

Site Specific Weed Management - Australian Potential



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Key Findings

- 1) Site Specific Weed Management (SSWM) has potential economic and environmental benefits.
- 2) Overseas research suggests herbicide savings of between 10 and 80%.
- 3) Techniques need to be adapted for Australian cropping systems.
- 4) Annual ryegrass and wild oats will probably be the first targets.
- 5) The most promising SSWM system for Australia may involve a cheap basal herbicide application, with variable application of a more effective and expensive herbicide to patches.
- 6) Efficient mapping methods and effective direct-injection sprayers are the current bottle-necks.
- 7) Ground-based sensors used during routine paddock passes at the early post-emergence stage will probably be most suitable.
- 8) Information is also needed about the stability of weed maps over time under Australian conditions.

Introduction

Increasing adoption of GPS guidance and rising costs of production inputs have encouraged interest in a range of VRT (variable rate technology) approaches to crop management. VRT fertilizer application has attracted most interest, but as technologies and knowledge improves there will be potential to apply pesticides using VRT. Weed mapping and patch spraying has generated overseas interest and research effort, and there is now a renewed interest developing in Australia. Weeds often grow in patches within a paddock. Spraying the whole paddock is the current norm, but there are potential economic and environmental benefits to spraying only where there are weeds. It is likely that annual ryegrass and wild oats will be the first targets for SSWM in Australia. The agronomic challenges and opportunities in Australia are similar in many ways to those addressed by on-going overseas research, but there are also some differences that need to be considered.

Overview

Potential Benefits

There are potentially economic and environmental benefits to SSWM. Herbicide under-dosing and over-dosing are inevitable when weed distribution and density varies across a paddock. Overseas research has shown that SSWM has the potential to reduce herbicide applications by 10 to 80%. The cost savings are obvious, but additionally weed-free crop areas not sprayed may yield 5 to 10% more, when phyto-toxic effects of the herbicide are removed. In Europe there is also a strong interest in SSWM for environmental reasons. Dr Roland Gerhards summarised SSWM in a conference in Germany last year, and observed that: “Using broad-acre blanket spraying results in the wrong application decision at almost every point in the paddock.”

SSWM Systems

The aim of SSWM spraying systems is to get the right dose of the right herbicide in the right place. There are a number of technical hurdles to be overcome, and this has resulted in an array of research approaches with different levels of complexity. SSWM has four main components: 1) weed mapping/sensing; 2) treatment decision 3) treatment application; and 4) documentation. The system components chosen will be influenced by each individual weed control situation.

Prior mapping vs real-time detection. Mapping prior to spraying is easier, but may involve an extra pass. Real-time detection requires sensors and on-board computers to process imagery and control nozzles.

Weed/crop biomass vs weed species ID. Simple reflectance systems can measure total plant biomass – this measures both crop and weeds together and can be misleading. Scanning only in the inter-rows is more challenging, but more accurate. More complex systems use both reflectance and image shapes to identify plant type. The more advanced research systems can identify up to 25 weed species.

Treatment decisions. The simplest is ON/OFF – this is most easily implemented, but missed plants outside of patches may cause problems. Another approach is to apply a uniform basal treatment and use an ON/OFF system to apply another treatment only to patches. More complex systems identify spatial variation in weed species and density, and may apply up to three herbicides at varying rates. These systems use sophisticated computerised weed control expert systems (eg Plant Protection On-Line).

Treatment scale. Most SSWM research has concentrated on treating patches (metres across) using boom section control, but more recent research in Denmark is working on “cells” (c. 11x3 cm) or even single plant targets.

Sensor types. The most readily available and sophisticated sensor is the human eye, but manual mapping prior to spraying is time consuming and real-time manual control may not be reliable due to periodic distraction of the operator. Digital imagery can be captured from the ground or remotely (satellite or aircraft), but for systems aiming to treat patches smaller than several metres remote imagery has insufficient spatial resolution. WeedSeeker is currently the only commercialised system linking sensors linked to spray control. This system senses green plant biomass using a ratio of red and near infra-red (NIR) reflectance and is mainly used for non-selective weed control in non-crop areas. There are other commercially available sensors (CropCircle, GreenSeeker and Yara N-Sensor) that can map biomass using red/NIR. More sophisticated systems under development in Denmark and Germany use a combination of red/NIR imagery with image shape analysis to identify weed species.

Documentation. Most systems under development log the “as applied” herbicide application map as a useful record of application.

R&D Challenges

The main bottle-necks for SSWM are efficient and accurate mapping/scanning systems and suitable direct injection systems for herbicides. Recent advances in research labs in Europe suggest that these problems may be overcome. Advanced imaging prototypes can identify 25 weed species real-time. Direct injection systems currently suffer from long lag-times because of the time taken for the herbicide to travel from the injection point to the nozzle (4 to 30 seconds). Late last year a German research team described an effective direct injection nozzle that would allow concentrated herbicide to be injected directly into nozzles with a lag time of less than a second.

Overseas Developments

Germany and Denmark have strong SSWM research efforts, driven by government funding aimed at meeting environmental pesticide reduction targets. There has been excellent technological progress made, but commercialisation of SSWM has been slow because growers generally consider herbicides to be cheap and have little incentive to adopt more complex systems. The closest system to commercial release appears to be a 21m three-tank sprayer ("CERBERUS") developed by Dr Roland Gerhards and his team at the University of Hohenheim, near Stuttgart, Germany. The sprayer has three parallel independent spray lines supplied by three separate tanks filled with different herbicides. Weed maps are used to switch 7 x 3m boom sections on and off simultaneously in each of the three spray lines. The control lag time is around 0.5 seconds, and they are currently working on real-time weed identification (c. 25 species) and treatment mixture determination. Studies in 13 paddocks over 3 years have given 10 to 80% herbicide reductions while maintaining good weed control. Efficacy has been tracked in 38 paddocks with c. 95% control, with no apparent weed seed-bank build-up. Laser-induced leaf fluorescence (Germany) and polarised light reflectance (France) are also being explored for weed identification. In Denmark Dr Svend Christensen and his team are developing extremely accurate autonomous spray delivery systems. The systems are modelled on ink-jet printers and will initially be used in horticultural crops. One system treats small areas (cells) of c. 11 x 3cm by switching nozzles on and off, while a second system identifies individual weed seedlings and fires either a laser beam or herbicide micro-droplets (0.2 micro-litres) at the growing point. Prototypes treating 100 broadleaved seedlings per m² have achieved water volumes as low as 0.2 L ha⁻¹.

Australian Potential

Overseas experiences suggest that SSWM may have a place in Australia. Initial development appears to be most suited to treatment of herbicide resistant weeds (eg annual ryegrass and wild oats) where patches might be treated with more expensive herbicides. As an example annual ryegrass might be treated with a uniform basal application of trifluralin, with triallate injected into the spray line in patch areas. The cost of herbicides as a proportion of returns is higher in Australia than in Europe, providing additional incentive. Retention of stubble is not common in Europe and may present us with some mapping/scanning challenges, but our wider row spacings may be an advantage. Table 1 suggests some potential windows of opportunity for SSWM.

Table 1. Windows of sensing/mapping opportunity for SSWM in Australia

Stage	Timing	Field Situation	Opportunity
Summer fallow	Dec-Mar	Dry stubble. Green summer weeds (eg Skeleton weed, SLN)	Summer weed mapping. Ground or remote. SSWM non-selective herbicide application possible.
Pre-sowing	April-June	Emerged winter seedlings. Probably standing stubble.	Emerged weeds – no crop rows. Ground or remote. SSWM non-selective herbicide application possible.
Early post-em.	July-Aug	Early post-em crop and weeds. Distinct crop rows.	Inter-row sensing (ground only); Crop+weed sensing (ground or remote);
Late crop	Sept-Nov	Closed crop inter-rows. Weed heads visible.	Wild oat, brome, ARG head mapping. (probably remote only); SSWM “crop-topping” possible.

Early Indications from Recent Australian Research

Recent work (funded by SAGIT, Uni of Adelaide and GRDC) has been undertaken by Mr Sam Trengove (Allan Mayfield Consulting, SPAA), Dr John Heap (SARDI, SPAA) and Dr Chris Preston (Uni. of Adelaide).

Sam Trengove's work has concentrated on using a range of ground scanning instruments (Yara N-Sensor, GreenSeeker, and Crop Circle) to map annual ryegrass and to make VRT spraying decisions. Annual ryegrass has been successfully mapped in canola and lentil crops, at the early post-emergence stage, before significant differences in crop biomass develop within the paddock. These maps have been used to vary herbicide rate in the following year with success.

John Heap has just begun to investigate patch stability in annual ryegrass over several seasons, and to experiment with ground and airborne imagery to map annual ryegrass. Annual ryegrass population levels are being monitored at 75 points distributed across PA zones in three paddocks in 2008. A pair of Crop Circle sensors linked to a data-logger have been used to collect annual ryegrass maps in barley, chickpeas and lentils. A small remote control plane has also been used to collect biomass data (colour/infrared image pairs) in a time series over small areas of the study paddocks.

A number of practical considerations for weed mapping have become apparent from the research so far:

- 1) Pre-sowing scanning window. In some seasons there is only a small window between the break of the season and sowing of some crops (eg canola). This means that in some cases it will be very difficult to map pre-sowing biomass.
- 2) Pre-sowing biomass and summer weeds. In some seasons there will be significant green biomass of summer weeds (eg common heliotrope, melons, Lincoln weed etc) present prior to seeding, depending on the amount and timing of summer/autumn rain. This may prevent meaningful mapping of winter weeds prior to sowing.
- 3) Volunteer cereals. In some paddocks there may be a significant flush of volunteer cereals prior to sowing. The rapid and large growth of these plants may interfere with the accuracy of annual ryegrass maps.
- 4) Pre-sowing wild oats. In seasons with an early break, wild oats may not have emerged by seeding, thereby precluding any mapping opportunity.

- 5) Header rows. In some paddocks weeds and volunteer cereals occur in distinct header rows prior to seeding. This pattern can also occur after seeding with annual ryegrass. This poses a challenge for ground-based mapping, as point sensors such as Crop Circle and Green Seeker scan only a narrow ground band (ie c.1m wide). If scanning is done in the normal direction of machinery travel (including the header), then the scanner may travel the whole length of the paddock either over a header row (over-estimating), or between header rows (under-estimating). The problem is probably not so serious for the Yara N-Sensor, because the scanning bands are wider and better integrate the high and low density weed strips. A more accurate map could be obtained by scanning at right angles to the header rows, but this would require machinery operating at right angles to wheel tracks/tramlines, and also involves a bumpy ride where furrows are pronounced.
- 6) Stubble. Preliminary research in an area of cereal and pea stubble suggests that Crop Circle scanners are not significantly affected by stubble, however changing soil surface moisture appears to alter the readings.

Conclusion

The potential economic and environmental benefits from Site Specific Weed Management justify continued efforts to devise techniques suited to Australian cropping systems. Annual ryegrass and wild oats will be the most likely initial targets. Ground scanning systems appear to offer the best potential, and the most likely useful scanning window will be early post-emergence.



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