Microwave – a fresh look at old technology for weed control

By Mary O'Brien

THERE is nothing new about microwave technology but the vast majority of us are only using it to reheat leftovers. Perhaps it is time to look with fresh eyes at its potential, particularly when dealing with resistant weeds. Dr Graham Brodie from the University of Melbourne has spent 10 years working on microwave technology and is optimistic about its possible uses in agriculture. Previously Graham worked with the forestry industry and found benefits from microwave treatment of wood which led him to look at potential applications in farming.

This technology first emerged during the early 1970s and for several reasons it has never really taken off as a method of weed control. This period of dormancy has been due to a variety of factors – mainly the costs involved in generating the energy required and the reducing cost of herbicides over the years. Prior to conservation tillage, the plough was a much more available and affordable option for farmers. With the advent of conservation tillage, the use of herbicides has been the preferred method of weed control in broadacre farming. With some serious resistance issues affecting our bottom line, does this technology have real potential or are we looking for a life raft in what some may consider the 'eleventh hour'?

How it works

It is no different to a standard microwave oven found in most kitchens; it heats up the plant using indirect heating and essentially cooks it. As the plants are treated, you can hear a crackling and hissing sound. The water contained in the plant cells is heated and 'creates a series of steam explosions' which ruptures the cell walls – a hard structure to break. The result is destruction of the plant cells and internal transport system, immediate and irreversible wilting followed by death. Pop a lettuce leaf in the microwave and see what happens.

Microwave antenna designed by Graham Brodie. (PHOTO: Mary O'Brien)

The amount of energy required to kill different weed species does vary but Graham has had good success with the following species:

- Ryegrasses – annual and perennial;
- Barnyard grass;
- Barley grass;
- Bellyache bush;
- Brome grass;
- Clover;
- Feathertop Rhodes grass;
- Fleabane;
- Hemlock;
- Mimosa pigra;
- Parthenium;
- Rubber vine;
- Wild oats; and,
- Wild radish.

For example, the field trials successfully treated fleabane 20 cm high and flowering. Larger fleabane plants can still be treated but require more energy to kill.

Benefits

When used for weed treatment, the most obvious benefit is the ability to treat herbicide resistant weeds and their seeds in crop and in fallow – no waiting for weeds to germinate. Secondly, applicators will not need to worry about spray drift or correct weather conditions for weed treatment as opposed to chemical sprays.

From a food safety view, there are no potential residues to contend with and no withholding periods on products. Treatment for weed seeds in the soil will act like a residual herbicide without lengthy plant back periods locking paddocks out for opportunistic cropping.

Impact on soil biota

When treating emerged weeds, the trials have shown that microwave treatment has little to no effect on the soil biota. Treatment of the seed bank significantly reduces soil bacterial numbers as more energy is used and the microwaves penetrate the top two to three cm of the soil surface. But this process does not completely sterilise the soil, it merely pasteurises it and within one month of treatment, trials have shown the populations have not only returned to normal but have been found to be much higher than before treatment. Examination is still underway to fully understand the soil benefits from microwave treatment but some surprising results have already appeared. One of these is an increase in available nitrogen following treatment. Pot trials have shown a yield increase of 200 per cent while field trials are showing a range of 35–92 per cent increase in yield compared to control crops.

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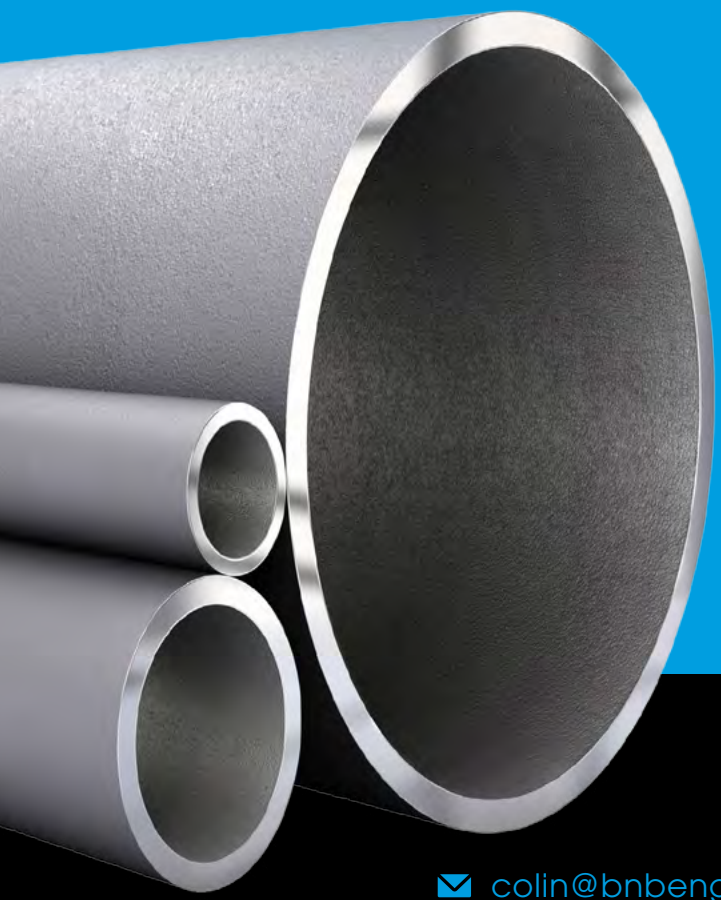

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Graham Brodie speaking about microwave technology at the Cotton Grower of the Year field day, Pine Ridge.
(PHOTO: Mary O'Brien)

Possible reasons for this include:

- The microwaves may release stored nitrogen in the soil;
- The treatment may favour re-colonisation by nitrogen producing bacteria; or,
- Production of nitrogen by bacteria recycling the dead bacteria killed during the treatment.

Factors affecting efficacy

All methods of weed control have limitations and factors that influence efficacy – microwave treatment is no different. As with chemical applications, the size of the weed, soil moisture, and plant stress also play a role in microwave weed treatments. Larger stressed weeds are going to be more difficult to kill than smaller fresh weeds. Think about reheating leftovers in your kitchen microwave – a smaller container with high moisture content and low density is going to heat faster and use less energy than a large container with lower moisture content and higher density. It is the same with weeds.

Soil temperature can also influence microwave efficiency when treating weed seeds or soil – colder soils will require more energy to heat up than warm soils.

Costs

The first questions asked by farmers are always 'how much does it cost' and 'how fast can it go'. The answer is $50 to $60 per hectare and 5–10 km per hour when used as a knockdown. To treat weed seeds and soil the cost would increase, as significantly more power is required and the speed is reduced. Treating soil is costly and difficult regardless of the method used (eg. soil fumigation).

The ability to do one operation that acts as both a knockdown and a residual herbicide, could be time saving and be more cost efficient than doing several passes.

It is quite feasible to develop a unit suitable for broadacre situations that would operate at speeds comparable to current chemical spray applications.

It is important to not compare the cost of this technology directly to a knockdown herbicide application. While cost is always going to be a major influence, factors that should not be undervalued include the intrinsic worth in reducing herbicide pressure, the potential to manage resistant weeds and the seed bank as well as reducing the environmental impacts.

Work Health and Safety

The antenna that Graham has designed complies with international standards and when used correctly, there is no risk of exposure to the operator. But it is impossible to make anything fool proof so putting your foot under the unit while it is operating would be an obvious risk. The design and engineering of the antenna ensures that it complies with all national and international thresholds for exposure to microwave.

Other uses

Graham has used microwave to treat hay and chaff for weed seeds with huge success. An added bonus from the treatment was a substantial increase in the digestibility of the hay for ruminants. The technology has also achieved great results treating soil pathogenic fungi in the strawberry industry. Graham is currently expanding his work into control of pests and diseases in stored grain.

Reducing the use of pesticides is beneficial for a variety of reasons, especially for slowing resistance, so the potential uses for microwave treatment may extend to a broad range of situations. These include but are not limited to: border quarantine, the home garden, school playgrounds, parks, sporting fields, and fire ant nests.

What's next?

Graham has built a trailer-based prototype with four antennas on it, each 11 cm wide, with the purpose of treating the inter-row space in crops. He envisages that initially a commercial unit would be about the same number of antennas and be a complete trailer based method or run on a PTO driven system. Larger scale products are certainly not out of the question but the challenge would be generating enough power. Each antenna needs about two kW of power when used as a knockdown treatment. This amount of energy is at the lower end for a commercial unit and would increase dramatically if the aim was to treat soil and weed seeds.

Graham's project has focused on building a workable first design which he has successfully done. More long-term field trials are needed as well as additional investment but Graham believes commercialisation is only a couple of years away.

This technology can be utilised on robotic machines such as the Swarm Farm robots and could work well with weed seeking camera systems. Having the ability to use it in a variable rate application scenario would potentially reduce energy costs.

Increasing populations of weed species that have developed resistance to multiple modes of action are causing issues for farmers in most regions with some returning to the use of tillage in an effort to limit overuse of herbicides. Microwave certainly could be a good way to combat these populations. While Graham does not declare microwave as the solution for all weed treatment, he does suggest 'it is an opportunity to do a reset; to clean up a messy patch'. Having a way to effectively treat a resistant population in a paddock or a section of a paddock without soil disturbance is definitely appealing. When asked if he thinks there is potential for the development of resistance to microwave treatment, he warns that we should never underestimate nature.