performer. The trial design relied on natural infestation as it was a field demonstration trial, and inoculating a commercial crop would be a large task and undesirable for the host grower. Possible alternative approaches to the method such as an inoculated pot trial could be used, but for practical demonstration purposes this may not be seen as in a commercial situation. However, the experimental approach could be changed to ensure a more reliable trial and results in future.

SCIENCE SECTION

Introduction

The objective of this trial was to compare a number of fungicides, of both experimental and commercially available products for efficacy against downy mildew (*Hyaloperonospora parasitica*) in planted crops of broccoli and cauliflower.

Downy mildew is a problem in all brassica crops, both edible and ornamental and is a globally occurring disease. The disease is an increasing issue for growers in the UK, mainly in climatic zones where extended periods of leaf wetness occur, such as those found in the south-west of England and Scotland. Infection of plants with downy mildew commonly occur through true seeds, stems, leaves, flowers and curd, as well as airborne and soil borne oospores (sexual spores) on crop residues and volunteers. The damage caused by downy mildew occurs mainly during spring and autumn, and can cause yield losses, and reduced crop quality rendering produce unmarketable. Initial development of leaf symptoms includes black speckling accompanied by pale-yellow lesions. These lesions typically stay between the leaf veins, with sporulation occurring on the underside of the affected areas. Black discolouration symptoms are not restricted to leaves, and can infect brassica heads, including the interior of curd, resulting in unmarketable product, especially for the floretting market as the black marks are more visible.

There are limited conventional chemical treatments for control of downy mildew for flowerheaded brassicas. Identifying alternative chemical and biological modes of action for control can help in the development of more sustainable integrated disease management (IDM) strategies for the future and guard against resistance development. Biological control methods are a continually emerging and learning how to integrate them to aid in the reduction of disease risk and support chemical control strategies is necessary to provide an alternative selection pressure to prevent resistance developing. Utilising effective treatments of biological controls could make a significant long-term difference for future crop protection strategies.

Materials and methods

The trials were located at East of Scotland Growers at two locations in Fife, Scotland. The broccoli trial was situated near Balmullo, in a crop of the commercially grown cultivar, Parthenon. The cauliflower crop was located at Wester Forret in a crop of the commercially grown cultivar, Liria. The trials were dependent on naturally occurring sources of inoculum and both crops were planted with an autumn targeted harvest date. This was chosen based on the epidemiology of *H. parasitica,* the history of disease at this site and grower experience.

The trial comprised a fully randomised block design with six treatments (Table 2), including one untreated control and a commercial industry standard (Amistar), and was replicated four times. An 11 m wide band of crop was made available, giving a total area for each trial of 11.0 m x 52.0 m (572 m^2). Each plot measured 1.8 m by 7.0 m, a total area of 12.6 m^2, and comprised three rows of broccoli or cauliflower. Altogether the trial was six beds wide with additional discard beds planted either side of the trial to avoid spray drift from fungicides used in the main crop. The central row of each bed was used for all assessments, excluding the 0.5 m at each end.

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Treatment number	**Product**	**Rate (L or kg/ha)**	**Product**	**Rate (L or kg/ha)**	**Product**	**Rate (L or kg/ha)**
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3	Revus + Phase II	0.6 1.0	Revus + Phase II	0.6 1.0	Infinito	1.6
4	AHDB 9958	-	AHDB 9958	-	AHDB 9958	-
5	Taegro	0.37	Taegro	0.37	Taegro	0.37
6	Taegro	0.37	Amistar	1.0	Taegro	0.37

* Timing 3 was not applied to the cauliflower trial due to harvest intervals

Table 3. Pesticide status of products used in the downy mildew trial at Balmullo, 2020.

Fungicide	**Active ingredient(s)**	**MAPP No.**	**EAMU number (if applicable)**	**Experimental approval needed**
Amistar	azoxystrobin 250 g/L	18039	On label	No
Revus	mandipropamid 250 g/L	17443	On label	No
Phase II	esterified rapeseed oil 842 g/L	N/A	On label (Cauli)	No
Infinito	fluopicolide 62.5 g/L + propamocarb hydrochloride 625 g/L	16335	2557/2015	No
AHDB 9958	-	-	-	Yes
Taegro	*Bacillus amyloliquefaciens* strain FZB24 130 g/kg	19204	N/A	Yes

Treatments were applied using a precision knapsack sprayer with a 1.5 metre boom and 02F110 nozzles at medium quality using 200 litres per hectare water volume. Treatments were applied at each timing as per Table 2. Three fungicide applications were made to the broccoli trial (Table 4) with the first application, on 23 August, three weeks after planting and before the appearance of disease. Application 2 was made 15 days after Timing 1 on 6 September and a third application was made on 19 September.

Table 4. Application details for the broccoli trial.

	Application 1	Application 2	Application 3
Application date	23/08/2020	06/09/2020	19/09/2020
Time of day	10:50	07:55	08:20
Crop growth stage (Max, min average BBCH)	BBCH 16 6 leaves	BBCH 17 7 leaves	BBCH 41 Early heading
Crop height (cm)	25	35	45
Crop coverage (%)	90	80	90
Application Method	Spray	Spray	Spray
Application Placement	Foliar	Foliar	Foliar
Application equipment	Azo small plot	Azo small plot	Azo small plot
Nozzle pressure	2.0	2.0	2.0
Nozzle type	Flat fan	Flat fan	Flat fan
Nozzle size	DG Teejet F1102	DG Teejet F1102	DG Teejet F1102
Application water volume/ha	200 L	200 L	200 L
Temperature of air - shade (°C)	13.5	11.5	13.7
Relative humidity (%)	79	69	71
Wind speed range (kph)	2	0	3
Dew presence (Y/N)	Y	N	N
Temperature of soil - 2-5 cm (°C)	10.3	10.6	11.4
Wetness of soil - 2-5 cm	Moist	Moist	Dry
Cloud cover (%)	100	70	50

Two fungicide applications were made to the cauliflower trial (Table 5), the third application was omitted as the crop grew too fast and the application would have been too close to harvest. Treatments were applied at each timing as per Table 5. Timing 1 was applied on 24th August 2020 at approximately three to four weeks after planting, and before the appearance of disease. If the host grower noted any mildew in the weeks before the application was due, then the timing could have been brought forward. Timing 2 was applied approximately 21 days after Timing 1 on 14 September.

For both trials - with the exception of the fungicide treatments, all other pesticides and fertilisers were applied as per commercial practice by the host grower

Table 5. Application details for the cauliflower trial

	Application 1	Application 2
Application date	24/08/2020	14/09/2020
Time of day	11:50	10:30
Crop growth stage (Max, min average BBCH)	BBCH 15 5 leaves	BBCH 17 7 leaves
Crop height (cm)	20	30
Crop coverage (%)	90	90
Application Method	Spray	Spray
Application Placement	Foliar	Foliar
Application equipment	Azo small plot	Azo small plot
Nozzle pressure	2.0	2.0
Nozzle type	Flat fan	Flat fan
Nozzle size	DG Teejet F1102	DG Teejet F1102
Application water volume/ha	200 L	200 L
Temperature of air - shade (°C)	14.2	10.1
Relative humidity (%)	77	70
Wind speed range (kph)	0	17
Dew presence (Y/N)	N	N
Temperature of soil - 2-5 cm (°C)	9.9	10.1
Wetness of soil - 2-5 cm	Moist	Moist
Cloud cover (%)	100	90

Assessment details – phytotoxicity both trials

To assess crop safety, any observed effects attributable to phytotoxicity such as chlorosis or scorch were recorded if present. Crop safety was assessed three times through the crop life at the same time as the disease assessments, approximately two weeks, four weeks and then six weeks after the initial 'Timing 1' treatment application.

Assessment details – broccoli trials

The level of foliar downy mildew present was assessed on three occasions; by estimating the percentage of downy mildew on 10 plants per plot, to give a severity value per plant, from which a mean was calculated. From the above individual levels of severity, the presence or absence of downy mildew could then be determined to calculate the incidence, with a score ranging from 0 (no disease) to 10 (high disease incidence). The initial baseline disease assessment found no disease incidence, therefore the data presented and analysed are the 'first' and 'second' disease assessments carried out on 3 and 22 September 2020. At these assessments downy mildew was present on all plant foliage. An assessment of mildew within the broccoli heads was carried out on 22 September by cutting the heads into quarters, and no downy mildew symptoms were observed.

Assessment details – cauliflower trials

The level of downy mildew present was assessed three times but recorded only once as disease levels were very low and did not visually change at the later assessment. Downy mildew prevalence was assessed by the same approach used in the broccoli trial. The initial baseline disease assessment found no disease incidence, therefore the data presented and analysed is from the only disease assessment carried out on 04 September 2020. A second visit to the trial was made in late September just before harvest by the agronomist, but no change in levels of downy mildew were seen so a second recording was not carried out

Statistical analysis

The results of these assessments were analysed using Analysis of Variance (ANOVA) with Duncan's multiple range test to determine where significant differences between treatments lay. Where significant differences between treatments were identified, Abbott's formula was applied to compare the percentage reduction of the treatments compared to the control.

Statistical analysis was carried out by the ADAS statistician, Chris Dyer.

Results – Broccoli trials

The Revus + Phase II and Infinito programme (Treatment 3), performed significantly better ($p= 0.013$) than the remaining treatments in limiting mean foliar downy mildew severity in broccoli at the first assessment on 3 Sept. Although caution should be taken with the results as disease levels were very low (Table 6). Treatment 3 caused a mean 49% reduction in downy mildew compared to the remaining treatments. There was no significant reduction in downy mildew from the rest of the treatments compared to the untreated control. Taegro (Treatment 5) performed the next best to Treatment 3, reducing downy mildew by 20% but the result was not significant.

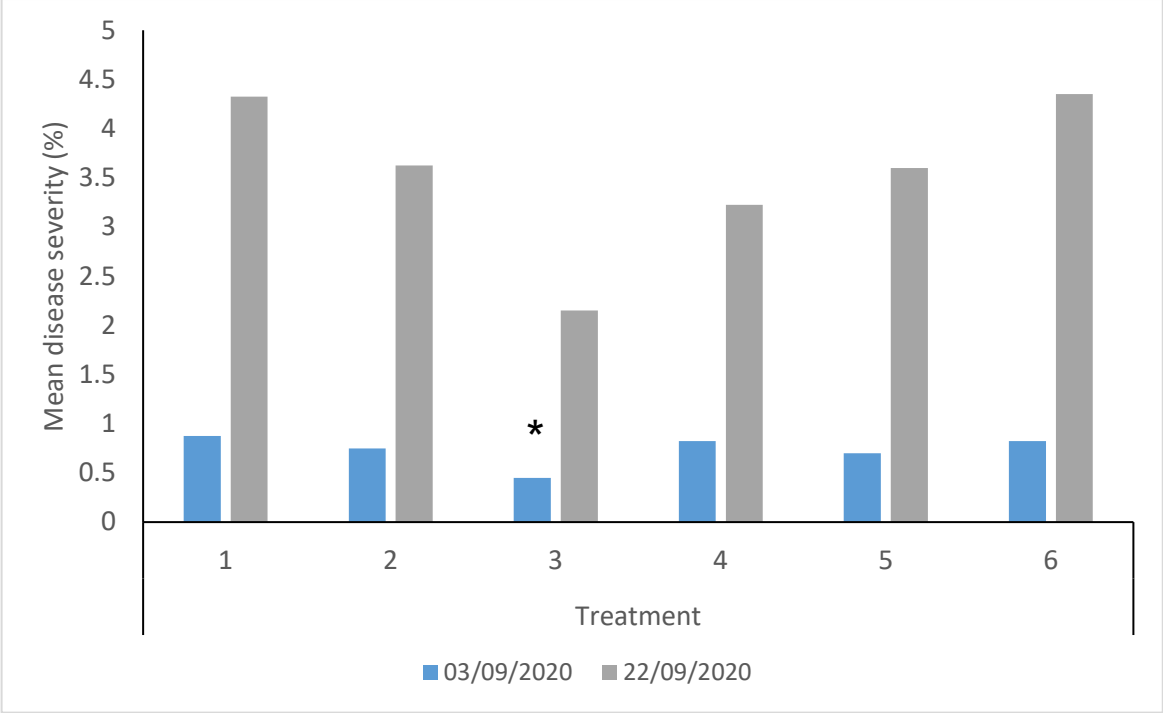
The third disease assessment on 22 September showed a similar trend in downy mildew reduction, with Treatment 3 plots showing the lowest mean disease severity overall, but despite an increase in disease severity at this assessment the differences were no longer statistically significant ($p>0.05$). Figure 3 illustrates those trends, which displays that the plots sprayed with the Revus + Phase II and Infinito programme gave the lowest disease severity scores. All other treatments, with the exception of the alternating Taegro and Amistar programme, gave a reduction in disease severity, but these results were not significant.

No downy mildew symptoms were seen in the broccoli heads, in any of the plots.

Table 6. Disease severity score showing original scores, back-transformed results and Abbott's reduction at two assessment dates. Sprays applied on 23 August, 6 Sept and 19 Sept.

		3 September 2020 Mean disease severity per plot			22 September Mean disease severity per plot		
Trt no	**Treatment programme**	**Original scores (%)**	**Back-transformed (%)**	**Abbott's reduction (%)**	**Original scores (%)**	**Back-transformed (%)**	**Abbott's reduction (%)**
1	Untreated control	0.87b	8.7b	-	4.3	43.2	-
2	Amistar, Amistar, Infinito	0.75b	7.5b	14.3	3.6	36.2	16.2
3	Revus + Phase II, Revus + Phase II, Infinito	**0.45a**	**4.5a**	48.6	2.2	21.5	50.3
4	AHDB 9958 x 3 applications	0.83b	8.3b	5.7	3.3	32.2	25.4
5	Taegro x 3 applications	0.70b	7.0b	20.0	3.6	36.0	16.7
6	Amistar, Taegro, Amistar	0.83b	8.3b	5.7	4.4	43.5	-0.6
	F pr. value	0.013	0.013		0.143	0.143	
	d.f.	15	15		15	15	
	L.S.D	0.24	2.24		1.751	17.51	

Figure 3. Mean foliar downy mildew severity from disease assessments carried out on 03/09/2020 and 22/09/2020 showing mean scores by date and treatment. F pr = 0.013, LSD – 0.24 (3rd September); F pr = 0.143 (NS), LSD – 1.751 (22nd September). * indicates treatment significantly different from the untreated control.



Results – Cauliflower trials

The results of this study were from a single assessment, which was taken near to harvest. There was no significant difference between any of the treatments compared to the untreated control regarding disease severity or incidence (P = 0.159, L.S.D. = 0.2476 – severity; 24.76 - incidence). The disease levels were too low and variable to determine differences between treatments with any confidence.

However, there are interesting trends where Amistar was used in two of the treatments. The least affected plants were treated with Amistar alone or Amistar + Taegro, with incidence scores of 47.5 and 45% respectively and have severity scores that also feature as the lowest at 0.47 and 0.45% respectively, indicating a trend for this product to possibly be involved in the control of downy mildew in both treatments. However, due to the lack of significance, we cannot confidently determine that these are due to treatment effects rather than natural variation (Figure 4).

Figure 4. Mean foliar downy mildew severity per treatment in the cauliflower trial on 4 September 2020, Wester Forret, Scotland. (F pr = 0.159 (NS), L.S.D. = 0.2476).

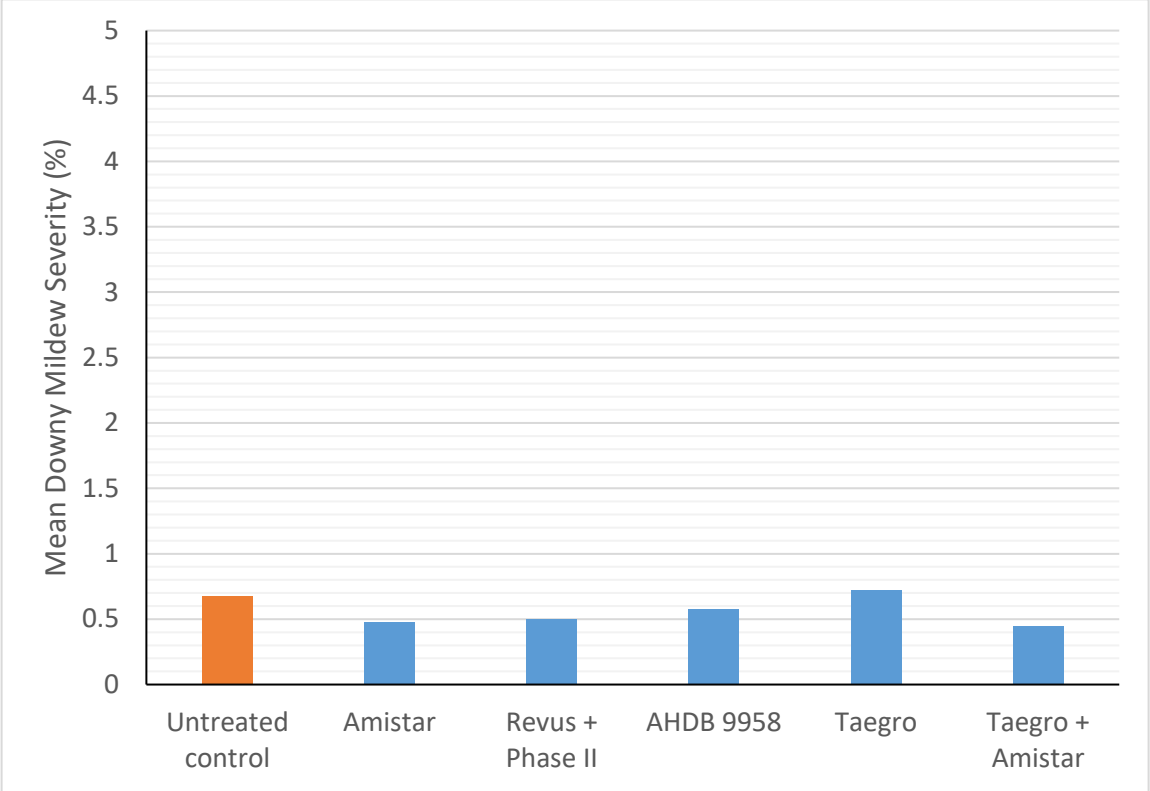
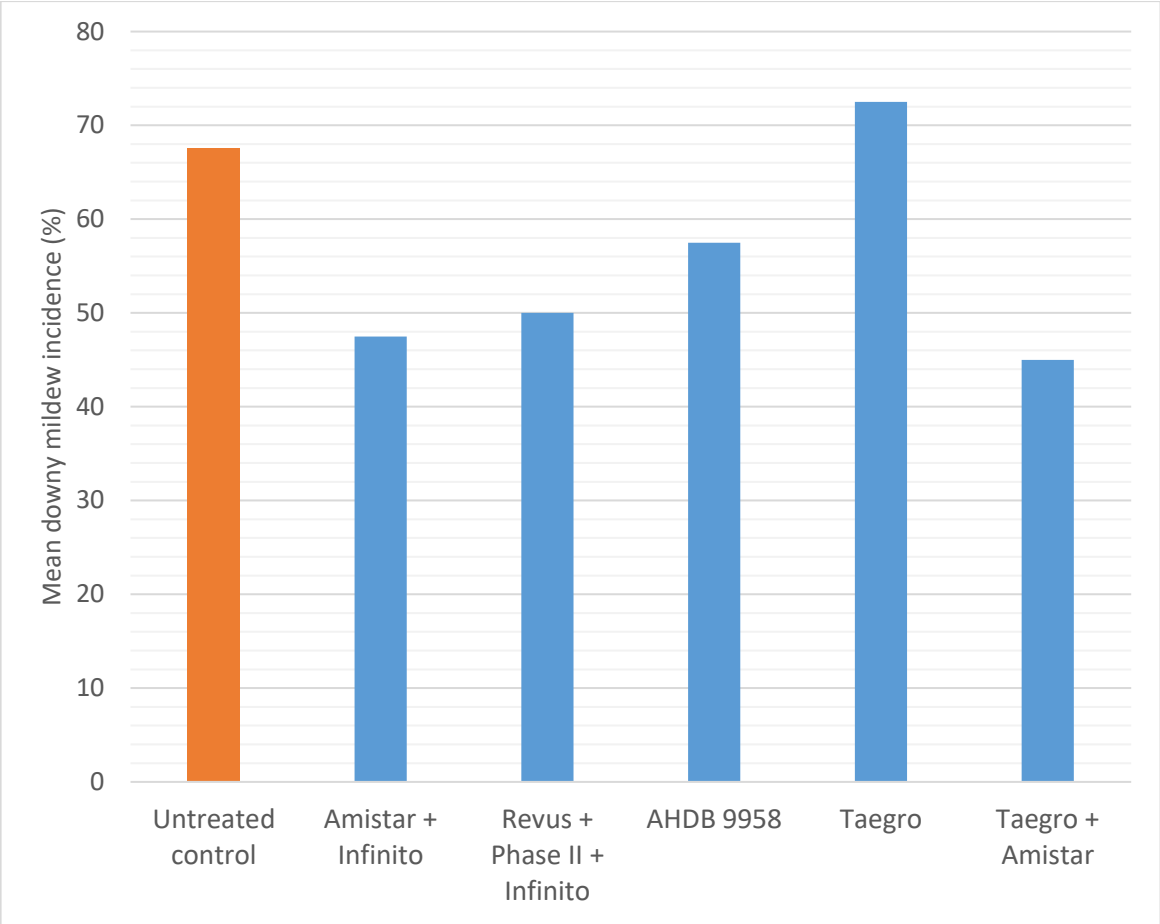


Figure 5. The incidence of downy mildew per treatment in the cauliflower trial on 4 September. (F pr = 0.159 (NS), L.S.D. = 24.76). The total number of plants in each treatment set was 40. Wester Forret, Scotland 2020.



Discussion

In the broccoli trial, the results indicate that the Revus + Phase II and Infinito programme performed best in reducing foliar downy mildew. Overall, downy mildew levels were very low throughout the trial area and assessment, and despite the significant reduction caution should be exercised when considering the result.

In the cauliflower trial, no significant differences between the treatments and the untreated control were observed, and again there was low downy mildew presence until the harvest assessment. As this experiment was reliant on naturally occurring inoculum to infect the crop, there was the risk that the downy mildew may not appear if conditions were not favourable, or, if downy mildew was present, it may appear within the trial crop in an uneven or unbalanced distribution. With the former being true during the application period no data was collected until 4 September, and the data which was collected did not reach levels where differences between treatments could be determined with confidence.

At the final assessment, disease was recorded and although there was no significant difference between any of the assessments as shown through the analysis of variance, there was a trend for a difference in incidence and severity with selected treatments.

Where Amistar was included, the disease incidence remained lower than 50% of the cauliflowers assessed, unlike all other treatments which had disease presence greater than 50%. With regard to total % disease severity, Amistar treated plants were also the lowest in terms of high severity individual plants within treatments and clusters of adjacent plants being infected. This was partly due to the low incidence across the entire crop, but also because of the low severity scores of only 1% for most plants, that skewed plant damage through the mean severity scores in favour of low incidences.

All other treatments showed little or no trend for noticeably effective results compared to the control, with the next best programme being the treatment of Revus + Phase II providing 50% protection for the crop.

The low disease levels may have been due to the high temperatures and low humidity experienced in the summer months, which would have discouraged long periods of leaf wetness. Despite rain showers through late August and September, the lack of leaf wetness would not have promoted favourable conditions for mildew growth for this reason. Therefore the differences between treatments were not pronounced in the cauliflower trial, and there was no statistically significant result in the second disease assessment of the broccoli trial. Although including Revus in the programme in the broccoli trial gave the only significant reduction in downy mildew, there was a trend in the cauliflower trial that indicated that Amistar reduced downy mildew by the greatest percentage, and it is important to alternate modes of action to prevent the development of fungicide resistance and not just rely on one product or active ingredient alone.

There were no crop safety issues caused by any of the treatments.

Conclusions

Broccoli

- Revus + Phase 2 and Infinito used in a programme, showed significantly lower severity downy mildew levels to the other treatments at the first assessment.
- There was a trend for the Revus programme to continue to give the greatest reduction in downy mildew severity at the second and final assessment at heading.
- However, disease levels were low through the trial.

- Despite disease levels being comparatively higher in the final assessment, they were still not high enough to reach a strong conclusion.
- There were no crop safety issues caused by any of the treatments.

Cauliflower

Although the trial did not show any statistically significant results, there was a trend that indicated that Amistar reduced downy mildew by the greatest percentage. The trial design relied on natural infestation as it was a field demonstration trial, and inoculating a commercial crop would be a large task. Possible alternative approaches to the method such as an inoculated pot trial could be used, but for practical demonstration purposes this may not be seen as in a commercial situation. However, the experimental approach could be changed to ensure a more reliable trial and results in future.

Knowledge and Technology Transfer

East of Scotland Grower Group day – spoke to small groups of growers in organised slots who came to view the trials – 23 and 24 September 2020

Video of overview of trials at Scottish Strategic Centre for Brassicas – https://www.youtube.com/watch?v=7kj8vNOogg8

Presentation to the Brassica Grower Association – 14 October 2020

Acknowledgements

AHDB for funding the work, and also the crop protection companies for their financial contributions as well as providing samples for the trials. Thanks should also be given to East of Scotland Growers (ESG) for hosting the trial and Kettle Produce for their input. Particular thanks should be given to James Rome and Duncan MacLachlan of ESG for their technical input and in-kind support with trial management and assessments.

Appendices

Duncans range test results for the broccoli trial

Table A. Duncan's multiple range test for Assessment 1 on 03/09/2020, by treatment number

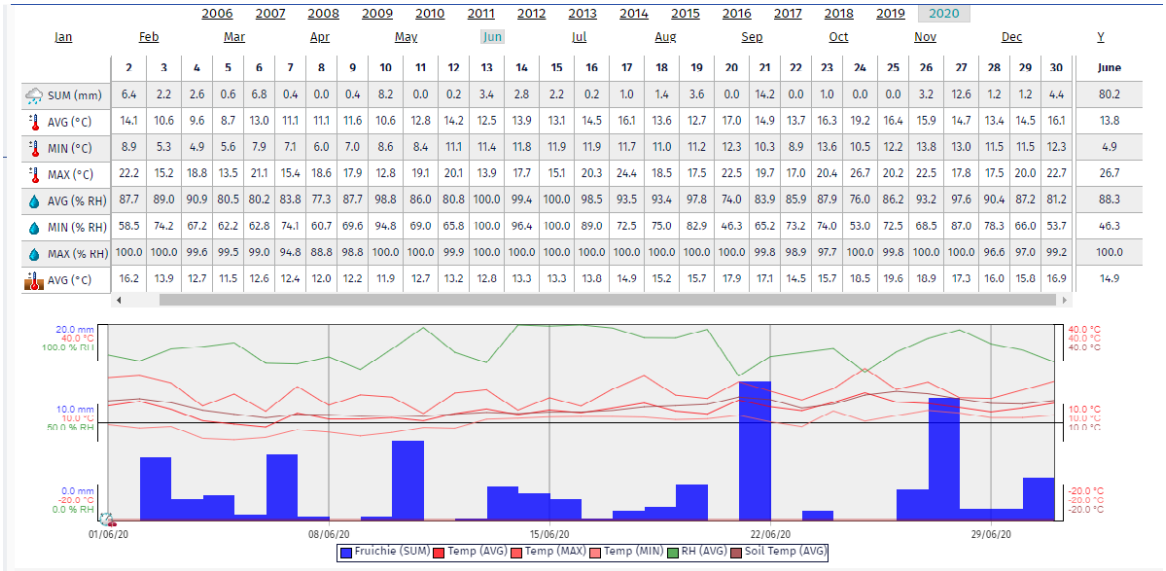
Treatment	Mean	
3	4.5	a
5	7	b
2	7.5	b
4	8.25	b
6	8.25	b
1	8.75	b

Table B. Table of values for % severity and incidence in the cauliflower downy mildew assessment on 04/09/2020, by treatment number

Treatment	% mean severity	% mean incidence
1	0.67	67.5
2	0.47	47.5
3	0.50	50.0
4	0.57	57.5
5	0.73	72.5
6	0.45	45.0
F pr	0.159	0.159
d.f.	15	15
L.S.D	0.2476	24.76

Weather data – provided by East of Scotland Growers

June

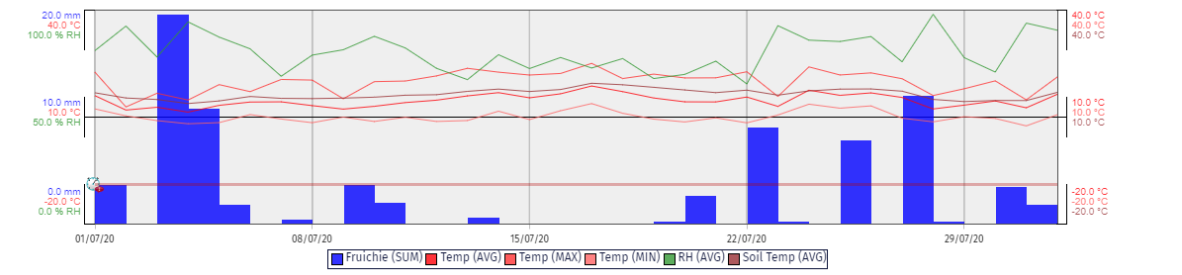


July

2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020

Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Y

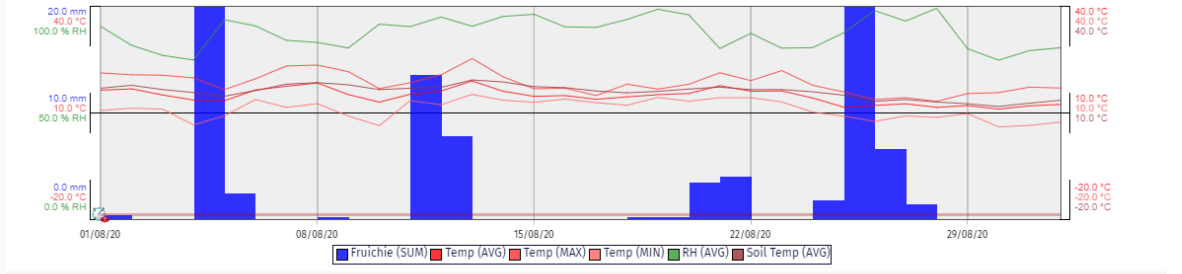
	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	July
SUM (mm)	0.0	19.6	10.8	1.8	0.0	0.4	0.0	3.6	2.0	0.0	0.0	0.6	0.0	0.0	0.0	0.0	0.0	0.2	2.6	0.0	9.0	0.2	0.0	7.8	0.0	12.0	0.2	0.0	3.4	1.8	79.6
AVG (°C)	12.8	11.4	13.3	14.3	14.3	13.2	12.3	13.1	14.1	14.8	16.0	16.9	15.4	16.6	18.8	17.2	15.4	14.3	14.3	15.7	13.0	17.6	16.1	16.8	15.5	12.3	13.4	14.6	12.6	16.	14.7
MIN (°C)	9.0	8.1	8.5	10.7	9.5	8.4	10.0	8.8	10.0	8.8	9.0	11.7	9.3	11.8	13.8	11.1	9.4	8.6	9.8	8.4	10.6	13.7	12.5	13.2	9.7	8.7	10.1	9.6	7.5	10.	7.5
MAX (°C)	16.7	14.8	19.2	17.2	20.6	20.4	15.2	20.0	20.2	21.6	23.8	22.7	21.9	22.3	25.1	20.9	22.1	21.0	21.1	22.8	15.8	24.2	21.9	22.5	20.8	16.1	18.0	20.2	14.9	21.	25.1
AVG (% RH)	78.2	94.7	87.6	82.1	69.2	79.1	81.6	88.0	82.5	72.9	67.6	79.3	72.8	78.0	73.1	77.5	68.1	70.1	76.3	65.6	92.9	86.2	85.5	87.8	76.0	98.3	77.9	71.2	94.1	90.	80.6
MIN (% RH)	63.5	69.8	69.2	65.2	47.8	50.5	62.4	53.5	56.2	50.1	44.2	53.9	50.7	55.3	56.0	57.1	44.6	48.0	51.1	42.9	75.9	57.4	63.2	67.7	47.9	93.2	61.3	49.6	79.3	75.	42.9
MAX (% RH)	96.3	100.0	100.0	100.0	89.9	93.6	96.1	100.0	100.0	95.8	88.5	96.4	95.9	97.0	87.7	93.8	97.6	90.1	94.5	92.7	100.0	100.0	99.7	100.0	99.1	100.0	98.5	90.4	100.0	100	100.0
AVG (°C)	15.0	13.8	14.6	15.8	15.3	15.2	15.4	15.6	16.2	16.3	17.3	17.9	17.2	17.8	19.5	19.1	18.4	17.7	16.9	17.6	16.2	17.4	17.9	17.9	17.3	15.0	14.4	14.7	14.7	17.	16.5



August

Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Y

	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	August
SUM (mm)	0.0	26.4	2.4	0.0	0.0	0.2	0.0	0.0	13.6	7.8	0.0	0.0	0.0	0.0	0.0	0.2	0.2	3.4	4.0	0.0	0.0	1.8	31.6	6.6	1.4	0.0	0.0	0.0	0.0	100.0
AVG (°C)	13.7	13.5	16.5	17.6	18.5	15.2	13.1	15.3	16.2	19.1	16.1	14.7	14.9	13.9	14.6	15.2	15.5	17.7	16.2	16.2	14.2	11.7	12.1	12.6	11.6	12.1	11.1	12.0	12.4	14.7
MIN (°C)	6.6	9.2	13.8	11.6	12.6	9.2	6.4	13.5	12.3	15.3	13.6	13.0	14.0	12.9	12.2	14.4	13.3	14.3	14.3	13.1	10.3	9.1	7.6	9.2	8.7	9.8	6.1	6.5	7.4	6.1
MAX (°C)	19.9	16.6	19.7	23.3	23.5	21.7	16.9	18.5	20.8	25.4	20.2	16.9	17.0	14.9	18.1	16.7	18.1	21.4	19.2	22.0	17.8	16.0	13.8	14.3	13.3	15.5	15.8	17.3	17.1	25.4
AVG (% RH)	75.0	93.9	91.0	84.2	83.3	80.6	91.8	90.7	95.2	90.8	95.5	96.5	90.6	90.3	94.1	98.9	96.2	80.4	87.5	80.5	80.8	87.8	98.2	93.3	99.3	80.3	74.9	79.4	80.7	87.8
MIN (% RH)	51.4	79.6	78.6	63.4	65.9	54.2	79.7	78.1	82.5	73.9	85.2	90.4	81.1	84.7	81.4	92.6	86.1	61.8	76.8	58.8	60.3	71.1	92.0	81.4	94.5	56.0	56.9	53.7	57.0	50.5
MAX (% RH)	98.8	100.0	99.4	99.4	98.1	99.5	100.0	98.9	100.0	100.0	100.0	100.0	98.3	95.9	100.0	100.0	100.0	100.0	98.3	94.6	98.5	100.0	100.0	100.0	100.0	100.0	94.1	94.9	98.8	100.0
AVG (°C)	15.8	14.7	16.3	18.1	18.6	18.0	16.6	17.0	17.3	19.3	18.8	17.4	17.2	16.2	15.7	16.1	16.8	17.3	16.6	16.6	16.0	15.0	13.3	13.8	13.1	12.6	11.8	12.8	13.6	16.0



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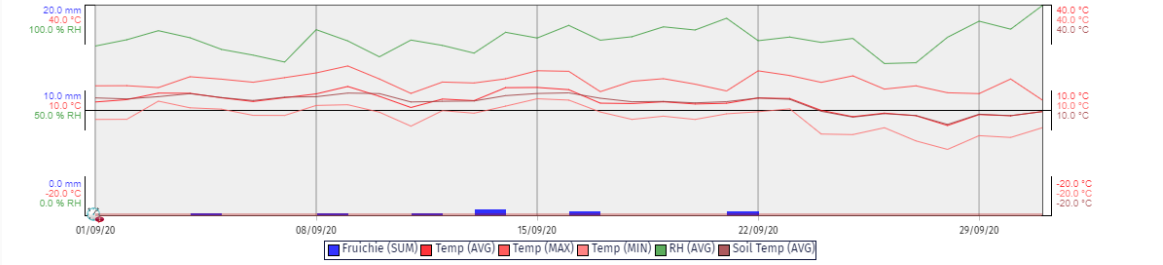
September – note the rain gauge may have been stuck in this month

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	September
SUM (mm)	.0	0.0	0.0	0.2	0.0	0.0	0.0	0.2	0.0	0.0	0.2	0.0	0.6	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0
AVG (°C)	.1	15.0	14.9	13.6	12.6	13.7	14.7	16.9	14.1	10.8	13.3	12.8	16.5	16.6	15.9	12.1	12.0	12.5	11.8	12.1	13.6	13.4	10.0	8.2	9.2	8.5	5.7	8.8	8.5	9.7	12.3
MIN (°C)	.5	12.7	10.8	10.4	8.6	8.6	11.4	11.6	9.5	5.5	9.9	9.2	11.2	13.3	13.0	9.6	7.4	8.4	7.4	9.0	9.6	10.5	3.2	3.1	5.1	1.3	-1.2	2.8	2.3	5.0	-1.2
MAX (°C)	.1	16.5	19.7	19.0	18.1	19.4	20.7	22.7	19.0	14.9	18.1	17.9	19.1	21.4	21.2	15.4	18.3	19.1	17.5	15.6	21.3	20.0	18.0	19.9	16.1	17.0	15.1	14.8	19.0	13.0	22.7
AVG (% RH)	.7	88.1	84.7	79.1	76.4	73.1	88.5	83.2	75.6	83.6	81.0	77.3	87.3	84.6	90.6	83.5	85.2	89.9	88.4	94.0	83.3	85.0	82.5	84.4	72.4	72.8	84.9	92.6	88.8	100.0	84.1
MIN (% RH)	.3	78.9	65.6	58.2	51.7	41.9	75.6	61.5	57.0	68.7	62.0	54.9	77.1	64.0	67.6	72.7	66.5	61.7	51.3	80.3	54.1	58.2	59.0	55.6	48.0	45.0	46.7	78.5	47.6	100.0	41.9
MAX (% RH)	.6	97.9	98.7	95.9	91.4	97.5	97.2	97.5	96.4	99.5	91.1	97.2	98.6	97.9	100.0	95.3	98.5	100.0	100.0	100.0	100.0	97.4	100.0	100.0	97.7	97.8	100.0	100.0	100.0	100.0	100.0
AVG (°C)	.3	13.9	14.8	13.7	12.8	13.8	13.9	15.0	14.8	12.4	12.6	12.7	14.2	14.9	15.0	13.5	12.5	12.6	12.2	12.5	13.6	13.2	9.8	8.1	9.1	8.6	6.0	8.9	8.5	9.7	12.2



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