

Project title: Demonstrating strawberry powdery mildew risk forecasting and biofungicide management – on farm assessment 2020

Project number: SF 157

Project leader: Scott Raffle, AHDB

Report: Final report March 2021

Key Staff: Angela Berrie, Plant pathologist

Location of Project: Vicarage Nurseries, Bretforton, Worcestershire

Date project commenced: 1 April 2020

Date project completed: 30 November 2020

GROWER SUMMARY

Headline guidance from trial

- In this trial, the risk of strawberry powdery mildew infection occurring was reliably worked out using the weekly weather forecast and a simple 'look-up' table (below).

Simplified Mildew risk in relation to daily average temperature and relative humidity		
Condition		Mildew risk
Temperature	Humidity	
< 14	Not relevant	Low
≥ 14	< 82%	Moderate
≥ 14	≥ 82%	High

- Assess the risk category for each day using the weather forecast and criteria in the table. The entire week of cumulative seven days is then estimated as a low, medium or high-risk week, but take account of farm conditions such as full cover poly tunnels. (Details on how to determine the risk are included in the appendix of the main report).
- Start the spray programme as soon as temperatures and humidity start to increase, even though the risk may still fall within the 'low' category. The start can often be delayed until May or even early June. Ensure excellent spray cover to the underside of the leaves and to the young leaves and developing flowers deep in the crown.
- A conventional mildew product should always be used for the first spray of the year.
- The two biopesticides assessed in this trial (Sonata and AQ10) only worked well in periods of low risk. Sonata and AQ10 were used without wetters and at the rates advised on the label.
- Watch the crop very closely at least once a week using a hand lens and move to conventional products immediately the tiniest specks of mildew hyphae are seen and especially if the forecast risk has increased.
- Moderate and high risks need conventional mildew products, not biopesticides for reliable control.

- In this trial, a weekly programme of conventional mildewcides, starting in early April, gave reliable control through the whole season for the rest of the farm and in the control area.
- In the trial tunnel, the spray programme started on 10 June when the risk had increased to moderate, resulting in a serious outbreak of mildew in the trial area. In hindsight, the risk judgements were perhaps too optimistic and the programme should have started a week earlier when the risk started to increase. This probably would have avoided the increase in mildew. At the start, biopesticides were used too optimistically in the trial area.
- Action taken by the grower using conventional products, including four potassium bicarbonate sprays, successfully dealt with this early epidemic in the trial tunnel, such that the mildew incidence had fallen considerably by the second assessment in August and was negligible and similar to that in the routine tunnel by the final assessment in September.

Background and expected deliverables

Over 15 years ago, a computer based strawberry powdery mildew risk prediction model was developed by Xiangming Xu at NIAB EMR in Kent. The model which uses knowledge of the optimum temperature and relative humidity for mildew infection to occur, was utilised in AHDB Projects SF 62 and SF 62a and demonstrated that growers can successfully use it to determine the need for applying protective fungicides to avoid infection.

However, despite being used successfully in these projects, UK growers have been slow to adopt it on commercial strawberry farms. Some growers have found it difficult and impractical to run the computer-based model using the required data loggers in the field. Furthermore, powdery mildew infection is so common in protected strawberry crops and can be so damaging to fruit yields and quality, that the majority of growers and agronomists feel more comfortable sticking to a routine prophylactic protective fungicide spray programme.

More recently, in an Integrated Pest and Disease Management Project funded by AHDB from 2015-2020 (SF 157), a simplified model employing weather forecast data and a 'look-up' table was used as part of a novel management approach to controlling powdery mildew and Botrytis in a protected everbearer strawberry (cultivar Amesti). The project demonstrated the potential to cut fungicide use for mildew by half. Instead of using the computer-based model, BBC weather forecast data (predicted for the next seven days) for the site was used in combination with a simple 'look-up' table to calculate the risk of mildew infection for the coming week. Criteria used in deciding upon the need to spray included this mildew risk 'look-up' table, weekly inspections of growth stage and rate of growth and weekly monitoring

for the presence of very early signs of powdery mildew infection. In addition, when the predicted risk of infection occurring was moderate, the biopesticides 'Sonata' and 'AQ10' were relied upon rather than conventional fungicides.

To consider whether such savings could be made and if biopesticides could be relied upon in a commercial setting using a similar approach in 2021, a demonstration trial was set up at Vicarage Nurseries, Bretforton, near Evesham in Worcestershire, by kind permission of Jaswinder Singh. The trial was set up using a single multi-bay tunnel of table-top (five rows per tunnel) everbearer strawberries (cultivar Murano) within a commercial plantation of the same cultivar.

No replication or statistical analyses were applied. The trial tunnel was managed using the same approach as Project SF 157, employing BBC weather forecast data in the simplified risk prediction table to determine the need to spray, coupled with weekly crop monitoring for growth stage, rate of growth and symptoms of early mildew infection. The trial was managed by plant pathologist Angela Berrie, aided by ADAS agronomist Robert Irving and farm manager Jaswinder Singh. The trial tunnel was compared to the remainder of the Murano crop which received routine weekly preventive fungicide applications from April until September.

At the end of the season, the total number and type of fungicides used on both the trial tunnel and the remainder of the crop were compared, whilst also contrasting the level of mildew control achieved in each. In addition, grower Jaswinder Singh and agronomist Robert Irving, offered their opinion on how confident they would be to adopt this management approach for mildew control in future.

There were two basic questions that they asked at the end of this trial:

- Was the weekly risk assessment, a forecast based on BBC weather data for the post code and assessed by Angela Berrie (took an hour per week) useful?
- Were the biopesticides AQ10 and Sonata useful?

Summary of the project and main conclusions

The trial began in March 2020. The everbearer cultivar Murano was planted in peat substrate bags on standard table-tops (five rows per tunnel) on 27 March 2020. This cultivar has good resistance to disease but in the UK shows low / moderate susceptibility to powdery mildew (but now appears more susceptible to mildew than the Amesti used in the earlier trials).

Data loggers were used in the trial tunnel to record daily average temperatures and humidities so that these could be used in the computer-based mildew risk model and compared, at the end of the season, to the simplified 'look-up' table which was managed by plant pathologist Angela Berrie. The computer-based mildew risk model cannot be used to predict forward mildew risk until forecast temperature and

humidity data is available to input. Data loggers in the tunnel only provide historic weather information.

Every week from the start of April until the end of September, from a remote site in Kent, Angela Berrie studied the BBC weather forecast data for the postcode for Vicarage Nurseries (WR11 7HW) for the week ahead and used the predicted average daily temperatures and relative humidities to work out the risk of strawberry powdery mildew infection occurring, using the simplified 'look-up' table below:

Simplified Mildew risk in relation to daily average temperature and relative humidity		
Condition		Mildew risk
Temperature	Humidity	
< 14	Not relevant	Low
≥ 14	< 82%	Moderate
≥ 14	≥ 82%	High

In addition to studying the weather forecast and calculating the risk of infection, the crop (both trial tunnel and the remainder of the crop) was monitored every week by ADAS agronomist Robert Irving and/or farm manager Jaswinder Singh. Plant pathologist Angela Berrie also visited the site to assess the crop in July, August and September. She had planned to visit once per month, but was prevented from doing so in April, May and June due to Covid-19 lockdown restrictions, preventing her from travelling from her home in Kent to Worcestershire.

Decisions on the need to use a fungicide in the trial tunnel

Low risk: When the mildew risk was calculated as 'low', unless any new powdery mildew lesions had been found, the decision was taken not to spray any fungicide in the early part of the season or to continue with a biopesticide once the programme had started.

Moderate risk: When the mildew risk was calculated as 'moderate', if no new powdery mildew lesions had been found, the decision was taken to continue with a biofungicide product. If there were any signs of new powdery mildew lesions, the decision was taken to apply a conventional fungicide.

High risk: When the mildew risk was calculated as 'high', the decision was taken to apply a conventional fungicide with good 'protectant' properties. If there were any signs of new powdery mildew lesions, the decision was taken to apply an additional conventional fungicide with 'eradicant' properties, such as potassium bicarbonate.

Decisions on the need to use a fungicide in the remainder of the plantation

In the remainder of the plantation, a routine prophylactic fungicide spray programme was applied every week from 25 April until 16 October, under the recommendation of ADAS agronomist Robert Irving and in line with mildew management on other everbearers on the rest of the farm business.

Choice of fungicide sprays

In the trial tunnel, when a biopesticide was used, a choice was made between Sonata (*Bacillus pumilus*) and AQ10 (*Ampelomyces quisqualis*). Sonata was kindly donated free of charge to the trial by Bayer UK. AQ10 was kindly donated free of charge to the trial by Fargro.

Choice of other biopesticides and conventional fungicides used in both the trial tunnel and remainder of the plantation came from lists provided in Tables 2 and 3 in the Science Section of this report.

All products were applied as foliar sprays by the farm using an air-assisted Berthoud sprayer at 1,000 L/ha. Both Sonata and AQ10 were used at the label rates. A wetter was not included as neither label nor their associated product support claimed a decisive benefit of doing so.

Summary of results

The risk of infection at the site was generally low in April and May. From early June, the risk started to increase and remained moderate to high until October. Interestingly, the risk determined from the computer-based model, run using the data loggers in the field, especially when conditions initially became favourable in June, agreed closely with those determined from the 'look-up' table and the BBC weather forecast.

The first treatment to the trial tunnel was delayed until 10 June, whereas treatments to the remainder of the crop were applied at around 7-10 day intervals from 25 April. After 10 June, treatments were applied to the trial tunnel at 7-15 day intervals in response to a continued mildew risk, mainly at moderate to high levels, based on the weather and on the incidence of new mildew lesions found in the trial tunnel (see images below).



New mildew lesion on underside of leaf



Mildew colonising seeds on Murano fruit

In the trial tunnel, a total of 19 products were applied between 10 June and 16 October, 11 of which were conventional fungicides and eight biopesticides. In contrast in the remaining crop, a total of 40 products, most of which were conventional fungicides, were applied.

Mildew lesions were first identified in the trial tunnel in mid-June, when no visible mildew was present in the remainder of the crop. By mid-July, the mildew incidence in the trial tunnel was high and it was treated with potassium bicarbonate and weekly applications of conventional fungicides. By late July, both the trial tunnel (92% of leaves) and the remainder of the crop (70% of leaves) had visible symptoms of mildew. The control measures used in both successfully reduced mildew symptoms. By September, symptoms were negligible in both. Images of the mildew symptoms seen are found in Figures 3 to 7 at the end of the Science Section of this report.

Full details of how the trial was managed, how decisions on spraying choice were made, the treatments applied, along with more information, can be found in the Science Section of this report. Key information is presented in:

Table 4: Criteria for mildew management decisions

Table 6: Action calendar and example in Appendix

Table 7: Trial diary showing weather forecast for week ahead from BBC and identified risk

Table 8: Treatments applied to trial tunnel and remaining plantation at Vicarage Nurseries in 2020

Grower and agronomist's views and findings

A useful summary on what the grower Jaswinder Singh and ADAS agronomist Robert Irving learnt from the trial is listed in the Headlines listed at the top of this report. A more comprehensive summary of their views and findings are also included

in the Science Section of this report under the heading: *'End of season views by the grower and advisor'*.

Conclusions on what we learnt from this demonstration trial

- The key to success of this management approach to powdery mildew in everbearer strawberry is having the skill and experience to detect the first mildew lesions early.
- The previous work on Amesti showed it to be highly susceptible to mildew on flowers and fruits but less so on leaves. In contrast in this work, Murano appears to be more susceptible to leaf infection and was more susceptible than the farm staff had anticipated.
- In both Project SF 157 (using Amesti) and in this demonstration trial (using Murano), temperature and humidity criteria for mildew infection were not reached until June, allowing early sprays for mildew protection in April and May to be omitted.
- The predicted risk of infection calculated from the simplified 'look-up' table using BBC weather forecasts, agreed closely with the computer-based NIAB EMR model using data from loggers in the tunnel. However, the trial tunnel was well ventilated from the outset. Had it been sealed from the time of planting, then tunnel conditions would have differed more widely from the outside weather forecast and the risk based on the simplified 'look-up' table would need to have been adjusted.
- **Conditions favourable for mildew started to develop in the week beginning 1 June. The risk was deemed to be minimal so the first spray in the trial tunnel was not advised until the following week when favourable conditions had increased. This approach had been successful with the cultivar Amesti but with the greater susceptibility observed with Murano, sprays should have started a week earlier. This probably accounted for the rapid development of mildew in the trial tunnel in June and July. Had the first spray been applied one week earlier, the mildew may not have developed so rapidly.**
- The conventional fungicides applied to the trial tunnel successfully dealt with this early epidemic, reducing mildew incidence by August and September.
- Mildew incidence in the remainder of the plantation (routine spray programme) was low to moderate in July, but significantly lower than in the

trial tunnel, demonstrating that these conventional products were effective at controlling the mildew.

- The trial tunnel received less than 50% of the products applied to the routine tunnel and almost half of the products applied were biopesticides.
- We have demonstrated that this managed approach to mildew control in protected everbearer strawberries employing a simplified risk model using BBC weather data and a 'look-up' table, can work effectively on a commercial strawberry farm. However, if using this managed approach, don't be too optimistic when making judgements on the risk of infection. Err on the cautious side and be prepared to start spray programmes as soon as temperatures and humidity start to increase.
- If the predicted mildew risk is 'low' then control can be based on biopesticides such as Sonata and AQ10, but intervention is required with conventional fungicides if symptoms of mildew develop and/or predicted mildew risk increases from low to 'moderate' or 'high'.
- Crucial to success are detecting mildew symptoms early and starting the spray programme at the appropriate risk in relation to the susceptibility of the strawberry cultivar used.

Financial benefits

In Project SF 157 where the same management approach to strawberry powdery mildew control was followed, both replicated trials at NIAB EMR and a demonstration trial on a commercial farm in 2018 demonstrated the ability to reduce fungicide inputs where treatments used for SPM and fungal rots were based on the simplified 'look-up' table using BBC weather data to predict the risk of mildew infection, compared to a routine or standard farm programme. The results were confirmed in the replicated trial at NIAB EMR in 2019. In both cases in 2018, cost savings were made (£699 /ha and £443 /ha respectively) with no adverse effects on yield, fruit quality or rot incidence. In this demonstration trial, where this management approach reduced fungicide use by half compared to a routine 7-day spray programme, similar savings would have been achieved.

In this on-farm assessment, the use of the management system resulted in a saving of four sprays by delaying the start of the spray programme until weather conditions were favourable. Overall, the trial tunnel received less than 50% of the products applied to the routine tunnel and almost half of the products applied were biofungicides. However, in this study the incidence of powdery mildew was higher in

the trial tunnel at the start of harvest with obvious consequences in loss of crop and fruit quality and this must be considered in the overall cost savings.

Action points for growers

Simplified Mildew risk in relation to daily average temperature and relative humidity		
Condition		Mildew risk
Temperature	Humidity	
< 14	Not relevant	Low
≥ 14	< 82%	Moderate
≥ 14	≥ 82%	High

- You can create a simplified powdery mildew risk model using BBC weather forecast data and the 'look-up' table above to dictate whether to spray or not. Each day is assessed to its risk category using the criteria in the table. The entire week of cumulative seven days is then estimated as a low, moderate or high-risk week.
- Monitor the crop closely at least once a week and switch to conventional products immediately the tiniest specks of mildew hyphae are seen.
- Always start the spray programme on the early side and always aim for excellent crop coverage.
- Use biopesticides when the risk is 'low' and there are no visual symptoms of mildew lesions. Sonata and AQ10 can be used at the label rates with no wetters. Biopesticides are protectant, not eradicant. Our experience in project SF157 indicates that Sonata and AQ10 worked best when used in blocks of treatments rather than alternating sprays. AQ10 is not compatible with many fungicides (check label), whereas Sonata, being a bacterial product, is compatible with most fungicides.
- Moderate and high risks need conventional mildew products, instead of biopesticides for reliable control.
- Be prepared to use a weekly programme of conventional mildewcides to guarantee reliable control through the whole season as necessary. There was a serious outbreak of mildew when the biopesticides were used too optimistically in this demonstration trial.

- If you lose control when using biopesticides, it can take a month to restore control using conventional products.
- You will gain confidence by trying this management system and using biopesticides in a few tunnels at first.
- Never forget that, because mildew can increase rapidly in favourable weather, infection develops into sporing colonies in as few as four days - the system is about mildew management and initially avoids the need for sprays in the early part of the season when the mildew risk is low or absent. Once the weather becomes favourable, usually in May, then a 7-day programme of sprays must be followed on susceptible strawberry cultivars.