Microwaving Goodbye to Charcoal Rot

Dr Scott Mattner[1], Cora Zon[1], Dr Dylan McFarlane[1], Sandra Shaw[1], Liam Hescock[2], and Associate Professor Graham Brodie[3]. [1]VSICA Research, [2]GroWave Pty Ltd, [3]The University of Melbourne

- World-leading research in the Australian strawberry industry has shown that terminating old strawberry crops using a prototype microwave unit kills up to 97% of disease-causing fungi (*Macrophomina* and *Fusarium*) in the crowns.
- This is a significant finding because pathogenic fungi surviving in infested crowns from old crops are the primary source of infection for new strawberry plants.
- Researchers hypothesise that the ability of microwave to kill these fungi in old plants will dramatically reduce the amount of disease in subsequent crops and form an important component of integrated management systems in the future.

Recent Advances in Charcoal Rot Management

Charcoal rot is a devastating disease caused by a fungus (*Macrophomina phaseolina*) that lives in the soil and kills strawberry plants. The disease has increased in importance in Australia and around the world since the withdrawal of the soil fumigant methyl bromide.

A recently completed national project conducted by researchers from the Queensland Department of Agriculture and Fisheries and VSICA has developed new management strategies for charcoal rot, including totally impermeable films (Figure 1), improved fumigants such as Tri-Form® 80 and EDN Fumigas™, and farm biosecurity practices. A collaborative effort between researchers, the fumigant industry and the Berries Australia team has communicated these practices to strawberry growers across Australia, which resulted in high levels of adoption.

Results from a recent disease survey showed that the adoption of these practices by growers was associated with a 25% reduction in charcoal rot from 2017 to 2020. Despite these advances, charcoal rot remains a significant problem for the strawberry industry.

For example, 15% of strawberry plants in Victoria were lost to the disease in 2020. Therefore, industry urgently needs additional measures to control the disease that complement and/or offset the current reliance on fumigants.

Figure 1. The use of totally impermeable films (TIFs) with soil fumigants (left row) can dramatically improve the control of charcoal rot compared with traditional films made from low-density polyethylene (right row). TIFs work by trapping fumigants for longer in soil and improving their ability to control *Macrophomina* and charcoal rot.
Photo credit: VSICA Research

New Concept for Improving Charcoal Rot Management using Crop Termination with Microwave

Crop termination is the practice of killing old strawberry plants and cultivating them into soil, before preparing beds and planting a new crop. Traditionally, growers in Australia have used herbicides for crop termination, but this practice does not kill *M. phaseolina* in the crowns of old plants and in some circumstances may increase it. Any of the fungus surviving in old, buried crowns is difficult to kill with current fumigants, because they do not penetrate woody tissue very easily. Research in the recently completed national project proved that *M. phaseolina* survives for more than 12 months inside old crowns and can re-infect new plants. Therefore, experts recommend removing sick and old plants from strawberry fields and destroying them off-site.

Although effective over time, this practice can be expensive and create a considerable amount of waste that must be removed from the property.

We trialed a new approach using microwave to terminate the old strawberry crop and kill disease-causing fungi inside their crowns, so they do not infect new crops when they are cultivated back into the soil. In the trial, old strawberry plants were first slashed and then treated with microwave for 10 or 15 seconds using a 5 kW prototype rig designed by the company GroWave Pty Ltd (Figure 2).

Currently, the field prototype is PTO powered and is towed behind a tractor, but future designs may include the option for autonomous operation. Other treatments included herbicides (Basta® immediately followed by Garlon®600) applied at label rates, and an untreated control. Individual plots were 20m long and we replicated each treatment eight times.

Figure 2. Prototype 5 kW microwave unit used for crop termination. Inset: Antenna targeting microwave energy to old strawberry plants. The unit is designed by the company GroWave Pty Ltd (www.growave.ag). Photo credit: VSICA Research

Figure 3. Strawberry crop terminated with microwave (left) compared with the untreated crop (right) at two weeks after treatment in a trial at Silvan, Victoria. Photo credit: VSICA Research

Results of Crop Termination with Microwave

The microwave unit heated strawberry crowns to between 81-96°C. The temperature inside the crown took several hours to cool to ambient temperature. Microwave killed old strawberry plants (Figure 3) much faster than the herbicide treatment and did not affect the integrity of the plastic mulch (i.e., the film could still be removed using normal practices).

Additional benefits of the microwave treatment were that high exposure times killed weeds (e.g. groundsel) in the planting holes more effectively than herbicides (Figure 4), and reduced DNA concentrations of *Pythium spp.* (causes stunt in strawberry) and *M. phaseolina* in soil at shallow depths by 80% and 95%, respectively.

Prior to the experiment we placed old crowns infected with *M. phaseolina* into the treatment plots. We also marked plants in the plots showing symptoms of charcoal rot. We recovered these crowns after the treatments, took them back to the laboratory and grew the fungi inside them on an agar media in Petri dishes.

We found that microwave had killed 97% of *M. phaseolina* and *Fusarium oxysporum* (the cause of the disease Fusarium wilt) in the crowns (Figure 5). By comparison, herbicides had no effect in reducing these pathogenic fungi. We aim to collect data over the coming season to quantify the effect of crop termination with microwave on disease in the subsequent crop.

Future Opportunities & Moving Forward with Charcoal Rot Management

The results with microwave are encouraging and the experiments are a world-first. However, the technology still needs further evaluation to optimise its efficiency and practicality.

For example, we anticipate that the exposure times to microwave needed to treat strawberry for crop termination commercially will be shorter than those in the current experiment. With further research and development, microwave also has the prospect of treating soil as a supplement or alternative to fumigation without the need to remove plastic mulch, with a plant-back period of just a few hours.

The National Charcoal Rot project ended in last year, but there are greater opportunities to improve charcoal rot control in Australia and the use of microwave is just one example. If you want more research on charcoal rot, like the use of microwave, it is vital that you let your representatives at Hort Innovation know.

If you are interested in trialling the prototype microwave rig on your farm or talking about its prospects, please contact

Liam Hescock at GroWave Pty Ltd | 0428 634 908

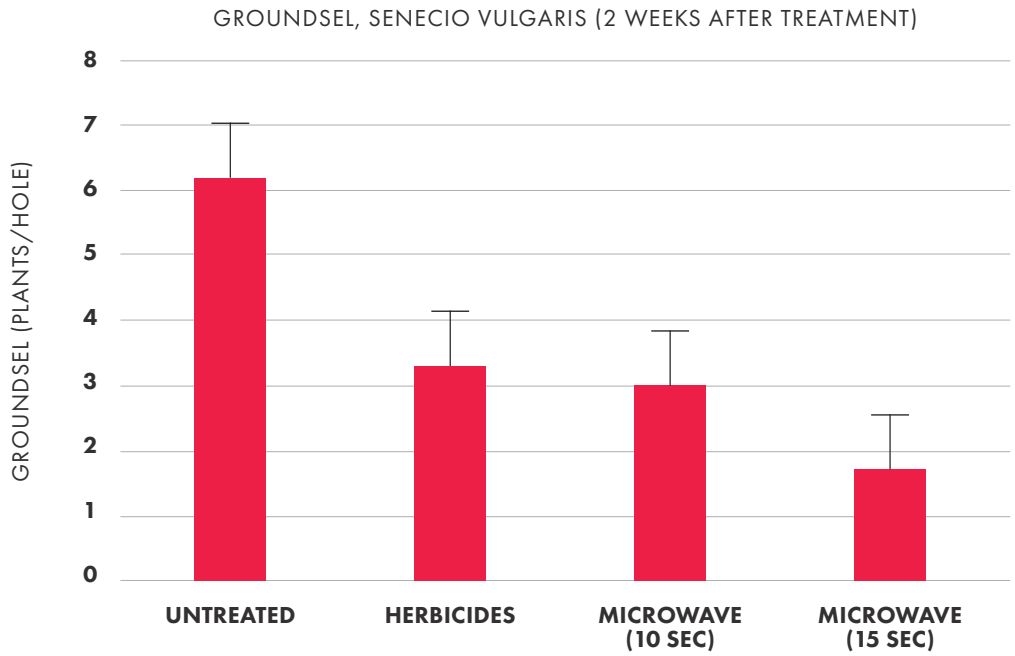

Figure 4. Weeds (groundsel) emerging in planting holes two weeks after treatment with microwave or herbicides in a trial in the strawberry industry at Silvan, Victoria.

Prior to the experiment we placed old crowns infected with *M. phaseolina* into the treatment plots. We also marked plants in the plots showing symptoms of charcoal rot. We recovered these crowns after the treatments, took them back to the laboratory and grew the fungi inside them on an agar media in Petri dishes. We found that microwave had killed 97% of *M. phaseolina* and *Fusarium oxysporum* (the cause of the disease *Fusarium* wilt) in the crowns (Figure 5). By comparison, herbicides had no effect in reducing these pathogenic fungi. We aim to collect data over the coming season to quantify the effect of crop termination with microwave on disease in the subsequent crop.

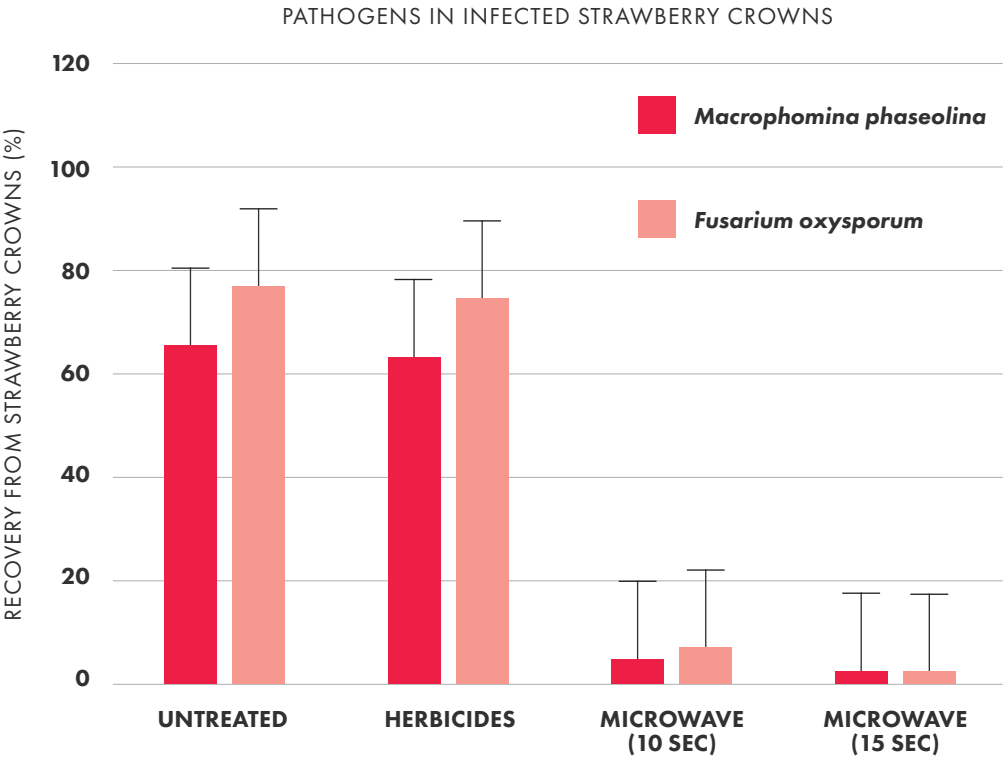

Figure 5. Recovery of disease-causing fungi (*Macrophomina phaseolina* and *Fusarium oxysporum*) from strawberry crowns following crop termination with microwave or herbicides in a trial at Silvan, Victoria.