UVC as a non-chemical alternative for managing strawberry diseases

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- The number of fungicides available to plant propagators and strawberry growers is limited and has seen the emergence of fungicide resistance* in multiple pathogens across multiple fungicides around the world.
- Fungicide resistance must be avoided as it puts pressure on other fungicide groups, potentially leading to significant yield losses.

To help solve this problem, researchers from the University of Florida joined with five other collaborators on a USDA-funded project that aims to integrate disease management across the nursery and fruit production systems, to break pathogen cycles and reduce the number of single-site fungicide applications.

Project collaborators:

- Lighting Research Center RPI, USA
- Cornell University, USA
- Norwegian University of Life Sciences
- Saga Robotics in Norway
- Norwegian Institute of Bioeconomy Research

One of the objectives of this project was to develop non-chemical alternatives for nurseries and field production.

Dr Natalia Peres, Professor of Plant Pathology, University of Florida, Golf Coast Research and Education Centre, gave a presentation at BerryQuest 2022 on the non-chemical alternative UVC which she and her colleagues have been working on. This article summarises Natalia's presentation. You can also view Natalia's presentation from BerryQuest 2022 at youtu.be/h3UkCM4YzZM

How UVC works

Lamps producing UV light have been commonly available for over 75 years, used in hospital settings, water filtration systems and, in more recent times, to disinfect hand-held devices like cell phones and toothbrushes.

Ultraviolet light in the UVB and UVC ranges has germicidal effects, with wavelengths from 250 to 280nm (the UVC range) being the most effective against pathogens.

UVC damages the DNA of pathogens. Many pathogens can repair DNA damage caused by UV during the day with mechanisms that are activated by the blue light and UVA available from the sun. This repair mechanism is not active during darkness, so UVC can be applied at night with deadly force.

UV is not effective against all pathogens and pests; it's a contact treatment, so is most effective against those that are exposed on the surface of the plant. Among the potential diseases, powdery mildew is a good target because it is wholly external to the host (the strawberry plant), being on the surface of the leaves or the fruit. Powdery mildew is also more persistent in protected cropping environments where UV light is disrupted. More intensive chemical control of powdery mildew in these environments can exacerbate resistance development in other pathogens like Botrytis which are controlled using the same chemical groups.

* For an Australian perspective on fungicide resistance, refer to PAGE 83 of the Autumn 2021 edition of the Australian Berry Journal.

Figure 1. Commercial usage of UV in greenhouses in Europe. Photo credit: ww.oreon-led.com

UV has been used in European greenhouse facilities for powdery mildew control for some years. In these environments, lamp arrays are suspended above the plants and turned on for several minutes, sometimes hours, during the night when there are no staff present (Figure 1). The challenge of this project was to build a system that works outdoors in the field.

Field application of UVC

As UVC is basically a contact treatment, the lamp array and reflectors must be designed to ensure the light reaches the inner canopy and underside of leaves. Lamps must also be close enough to the canopy to achieve the target J/m² within practical application times (tractor speeds). The prototype built as part of this project used 20 UVC germicidal lamps (254nm) in a hemicylindrical array (Figure 2).

J/m² : Joules per square metre is the standard unit of measurement defined by the International System of Units (SI) of radiant exposure.

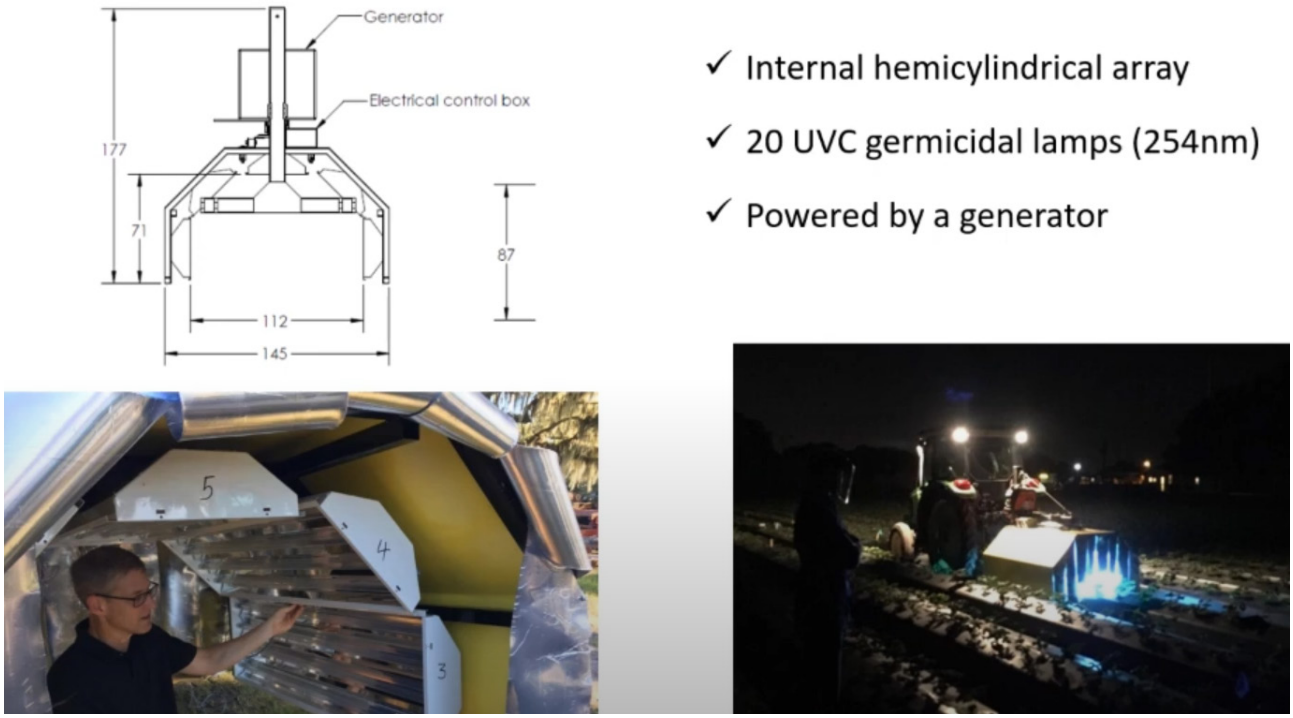


Figure 2. Prototype UVC applicator designed to suit the dimensions of strawberry beds in Florida.
Photo credit: Natalia Peres

Measuring dosage rates

It is important to calibrate UVC dosage rates throughout the season. This is done using UV meters located throughout the field to check that the tractor (or if you're lucky, robot) is travelling at the correct speed to achieve the target number of J/m² per application (Figure 3).

Figure 3. Light meters used to calibrate and check UVC dosage rates (Joules/m²).
Photo credit: Stock image

UVC treatment results

Field trials in 2016/17, 2017/18 and 2018/19 showed that UV treatments were similar or more effective than standard fungicide sprays for the control of Powdery mildew (Figure 4 and Table 1).

Twice weekly applications of UVC at 85 J/m² (equivalent to a tractor speed of 4.5 km/hr with the prototype shown in Figure 2) showed similar efficacy to standard fungicide treatments; the 85 J/m² UVC treatment significantly outperformed the standard fungicide treatment in 2018/19 due to suspected fungicide resistance.

Treatments of 170 J/m² UVC and UVC treatments in addition to standard fungicide treatments showed even better control of powdery mildew on leaves and fruit.

Once weekly applications of UVC were also found to be as effective as standard fungicide sprays (Figure 5). The effectiveness of weekly UVC applications will depend on the susceptibility of the strawberry cultivar to powdery mildew and the prevalent disease pressure.

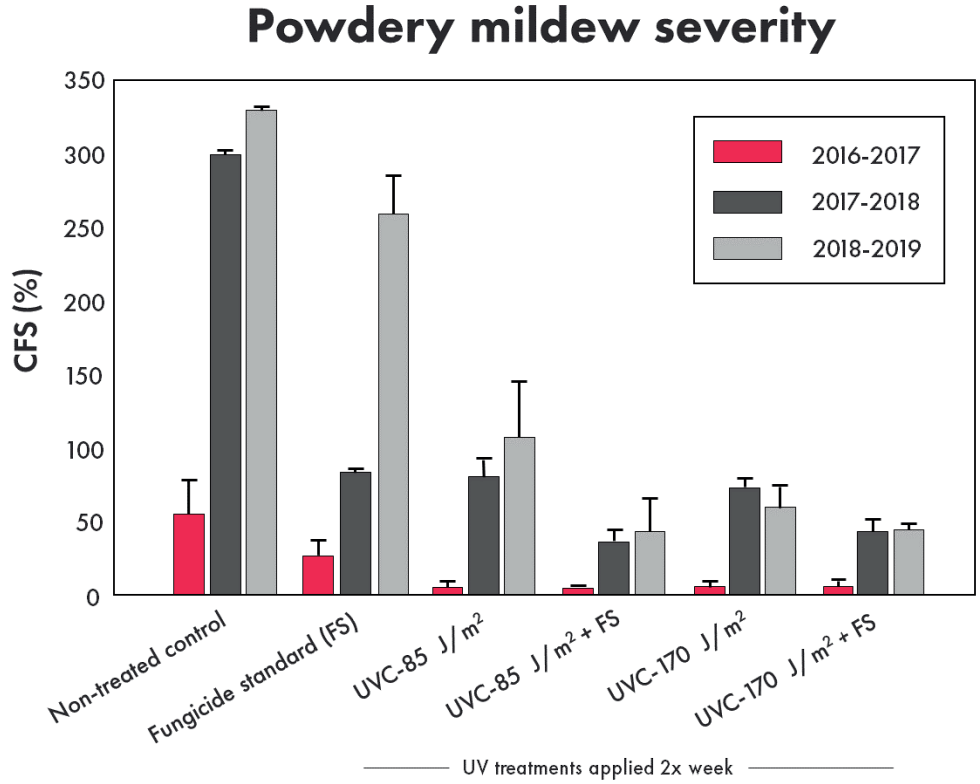


Figure 4. Severity powdery mildew symptoms on foliage comparing standard fungicide treatments to twice weekly UVC treatments and twice weekly UVC treatments plus standard fungicide treatments.

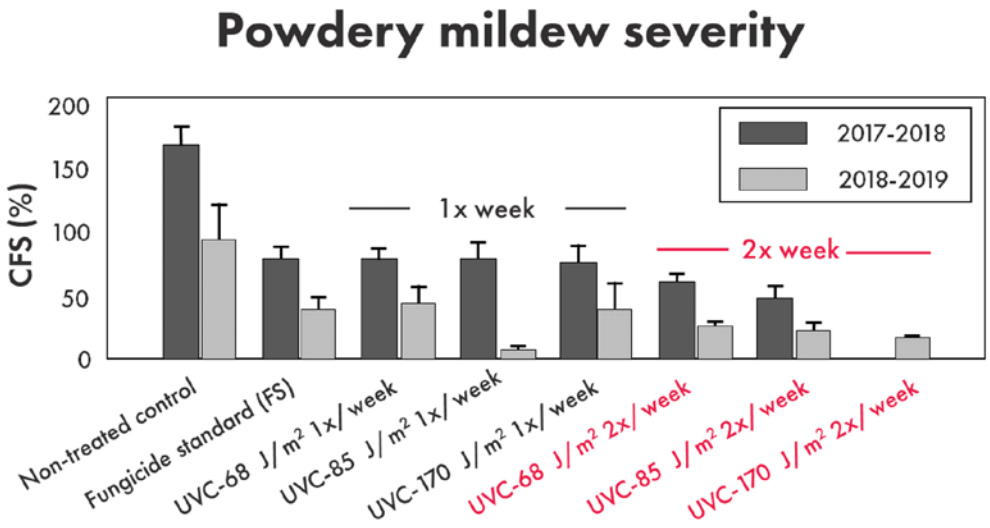


Figure 5. Once weekly UVC applications compared to twice weekly UVC applications.

Table 1. Incidence of powdery mildew on fruit comparing standard fungicide treatments to twice weekly UVC treatments and twice weekly UVC treatments plus standard fungicide treatments.

Treatments *(UV treatments applied 2 x week)*	**Fruit Powdery Mildew incidence (%)**	
	2017/-2018 Season	**2018/-2019 Season**
Non-treated control	**67.1 a**	**41.9 a**
Fungicide standard (FS)	36.1 b	30.1 a
UVC-85 J/m²	37.9 b	**4.7 b**
UVC-85 J/m² + FS	20.2 cd	**1.0 b**
UVC-170 J/m²	31.2 bc	**4.2 b**
UVC-170 J/m² + FS	14.0 d	**1.7 b**
P value	0.0003	0.0018

Tractor pulled and autonomous robots

There are many UVC units being built and tested in Florida and in other parts of the world for use in nurseries and in fruit production fields. Figure 6 shows some of the different tractor pulled units that are currently in use.

Figure 6. A) system used in a nursery production field; B) system used in a nursery production field; C) unit built for a Californian fruit production bed configuration; D) unit built for use in grapes in New York.
Photo credit: Supplied, Natalia Peres

The project team has also been colaborating with Saga Robotics to evaluate an autonomus robot they have developed called Thorvald (Figure 7).

Figure 7. Saga Robotics 'Thorvald' autonomous robot that can apply UVC without the need for a tractor.
Photo credit: Kristoffer Skarsgård, Saga Robotics

KEY MESSAGES

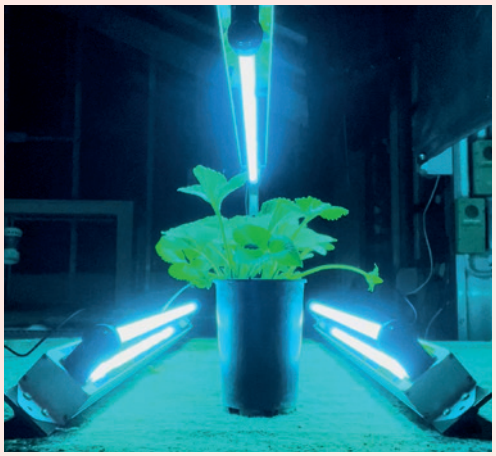
- UVC is an alternative to reduce the use of single site fungicides for the control of powdery mildew in nurseries and fruit production fields.
- This potential reduction in fungicide use is economically sound, good for the environment and may extend the life of fungicides by reducing the selection pressure for resistance for powdery mildew and other pathogens that co-exist in the open fields.
- In addition to powdery mildew, UVC has also been found to be effective against two spotted spider mite eggs. Adult mites appear to be tolerant of the treatment.
- Tractor pulled UVC units and autonomous robot applications are equally effective.

UVC testing in Australia

Powdery mildew is also an important disease for runner growers and fruit producers in Australia. Management currently relies heavily on fungicide intervention with a limited number of fungicide groups that must be rotated regularly to avoid the risk of resistance. Evaluation of non-chemical options is warranted to prolong the effectiveness of the current fungicides registered, reduce reliance on chemicals and improve long-term sustainability.

Apollo Gomez, Senior Plant Pathologist at the Department of Agriculture and Fisheries (DAF) in Queensland, has received funding from the *'Driving ag-tech adoption across Australia (AS20007)'* project to investigate the efficacy of locally sourced UVC lamps against powdery mildew in strawberry. A small glasshouse pot trial study is currently underway at the DAF Nambour facility to gather efficacy and/or severity data. Trial results will be presented in future editions of the Australian Berry Journal when available.

Driving ag-tech adoption across Australia (AS20007) is funded by the Hort Frontiers Advanced Production Systems Fund, part of the Hort Frontiers strategic partnership initiative developed by Hort Innovation with co-investment from the Department of Agriculture and Fisheries, Queensland.



(Top) a UVC light treatment in the small glasshouse trials (Bottom) UVC exposure can cause eye and skin injuries so it's important to wear protective clothing and face shields. Photo credit: Apollo Gomez, DAF