Guy Coleman with his robot Gordon.

So why compare energy?

Every weed control option – be it mechanical, thermal or herbicide – requires energy for both its production (eg. steel, chemical) and its application (eg. draft force, power take-off, fuel). In the case of site-specific weed control, there are also significant energy requirements for real-time image collection and computer processing.

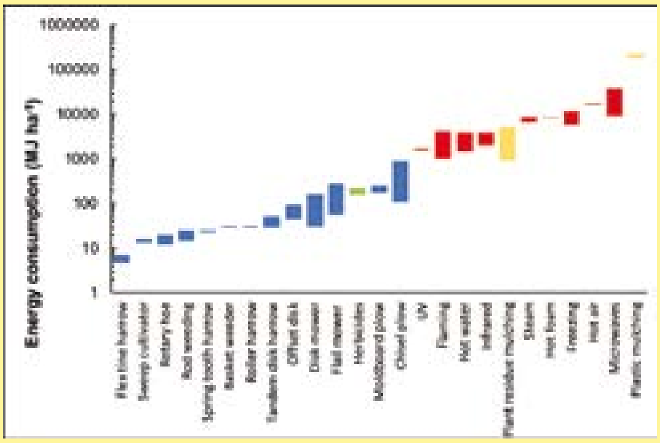
By calculating the total energy requirements to control a given weed population, the University of Sydney team has been able to compare the energy use between a range of alternative weed control options. This provides an indicative comparison of weed control costs for both broadcast (Figure 1) and site-specific (Figure 2) applications, including their viability for broadacre cropping systems.

The low energy use of tillage-based weed control means it may still have a role in broadacre cropping as a strategic tool for specific weed species. But thermal weed control options are obviously better suited to no-till farming systems and it now seems they have significant potential in site-specific application. Imagine having an autonomous, optical weed steamer?

The key to this alternative weed control utopia is accurate and consistent weed recognition – something which is currently a limiting factor. But it's a fast-moving space and as processing speeds and detection accuracies increase, it's one that will have a significant impact on broadacre weed management.

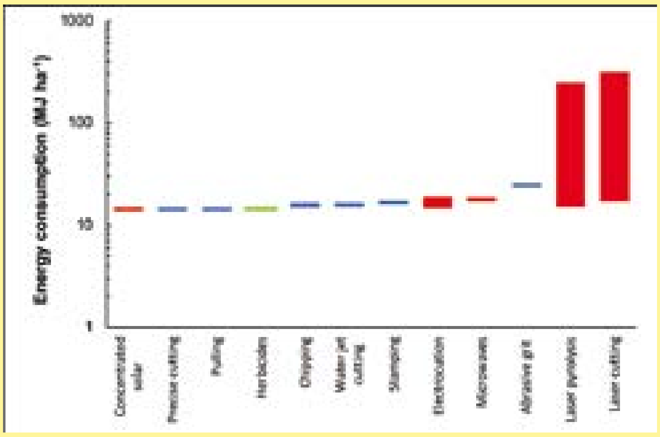
So yes, thermal weed control is definitely much more than just hot air. ■

FIGURE 1: Total energy estimates required to control two-leaf broadleaf weeds at a density of five plants per m² using broadcast (blanket) application



Mechanical treatments (blue bars) generally had much lower energy requirements than the thermal treatments (red bars). Herbicides (green bar), mulching (yellow bar). Source: G. Coleman.

FIGURE 2: Total energy estimates required to control two-leaf broadleaf weeds at a density of five plants per m² using site-specific application



These values include the 14.4 MJ/ha used for image processing and weed detection. Mechanical treatments (blue bars), thermal treatments (red bars), herbicides (green bar). Source: G. Coleman.

How sensor technology is helping map soil in the paddock

GRAIN growers may one day soon be able to map soil in their paddocks without sending a single sample to the laboratory thanks to the efforts of an innovative young researcher. Edward Jones is a postdoctoral research fellow from the University of Sydney, who is working on new technology with GRDC investment, examining how sensors can be used to scan soil for properties such as clay content, water holding capacity, sodicity and pH.

His work has shown that by using a range of sensors to scan multiple soil samples across a paddock, it is possible to build an accurate digital soil map identifying variation within a paddock.

GRDC Manager Agronomy, Soils and Farming Systems – North, John Rochecouste, said the ability to map soil types in paddocks, without sending samples to the laboratory, would be an invaluable management tool for grain growers and potentially save them significant costs.

"Soil properties do not change rapidly, so once growers have developed a digital map it would become an important tool to guide their decision making and importantly it would not need to be updated annually," John said.

"Soil properties don't change significantly for pretty much decades, if not longer, unless there has been major intervention such as incorporating significant amounts of lime or gypsum.

"Things like sodicity and clay content are pretty fixed without intervention. While pH can decrease (acidify) gradually with time, but essentially they are pretty much fixed properties.

"Nutritional element can vary significantly over seasons so that's why nutritional sampling is treated differently. To 3D characterise a paddock is very expensive in terms of sampling costs, so this work by Edward is looking at significantly reducing this expense.

"Knowing your soil characteristics across a paddock, and the variation within paddocks, is invaluable information and really is the foundation for effective crop planning and management."

Calculating soil properties

But there is a series of complex steps required to develop sensors which can effectively calculate soil properties.

"To be able to predict properties of a new soil sample you must first build a soil spectral library. Fortunately, the University of Sydney has been stockpiling soil samples from research projects dating back decades," Edward said.

"So far in the project we have delved deep into this stockpile and scanned more than 8000 samples, primarily from the wheat-sheep belt of eastern Australia."

The digital soil scientist said when samples were scanned with one of the sensors, they produced a unique response, like a spectral fingerprint. From here he has been able to build models using the samples in the spectral library to estimate the properties of new samples that were scanned.

"The most exciting thing has been the speed at which this technology is developing. One of the sensors I am using is a visible near-infrared spectrometer – the same technology used to estimate grain protein and moisture content at receival depots," Edward said.

"When I started my PhD in 2014 one sensor was the size of a briefcase and cost around US$60,000. A sensor that I am currently testing is the size of a deck of cards and costs only US$3000."

GRDC Agronomy Soils and Farming Systems – South Stephen Loss with University of Sydney digital soil scientist Edward Jones, who has been working with a range of sensors – including a near-infrared spectrometer – to scan soil samples and develop a map identifying soil variations across a paddock. (PHOTO: GRDC)

He said the next generation sensor was the size of a postage stamp and could be incorporated into a phone case and run using a smart phone. The same sensor could also be used to scan plant leaves to diagnose a range of nutrient deficiencies.

"I am very excited for the day that this technology is widely available to growers and advisers, because getting as much information that you can about your soil is crucial to good crop management," Edward said.

"Understandably the sensor does have its limitations. Everybody wants to be able to predict plant available nitrogen, but the technology is not advanced enough at this stage.

"Some private companies are saying that they can predict all of a crop's nutritional requirements from a single scan and this is simply not true."

Be wary of 'sensored' fertiliser claims

Edward advised growers to exercise caution with any organisations claiming fertiliser recommendations could be made using sensor technology.

"At the moment, the sensor technology is not advanced enough to assess fertility management, so for that sort of information growers need to keep sending samples to the laboratory for accurate assessment."

Edward has been trialling the new sensors and digital soil mapping techniques at the US's northern NSW L'lara research property at Narrabri. His plan is to showcase these digital technologies destined for broadacre agriculture to growers, farm advisers and industry stakeholders at a field day in early 2020.

In the meantime, growers interested in more information can go *https://bit.ly/2Y7QePp* ■