VG15038: Investigating novel glass technologies and photovoltaics in protected cropping

Facilitators

Project VG15038 was led by Professor Baohua Jia from Swinburne University of Technology.

Major findings

Project VG15038 investigated the use of smart glass and other renewable energy technologies in greenhouses. Running from 2016 to 2021, the project collaborated with another similar project – *Research and operations to trial innovative glass and photovoltaic technologies in protected cropping* (VG16070) – and aimed to evaluate the cost-effectiveness and viability of these technologies for use by vegetable growers.

Smart glass is glass with adjustable light transmittance and high thermal insulation, which blocks the heat from the sunlight in summer to reduce the cooling cost, and maintains the heat inside the glasshouse in winter to reduce the heating cost.

The other renewable technologies investigated were photovoltaic technology, which converts light energy to electricity, and solar thermal collectors, which are used to store heat from the sun in water.

Two main activities were undertaken by the research team. The first was to build a cost-effectiveness model that would take into account all the factors present in a single location.

"The model was built to consider the real weather conditions at different locations specifically in Australia, the sun irradiance, the structure of the greenhouse and the glazing materials, the different renewable energy strategies selected and the real installation cost," project leader Professor Baohua Jia said.

"This would allow us to provide good and customised recommendations on the annual energy generation, energy cost saving, and payback period for growers."

The second activity was to carry out a field test in collaboration with the Project VG16070 team at Western Sydney University. This allowed the team to input real data into the cost-effectiveness model.

The project's activities resulted in several major findings. Firstly, the cost-effectiveness model suitable for Australian growers was found to accurately predict the energy savings of smart glass technologies, based on a grower's greenhouse structure and local environment.

Another key finding was that smart glass can significantly save cooling costs and lower water consumption by up to 20 per cent, by blocking the thermal energy from the sun.

"Surprisingly – along with the decrease of temperature in greenhouses with smart glass – the plants evaporate less water, saving water consumption," Professor Jia explained.

It was also found that different vegetables are impacted in different ways by the smart glass. Capsicums and eggplants grown in greenhouses with smart glass had slightly decreased quantity and improved quality, compared to those grown in greenhouses without smart glass.

Meanwhile the smart glass was seen to significantly increase the number of leaves on plants, leading researchers to conclude that it is most suitable for growing leafy vegetables.

Finally, the cost-effectiveness of renewable energy solutions was found to depend on the scale of installation. The larger the scale, the better the cost-effectiveness and the shorter the payback period.

Professor Jia explained that good maintenance is necessary to ensure high efficiency and a long life, thus maintenance costs should be considered in growers' evaluations. The overall cost, however, is still a worthwhile investment.

"By adopting these energy efficient technologies, growers can significantly save on the running cost of greenhouses," she said.

"In the meantime, the quality and yield can be maintained. As a result, the overall cost of production can be reduced to bring in more profit for growers. The lifetime of the proposed technologies is long, more than 10 years, and the maintenance cost is low. Therefore, there is expected to be a short payback period for those technologies."

Professor Jia has several recommendations for growers. Installing smart glass is recommended, and the type should be chosen according to the location's weather condition and the crop. Solar thermal management devices should be considered in most cases, especially in cold areas, to compensate for heating and cooling costs. Photovoltaic technologies can be integrated with solar thermal collectors to simultaneously generate electricity and hot water, and save space.

It was also recommended that growers consider replacing an energy curtain with flexible solar panels to generate electricity without modifying the infrastructure of the greenhouse or requiring extra space.

Background

Protected cropping requires climate to be controlled in greenhouses, with light, temperature, relative humidity and carbon dioxide enrichment accounting for a major part of the running costs. The cost varies greatly depending on crop, greenhouse design, and regional climate conditions. In general, the energy cost has increased significantly in recent times, resulting in smaller profit margins.

Because of this, it was deemed valuable to investigate solutions that are more cost-effective. While the current project has confirmed that smart glass and other renewable energy technologies are viable solutions, more research is needed.

The current smart film used is not specially designed for greenhouses; therefore, the productivity was slightly decreased. This can be improved by designing new smart film specific to greenhouses.

Further developing the modelling software to be more user-friendly for growers is also needed.

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Further information

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The final report for this project is available on InfoVeg. Readers can search 'VG15038' on the InfoVeg database: ausveg.com.au/infoveg/infoveg-database.

VG15070: A strategic approach to weed management for the Australian vegetable industry

Facilitators

Project VG15070 was led by Associate Professor Paul Kristiansen from the University of New England.

Major findings

Project VG15070 ran from 2016 to 2021 with the goal of identifying and improving integrated management strategies for high-priority weeds. It followed an earlier scoping study (*Project VG13079: Weed Management for the Vegetable Industry – Scoping Study*), which identified the current strategies being used, the most common weeds and the most pressing research needs.

"The project involved a series of research activities to determine how certain non-herbicide weed management techniques may contribute to improved weed management in vegetable crops," lead researcher Dr Paul Kristiansen said.

"This work coincided with the collection of economic data on the impact of weeds on different vegetable farms, as well as the development of a range of extension materials to highlight proven methods of control, including for several of the industry's most important weeds."

Researchers measured the weed seed bank in different vegetable crops and production regions by collecting soil samples across Australia. They also completed trials of winter and summer cover crop varieties in four regions nationally to determine which varieties were better at suppressing weed growth and in making weeds less of a problem in subsequent vegetable crops.

Other activities included evaluating the competitiveness of cover crop varieties with important weeds in a glasshouse trial; completing a field trial of different hand weeding implements to determine their effectiveness and user-friendliness in weed management; reviewing current literature for a variety of other supplementary weed control methods; and interviewing growers to collect data on the costs of weed management and their impact on crop profitability.

A key finding of the research team was that no single integrated weed management strategy suited all vegetable farms. This was due to the nature of different crops, diverse weed species present, the time and resources available to the grower, and seasonal variation. Rather, it was the level of diligence of the grower in following their chosen strategy that predicted success.

"There was little in the study of the weed seed bank to tie particular weed management practises, or crop type, to the quantity of viable seed found in the soil on different vegetable farms," Dr Kristiansen said.

"We did, however, identify some highly effective strategies being used on different farms. These included a mix of common techniques, such as herbicide, and reintroduction of some 'old' pre-herbicide methods, such as tillage between crop rows and diligent hand-weeding on smaller-scale farms.

"Our main observations were that weed management will be most effective where the vegetable grower makes a detailed plan, uses several weed control methods together and implements these diligently, but is willing to innovate when things aren't quite working. The objective is to minimise the number of weeds that flower and produce seed. If growers can achieve this, the burden of weeds will become less over time."

The collection of economic data showed that introduction of new approaches to weed management – such as increasing hand weeding labour or purchasing inter-row tillage equipment – is likely to cost the vegetable grower more in the short- to medium-term. However, the benefits of this investment become obvious in the longer-term – providing the grower is happy to persist with the new approach and is confident of its success.

"We suggest that vegetable growers research any options they are considering before putting them in place," Dr Kristiansen said.

Finally, the economic impact of weeds was at its most severe on organic farms, where herbicides are not an option.

"Therefore, for conventional vegetable growers, we don't recommend going away from herbicides – just including other techniques strategically that can supplement herbicide usage to deliver better results and hopefully a higher yielding crop," Dr Kristiansen concluded.

Background

In recent decades, weed management on Australian vegetable farms has largely relied on tillage, non-selective herbicides such as glyphosate, and in some cases chemical fumigation in between vegetable crop plantings.

These approaches are not necessarily sustainable in the long-term. Chemical fumigation has negative impacts on soil biology, and potential animal and human health impacts. Herbicide resistance is becoming more common in cropping, and frequent tillage has negative impacts on soil health and productivity. Hand weeding is expensive due to the high cost of labour.

Until Project VG15070, there had been relatively little research into improved management in vegetable crops in recent decades – despite work being carried out in other systems such as broadacre grains and cotton production in Australia. This is likely because traditional approaches were still working relatively well, despite sustainability problems being identified. However, there was scope to make gains in sustainable weed management in vegetable production by integrating other techniques, with the goal of reducing the amount of viable weed seed in the soil over time.

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The final report for this project is available on InfoVeg. Readers can search 'VG15070' on the InfoVeg database: ausveg.com.au/infoveg/infoveg-database.