New developments in SSWM

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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. GPS has opened the way for Site Specific Weed Management (SSWM) – targeting control measures only to where they are needed. In a recent visit to Europe Dr John Heap, SARDI had the opportunity to learn about technological developments in SSWM.

Herbicide under-dosing and over-dosing are inevitable when weed distribution and density varies across a paddock. Dr Roland Gerhards observed at a conference in Germany last year, "Using broadacre blanket spraying results in the wrong application decision at almost every point in the paddock."

Site specific weed management (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.

SSWM systems

The aim of SSWM spraying systems is to apply the correct dose of the appropriate 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 six main components and the system components chosen will be influenced by an individual weed control situation.

1) **Prior mapping versus 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.

2) **Weed/crop biomass versus weed species identification.** 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 on-the-go.

3) **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.

4) **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' or even targeting a single plant with micro droplets.

5) **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 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.

6) 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 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.

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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 by 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 of approximately 25 weeds species and treatment mixture determination.

Studies in 13 paddocks over three years have given 10% to 80% herbicide reductions while maintaining good weed control. Efficacy has been tracked in 38 paddocks with about 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 about 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 square metre have achieved water volumes as low as 0.2L/ha.

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.

For more information
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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, silver leaf nightshade)	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.