New technology targets cost-effective weed control

Key facts

- A range of new technology is available, enabling growers to target weeds with more precision and cost effectiveness through site-specific weed management (SSWM).
- Identifying and locating weeds across the paddock is the first step towards targeted weed control.
- Remote and proximal sensing technology can discriminate weed infestations from weed-free crop areas, but still requires ground-truthing for appropriate chemical selection and application.
- Machine vision weed sensors will be the next generation of sensors that advance the capability of site-specific weed management.
- Optical sensing devices can be used to 'spot spray' weeds during summer resulting in savings of up to 90 per cent in herbicide costs, while improving the management of 'hard-to-control' weeds.

Weeds are rarely distributed uniformly across paddocks, however most weed control tactics are delivered in a blanket approach regardless of weed density and distribution. This blanket approach results in excessive and inefficient herbicide use, with product being over or under applied across the whole paddock. Management strategies that target individual weeds, or 'weedy patches', either in crop or during the summer fallow are more cost efficient.

A range of new technology is now available allowing growers to better target weeds through 'site-specific weed management', (SSWM) — reducing the amount and cost of herbicide and increasing the target-specificity of weed control efforts.

The four main steps to implementing an effective SSWM program include:

1. identifying and locating the target weed
2. determining the control tactic
3. applying the control tactic
4. documenting the application.

Identify and locate the target weed

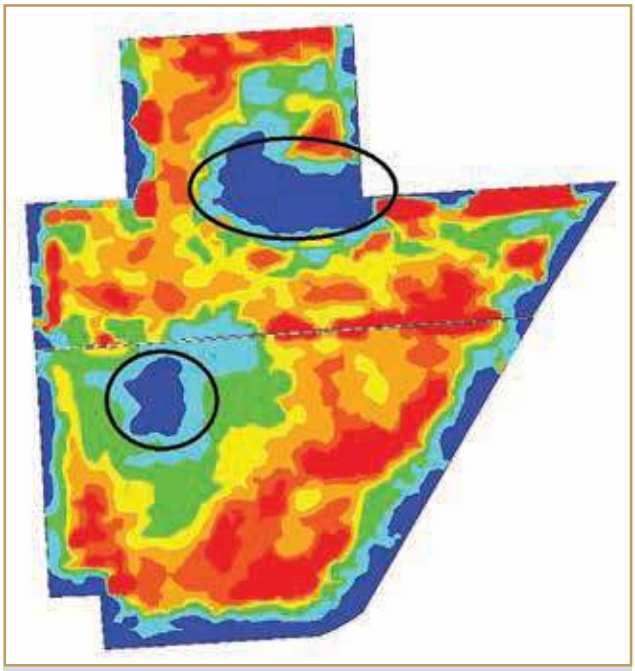
Growers can identify and map the location of target weeds species in several ways: ground-based visual estimation, remote and proximal sensors, machine vision or by soil type.

Many growers try 'patching out' weeds, usually based on their own observation of weed patches and the weed map they have in their mind. This can be successful, but often the reality is they should have sprayed more or sprayed the whole paddock because they missed weeds and this was obvious later in the season when the weeds went to seed. This experience indicates the weed map was not accurate enough.

Either more effort needs to be invested in developing the weed map, or a more robust and reliable method needs to be employed. However, a lack of reliable and robust mapping methods remains the biggest stumbling block to the uptake of SSWM, which current research efforts are addressing.

PREVIOUS PAGE: Plant-sensing technology can reduce input costs by targeting weeds, saving on herbicide. Photo Ed Cay

ABOVE: Optical sensing technology, such as the GreenSeeker, scans the crop canopy capturing collecting plant reflectance information. Photo: Matt McCallum



ABOVE: Landsat NDVI image showing high-density ryegrass patches in crop. Source: Sam Trengove, Trengove Consulting.

Ground-based visual estimates: Ground-based visual estimates can produce accurate weed maps. Methods for recording this information include touch-sensitive screens flagging weed presence and density with GPS location. This can be carried out while performing other paddock operations, such as harvest, spraying and spreading. However, the accuracy of a map generated this way depends upon the skill, experience and attention to detail of the operator, particularly when identifying weeds at lower densities.

Remote and proximal sensor: Remote and proximal sensor measurements of vegetation indices, most commonly the normalised difference vegetation index (NDVI), can discriminate weed infestations from weed-free crop areas based on the change in reflectance due to increased biomass associated with increased weed density.

The NVDI identifies the location of weed infestations, but cannot identify the weed species, so requires ground-truthing for appropriate chemical selection and application. Sensing platforms can include satellite, aeroplane, unmanned aviation vehicles (UAV), and vehicle-mounted sensors such as GreenSeeker™, N-Sensor™, Crop Circle™ and Crop Spec™.

The success of this approach and the weed densities that can be detected are affected by differences in growth rates of weed and crop, time of emergence, differences in vigour and timing of flowering and maturity. This approach can also be used during the fallow period to identify weed patches. In general, this is an opportunistic approach to mapping weeds that will only be possible when the right set of crop and weed conditions are present. That is, when the crop is relatively uniform and the weed patches of interest have big enough leaf area to affect the vegetative index.

Machine vision weed sensors: Machine vision weed sensors are the next generation of sensors that advance the capability of SSWM. These sensors identify weeds within a growing crop based on shape parameters from high-resolution images. Crop and weed shape features are extracted from the image and compared to a database for classification.

A South Australian Grains Industry Trust (SAGIT)-funded project is currently investigating the capability of the H-Sensor for application in South Australian cropping systems. Developed in Germany by Agricon it is designed to identify weeds within a growing crop. It uses leaf shape and size parameters to classify different plants into different shape classifications and has been successfully tested in Europe on wheat, canola, sugar beet and maize to target both broadleaf and grass weeds in these crops. The sensor can directly control a sprayer or can be used to generate a map for later use.

Soil type: Soil type can be used to map some weeds indirectly where weed density is related to soil type. Soil type characteristics can be mapped with sensors such as EM38, gamma radiometrics, Veris pH, organic carbon (OC) and electrical conductivity (EC) or yield data can be used to identify different production zones often related to soil properties. Ground truthing is always required in these situations to ensure the soil zones properly reflect the weed patches.

ABOVE: Cutting-edge technology is on the horizon, which will allow growers to accurately target weeds within the crop. Photo: Emma Leonard, AgriKnowHow

Summer control offers maximum impact

The GRDC-funded National Water-Use Efficiency (WUE) Project (2008–13) highlighted overwhelmingly that summer weed control is the single most important management practice growers can undertake to improve crop WUE.

The average additional yield benefit across 15 trial sites in South Australia, New South Wales and Victoria from summer weed control was 0.9t/ha, ranging from 0.2–1.7t/ha. The additional yield was primarily due to increased moisture (average 33mm) and nitrogen (average 38kg/ha) available for subsequent crops following summer weed control.

Summer weed control has other benefits, including improved trash flow at sowing and increased pre-emergent herbicide efficacy. Fewer weeds following summer control also reduces the potential for disease and insect carryover by reducing potential plant host options.

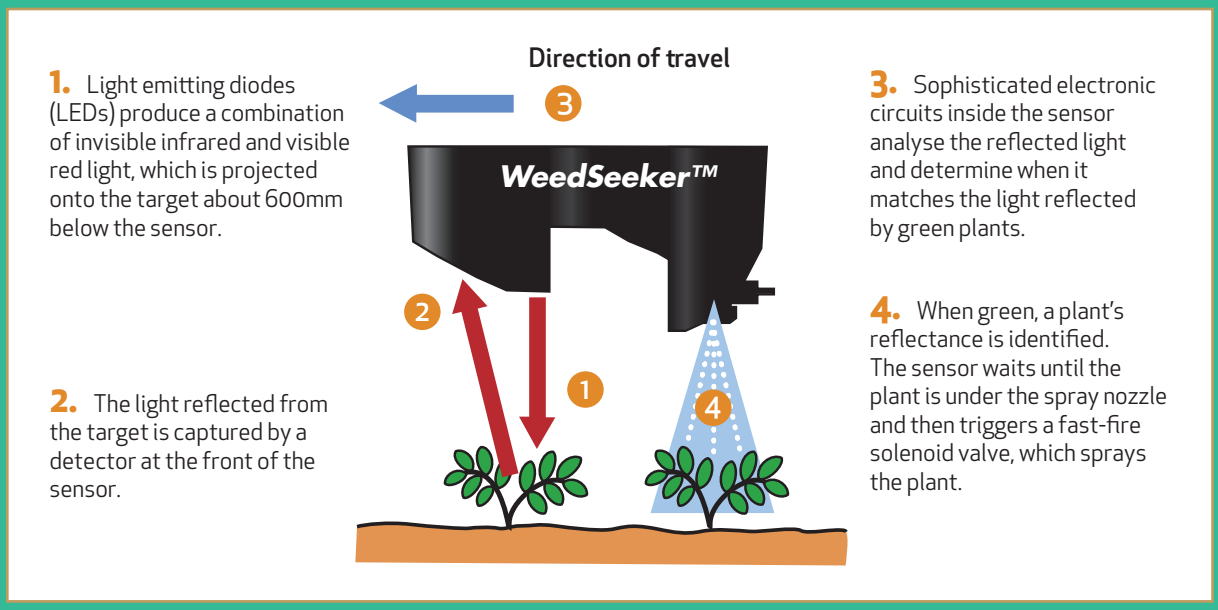
Optical sensing technology

A number of companies now produce optical-sensing devices, which can detect plants by using near infra-red reflectance (NIR) technology to measure the chlorophyll reflected by plants when exposed to a light source. At this stage the technology does not discriminate between crops and weeds, so is used when there is no actively-growing crop present, (e.g. summer fallow).

When combined with a solenoid that switches the spray nozzle on and off, this technology can be used to 'spot spray' weeds. Optical-sensing technology has been proven to reduce summer weed-spraying costs by up to 90 per cent and help kill 'hard-to-control' summer weeds (e.g. fleabane, onion weed, Lincoln weed) by using higher doses of herbicide and/or more expensive products.

There are currently two commercially-available optical-sensing systems available in Australia — the WeedSeeker™ and WEEDit™ spray systems (Figure 1).

Figure 1. How weed seeking sensor technology works



Source: Adapted from www.cropoptics.com.au

Determine the weed control tactic

The most effective weed control tactics will depend on the weed in question and the crop scenario. Some SSWM tactics are detailed in Table 5.

Growers have successfully controlled annual ryegrass, brome grass, wild oats, wild radish and skeleton weed by using weed maps to target high-density weed patches. Often targeted control approaches, such as in-crop desiccation of weedy patches during spring with high rates of herbicide to ensure 100 per cent control, are more aggressive and effective than a standard 'whole-paddock' treatment, which effectively only targets 10–15 per cent of the paddock in many cases.

Practical strategies, where growers are using SSWM include:

- **Desiccation:** weedy patches are sprayed with a non-selective herbicide (e.g. glyphosate) before weeds have set any viable seed. Generally, desiccation is considered a targeted brown manure strategy, which requires crop to be sacrificed.
- **Hay production:** annual ryegrass patches in wheat and barley crops are cut for hay.
- **Narrow windrow burning:** high-weed-density patches are harvested separately from the rest of the paddock and narrow windrows are burnt during autumn.
- **Stubble burning:** a fire break is formed around patches of annual ryegrass so the stubble can be burnt after harvest to destroy weed seeds.

Table 5. A range of site specific weed management tactics and their requirements

Site specific control	Requirements and comments
Non-chemical control	
Hay cutting and baling	Hay equipment and a weed map.
Stubble burning	A fire break will be required around the weed patches.
Increased crop competition through increased sowing rates	A georeferenced prescription map based on weed density can be used to automatically adjust crop sowing rates. This relies on a historical weed map. Most modern sowing equipment is fitted with GPS-ready rate controllers. Alternatively sowing rates can be doubled by completing a second sowing pass, or adjusted by using a manually-operated variable seed rate controller.
In-crop herbicide control	
On/off decision	A conventional boomspray and a weed map can be set up for automatic switching through a rate controller or switched on/off manually by the operator.
Add an extra herbicide to a base tank mix where the weed patches are	This approach can only be achieved with a standard boomspray by spraying the base tank mix in one application and then completing another pass across the paddock with the additional herbicide — only turning on the boom over the weed patches. A boom set up with direct injection and dual lines can achieve the same thing in one pass. The base mix is mixed in the tank and sprayed through the first boom line. Additional herbicides can be injected into the second boom line, which is also primed with the base tank mix. When the additional herbicide is required the second boom line is switched on and the first boom line switched off. Direct injection into a single line alone cannot be used for variable-rate herbicide application due to the long lag time from the point of injection to the time it reaches the last nozzle.
Adjust the rate of a herbicide mix	Currently the only way rates can effectively be adjusted in real time is by adjusting the spray carrier volume as this can be changed instantly and equally across the boom. Limitations to this process include the relationship between nozzle flow rate and droplet size distribution, and all herbicides in the mix are altered by the same percentage. With conventional booms and nozzles the limitation of the nozzle flow rate restricts the amount the carrier volume can be varied, however this can be compensated for somewhat by adjusting ground speed. Dual line systems, variable orifice nozzles (VariTarget), nozzle banks (Arag Seletron and Hypro Duo React), and pulse width modulation (Aim Command Case IH, Pinpoint Capstan, Hawkeye Raven and Dynajet Flex 7120 TeeJet) provide more flexibility in flow rate and so carrier volume can be varied more without sacrificing ground speed. Flow rates from 1x up to 8x can be achieved at the same ground speed. The latter two options allow independent rate control of the individual nozzle, increasing application resolution compared with most other options that operate at the resolution of the boom section or whole boom.
Apply a different herbicide mix to different weed zones	Multi-tank boomsprays are designed as two or more sprayers on the same chassis. The boom consists of two or more tanks and each has a separate pump, lines and nozzles that can be controlled independently. Different herbicides or herbicide mixes can be added to each tank and they can be turned on or off based on separate prescription maps. The rates of each tank mix can be varied as for a normal boom. There are examples of growers plumbing a second (smaller) tank into the second boom line allowing two different tank mixes to be applied independently.

Source: Sam Trengove, Trengove Consulting

- **In-crop 'spot spraying':** wild radish patches in pulse crops are sprayed with a late-season application of glyphosate using a second spray tank in conjunction with insecticide applications.
- **Fallow 'spot spraying':** patches of skeleton weed are sprayed using 2,4-D amine in a second spray tank during summer spraying.
- **Increased herbicide rates:** pre-emergent rate of herbicides are increased in high-density annual ryegrass, brome grass and wild oat areas to improve weed control.
- **Variable rate sowing:** higher sowing rates are employed across high weed density patches to out-compete weeds.

Documentation

Documentation is important for compliance, quality assurance and for future reference. Knowledge of herbicide use and other weed control tactics is important for understanding herbicide resistance issues and potential plant back issues in cropping rotations. Therefore it is important to have an accurate record of where treatments have been applied.

Further information

- **New Technology For Improved Herbicide Use Efficiency:** http://www.grdc.com.au/Research-and-Development/GRDC-Update-Papers/2015/02/New-technology-for-improved-herbicide-use-efficiency#sthash.K9qvnaGe.dpuf
- **Site Specific Weed Management (SSWM) — weed mapping and patch spraying:** http://www.spaa.com.au/files/catalog/SSWM_Heap__Trengove.pdf