Powdery mildew — flattening the curve

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The setting: November 2019, a pleasantly warm polytunnel of young strawberries at Costa Berries East Devonport farm, Tasmania. Here a cohort of student, research team and industry are planning a study of powdery mildew disease that will have direct benefit to the strawberry industry. Our student researcher in this story is Anna Mackintosh, University of Tasmania fourth year Agricultural Science Honours student and recipient of the Costa Honours scholarship. She is set to embark on a study of this increasingly important strawberry disease, supported by the Tasmanian Institute of Agriculture (TIA) and Costa Berries.

Anna Mackintosh, TIA. Photo credit: TIA

> **The scholarship, alongside support from the Costa strawberry farm in East Devonport, allowed me to invest in a project that has direct benefits to industry, Anna said.**

Powdery mildew disease of strawberries has most recently come to prominence in Australia with the move from field to protected cropping, particularly in Tasmania where most strawberries are grown in polytunnels in substrate.

The poly tunnel environment — a match made in mildew heaven

Anna's research showed how a polytunnel environment creates the perfect storm for strawberry powdery mildew infection. "Powdery mildew is a disease that thrives in low UV, mild temperatures and high humidity. Throughout the study, conditions in the tunnel were ideal for powdery mildew development. Temperature was in the optimum range 87% of the time and humidity 61% of the time," Anna said.

Fundamental to managing a disease like powdery mildew is understanding how the disease develops in both time and space, how fast epidemics develop and how the disease spreads. This is called epidemiology and formed a major part of this study. In a golden opportunity for Anna, Costa Berries provided a tunnel of strawberries that received no powdery mildew sprays for 91 days of the strawberry season.

The picture it painted was not pretty, but incredibly revealing. A whopping 60 hours and 38,000 leaflets later, Anna plotted the curve and mapped the disease showing how dramatically powdery mildew can take hold when no management is in place.

"I assessed disease incidence, which is the number of leaves with powdery mildew symptoms, and disease severity, which is the area of leaf tissue affected by powdery mildew. By the end of February disease incidence reached 95%, meaning almost the entire crop was infected with powdery mildew. Disease severity reached 14%, meaning that 1/8th of the total leaf area was covered by mildew. Put simply, to prevent an epidemic, disease management needs to be applied early in the season before symptoms appear," she said.

Disease spread

Whilst the disease was at a low level at the start of this study (2% incidence) it was scattered widely throughout the tunnel with no obvious entry point. Over time, the disease formed localised hotspots with the southern side of the tunnel favouring disease.

Flattening the curve — a management strategy for Powdery mildew

Unlike people, strawberry plants cannot socially distance. This means other strategies such as hygiene, environmental management and fungicides are necessary. Prevention and suppression of powdery mildew relies on a relatively narrow choice of chemical options, only recently expanded with the release of cyflufenamid (Flute®). With the strawberry season in Tasmania extending over nine months, this also adds a logistical challenge for chemical rotation and resistance management.

One of the key questions posed by the Costa team at the beginning of the study was "How effective is our current management program based on myclobutanil (Systhane®) and potassium bicarbonate (Ecocarb®) and can we improve this?"

The research trial tested the current commercial program alongside three variations, applied in a two-week rotation:

Commercial practice = Systhane alternating Ecocarb

Variations:

1. Systhane alternating Ecocarb + SARSil
2. Systhane alternating Ecocarb + Basal leaf removal
3. Ecocarb alternating Ecocarb

With active ingredients

- Systhane (myclobutanil)
- Ecocarb (potassium bicarbonate)
- SARSil (potassium silicate)

The research team chose treatments based on the following logic: (1) Silicon is a compound that has scientific evidence supporting its ability to suppress powdery mildew in a range of crops; (2) Removing basal leaves aims to reduce the humidity and provide less favourable conditions for powdery mildew around the plant; (3) The Ecocarb/Ecocarb treatment substitutes the single mode of action chemical Systhane with the multisite fungicide, Ecocarb.

Powdery mildew symptoms on strawberry showing white mycelium. Photo credit: TIA

Mid-late season spread of powdery mildew in an unsprayed tunnel of strawberries

Anna's results showed that whilst there was no difference in disease incidence (the number of leaves infected), there were clear differences in disease severity due to the treatments. Supplementing the commercial program with SARSil and replacing Systhane with Ecocarb both significantly reduced powdery mildew severity compared to the standard commercial program. In a surprising twist, removing basal leaves increased disease severity. Anna suggests a possible reason for this. "When you remove leaves, plants compensate by producing a flush of new growth. These young leaves are much more susceptible to powdery mildew infection than older leaves and so ironically we saw the opposite to what we were trying to achieve," she said.

Predicting disease severity

Anna also found that a close relationship exists between disease incidence and severity. Validating this relationship in different situations and over different seasons could be used to produce a rapid monitoring and prediction tool for powdery mildew severity.

Management affects fruit quality

A snapshot look at fruit quality in March 2020 also demonstrated the positive effects of both SARSil and Ecocarb. The SARSil supplemented treatment and the alternating Ecocarb treatment both produced the sweetest fruit, measured as brix percent. Fruit from plants with basal leaves removed were softer than fruits from all other treatments. This supports the idea that these plants produced a flush of young new leaves which may lead to softer fruit.

Anna Mackintosh assessing strawberry fruit firmness and sweetness at the University of Tasmania.
Photo credit: TIA

Silicon uptake: Foliar versus coir application

The positive results with SARSil prompted Anna to investigate silicon a step further. From her reading of the literature she noted that silicon is not effectively absorbed by leaves for many plant species. This raised the question 'what is the best method of application?'

In a glasshouse strawberry trial, she applied recommended rates of potassium silicate either as foliar sprays or as a liquid drench to the coco coir media. Leaf application resulted in over double the level of silicon in leaf tissue compared to media application. This provides industry with a greater level of confidence in the benefits of applying potassium silicate as a foliar spray as part of their fungicide program.

Does strawberry powdery mildew produce viable overwintering spores in Tasmania?

Strawberry powdery mildew is host-specific and parasitic on living tissue. Whilst strawberry powdery mildew most often survives overwinter as mycelium on partially dormant green tissue, it can also produce persistent spores from sexual reproduction that overwinter in the absence of leaf material.

When disease levels are high, there is a greater chance of different mating types converging to produce the overwintering spore bodies called chasmothecia. These are significant to industry as they have the potential to both reinfect the next crop and allow the fungus to develop mutations such as fungicide resistance.

In this research study, Anna collected leaflet samples in spring to look for chasmothecia and viable spores. She found many structures with the physical characteristics of chasmothecia. However, when these were physically squashed open, no spores were found inside. They were more abundant on leaves from the unsprayed tunnel than fungicide treated tunnels.

This raises the question as to whether the collection time or the overwintering environment impacted on spore production.

The likely presence of chasmothecia does raise warning bells for the potential of strawberry powdery mildew to produce overwintering spores in polytunnel grown strawberries in Tasmania but requires more investigation.

Key findings

- Crop protection needs to occur early, before symptoms become apparent, especially when environmental conditions of temperature and humidity favour powdery mildew.
- Amending the spray program with potassium silicate (SARSil) had a positive effect, providing added suppression of powdery mildew and improving fruit quality.
- Substituting the single mode of action fungicide Systhane® (myclobutanil) with the multisite fungicide Ecocarb® (potassium bicarbonate) reduced disease severity.
- Foliar application of the potassium silicate product SARSil to strawberries results in leaf uptake of silicon whereas application to the growing media was less effective.
- Structures resembling the overwintering spore bodies of powdery mildew (chasmothecia) were found on leaves of tunnel grown strawberries in Tasmania, but no spores were present. This requires further research.

Implications and future research

- The improvements seen in powdery mildew suppression with SARSil amendment or exclusive use of Ecocarb® in the fungicide program is a positive result. This has benefits for both mildew management and preserving the limited chemistry available by including these options as part of a resistance management strategy. The use of sulfur in the early program is an alternative that could be assessed.
- Polytunnels in their current form remain an environmental bliss point for powdery mildew. Designs that allow better humidity management combined with tunnel orientation and siting for air movement are ideals that could improve strawberry powdery mildew management.
- Further investigation of powdery mildew inoculum sources in the whole lifecycle of the strawberry, from propagation to winter hygiene, could help reduce disease pressure.
- New technologies such as UV light treatments offer exciting possibilities when teamed with more multipurpose automated application technology via automated tractors.

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