Weed Sensing

What is weed sensing?

At the heart of 'Weed Sensing' is the use of a machine or instrument to detect a weed; a plant that shouldn't be there. It is achieved by an optical sensor directed at the ground, using light reflectance to detect the presence of a green plant/weed as the sensor unit lights it up.

Weed sensors are broadly used for:

1. Optical Spray Technology – principally used for summer weed detection and spraying, and

2. In-crop weed detection.

Where can it be used?

Optical Spray Technology (OST) systems are used for broad spectrum weed control for summer weed and fallow weed control. This type of sprayer is widely accepted in broad-acre cropping situations.

In-Crop weed detection is the sensing and identification of non-crop plants within the growing crop. This technology is not as advanced, nor as widely used as the optical sprayer technology.

Optical Spray Technology (OST) Systems

There are two commercial OST units currently on the market. There are a number of reviews available online comparing the WEEDit and Weedseeker units. For more information see the relevant web sites listed in the Resources section below. The main points of difference are:

• WEEDit are generally tow-behind units; to eliminate boom height variations. WEEDit uses one sensor eye with five lens controlling five nozzles per one metre spacing on the bar.

• Weedseekers can be fitted to tow behind or self-propelled sprayers. Weedseeker uses one sensor for each nozzle.

In southern Australia the capacity of soils to store summer moisture and the incidence of summer rainfall are important considerations in contemplating purchase of an OST system. In many parts of southern Australia, where the farming system is able to store significant summer rain in the sub soil, the French-Schultz yield potential model and experience shows that a third or more of this moisture is available for the following crop; boosting yield and or grain quality. In the case study Robin Schaefer in low-rainfall country at Loxton, SA, on average receives a third of his rainfall out of the growing season. Summer active weeds such as melons, heliotrope, fleabane, skeleton weed, caltrop etc. quickly deplete soil moisture reserves. Saving summer moisture for use in six months time often determines the success or failure of Robin's crops.

Farmers will debate and delay spraying summer weeds 'until more weeds are up' because of the cost of blanket sprays. James Hunt (CSIRO) confirms that controlling summer weeds early saves moisture and nutrients - control should start promptly (10 days) following germinating rains. The OST systems are a cost effective means of controlling weeds early without excess cost. In the Bulla Burra case, it often means another weed control pass over summer.

	Benefits	Limitations
Optical spray technology systems	• Significant reduction in chemical usage with resultant cost savings • Timeliness of spraying weeds at a smaller, younger stage at higher water volumes when plants are more susceptible to lower chemical rates • Cost effective alternative to blanket spraying operations • Cost effective alternative to summer tillage operations and therefore potential increased protection of fragile soils and retention of soil nutrients, summer moisture and organic matter • More environmentally sustainable than tillage options • Reduction in community exposure to farm chemicals • Ability to use higher rates strategically on hard to kill weeds • Spraying in otherwise adverse spraying* conditions e.g. higher Delta T • Use in low light or night time operation • Fewer tank fills per day and therefore improved spray work rate	• High cost of spray system and bar (approx. $4 000 per metre) • Some spray bars have needed increased engineering because of high maintenance requirements. • Increased number of trips over paddocks in summer for optimum moisture saving, requiring extra labour
In-crop weed sensing	**Drones and aircraft** • Drones are used to produce maps on a needs basis • Price of suitable drones is reducing • Can produce high resolution imagery • Ease of use of drone and software controlling drones • Relative rapid turn around time for production of paddock maps • Predominantly using NDVI imagery and patching by eye or creating spray prescription maps **Satellite** • Satellite image maps are very cheap per unit area • Satellite maps are quality controlled for data - altitude, angle and luminosity **H sensor technology** • Exciting new possibility with capacity to 'learn' new weeds and expand its database of weeds • Future capacity to operate on the fly, similar to OST systems • There are a number of groups working in this space globally	• Sensing and spray application are two separate paddock operations. This may also involve a ground-truthing trip over the paddock **Drones and aircraft** • Limited flight time and tight flight weather conditions required • Requirement for high speed internet connection for upload of images for processing • Inconsistency and lower quality of data from drones requiring higher processing due to variations caused by clouds, time of day – sun angle, camera angle, yaw and pitch in the drone flight, and luminosity at time of flight **Satellite** • Cloud cover at satellite fly-over, delays timely production of images. (Some regions and years experience significant cloud cover through winter growing season resulting in extended periods between satellite images) **H Sensor technology** • Remains in testing and evaluation phase • Sensor units are currently very costly

* SPAA recommends using optimal spot sprayers as per manufacturers guidelines.

Optical Spray Technology

Optical weed spraying systems use Near Infar Red (NIR) and red light sensing technology to detect living green material on the ground.

When red light is passed over live plant matter the chlorophyll in the plant absorbs some of the red light and fluoresces Near Infra Red light (NIR) back out to the environment.
WEEDit Spot-On Spraying

In response to the presence and absence of living green plant material the sensor controls nozzles on a boom spray, switching on and off as it detects green plant material and in this way spraying only those areas of a paddock covered by weeds. The manufacturers claim an 80% reduction in chemical usage in a normal summer spraying operation.

WEEDit spray bar, sensors on the left and nozzles on the right.

In-crop weed sensing technology

NDVI technology has been used in a range of crop types and environments for limited application of mapping of weed populations in-crop. Nevertheless there is promising on-going work with a SPAA project investigating the Agricon H Sensor: a weed ID and mapping system.

NDVI maps can be generated from tractor mounted sensors, UAV's or aircraft mounted with NDVI cameras, or from airborne image service providers.

Remote and proximal sensors measure vegetation indices; most commonly the normalised difference vegetation index (NDVI), and can be used to discriminate weed infestations from weed free crop. Sensing platforms can include satellite, aeroplane, UAV, and vehicle mounted sensors such as Greenseeker, N-Sensor, Crop Circle and Crop Spec.

These sensors are not connected to nozzles sprayers but used to map weed populations for later treatment. Mapping and spraying of weeds identified in-crop is then a separate paddock operation to the sensing.

Maps produced by these techniques identify the location and extent of weed infestations but not the weed species. 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.

Mark Branson, Stockport, SA, uses a rotary wing UAV to scan and photograph a paddock for weeds. The flight may produce 500 high resolution colour digital images, which are uploaded to a suitable image processing provider (e.g. Drone Deploy) for specialised processing. A digital geo-referenced image of the paddock is produced from which weed zones are identified by eye and can be 'zoned' in a spray prescription map or sprayed by 'patching' out by eye. The UAV flight time is limited by battery time. The success of this is restricted to early crop stage; nevertheless Mark is able monitor trends in weeds population.

Machine vision weed sensors will be the next generation of sensors that advance the capability of site specific weed management. 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. There are a number of groups working in this space globally. A SAGIT funded project is currently investigating the
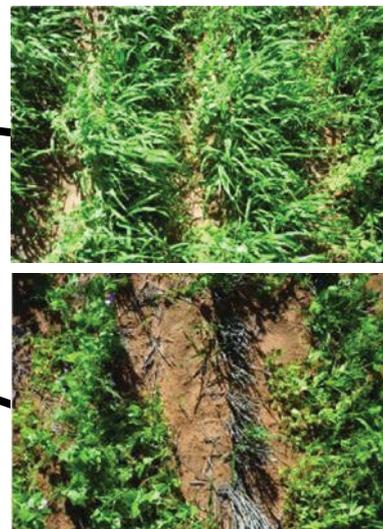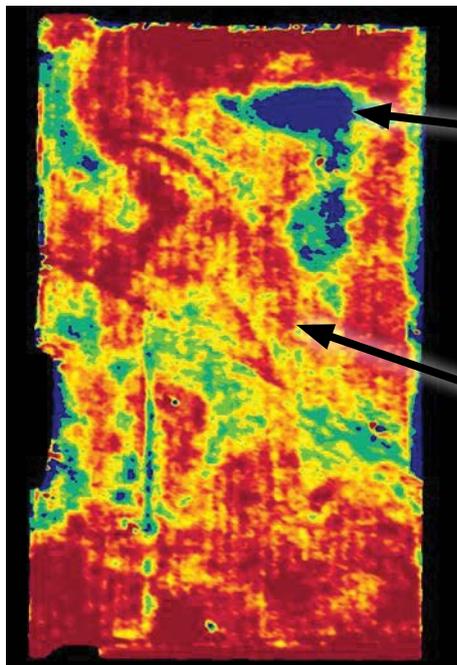
NDVI image of a field pea crop with patches of brome grass, wild oats and ryegrass. Grass weed patches are represented by high NDVI in blue and green.

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. The sensor can directly control a sprayer or can be used to generate a map for later use.

Case study – Robin Schaefer from Bulla Burra

Farm location:	Loxton, South Australia
Farm size:	11 000 ha
Rainfall:	Loxton, long term: 270 mm annual rainfall, 172 mm growing season rainfall
Crops:	Wheat, barley, lentils, chickpeas, field peas, canola, vetch

Bulla Burra moved into weed sensing technology with the purchase of a WEEDit at the end of 2013. Since then it has been used for the past three seasons in summer weed control across the farm.

Robin said their focus on sustainability and farm performance over a large cropping program is what led them to taking ownership of a WEEDit optical spot sprayer.

Bulla Burra has an 11 000 ha yearly cropping program. This represents some challenges such as being able to target problem weeds but also maintain

operational efficiency when running one self propelled sprayer over such an area.

The WEEDit was considered not only for the ability to save on the overall chemical costs but for the capability of targeting harder to control problem weeds such as fleabane, skeleton weed and feathertop Rhodes grass. These typically require higher chemical rates to control but a blanket spray would be uneconomical to apply over such a large area at these higher rates. The WEEDit, being a separate unit, could also provide that crucial support and compliment the use of the self propelled sprayer.

The key benefits of the WEEDit for Bulla Burra are:

- Ability to selectively spray over a large area
- Higher rates can be used more economically on harder to kill weeds
- Allows spraying to occur in more marginal conditions where a blanket spray could not be justified
- Overall chemical cost savings, however these vary depending on the season and weed cover
- It allows earlier blanket spraying on smaller weeds as the WEEDit can clean up remnants assisting with reduced herbicide resistance.
- Potential for improved paddock water use efficiency with the eradication of tough weed populations that can otherwise be drawing moisture.
- Less risk of chemical trespass

Robin suggests that on its own this machine may not significantly influence overall profit but due to many variables (e.g. summer rainfall) it has been difficult to quantify.

However, with the scale of Bulla Burra's cropping program and the integration of the WEEDit alongside the self propelled sprayer, rather than sole reliance of the self propelled sprayer, Robin believes the WEEDit holds its own for them. Being able to save time when spot spraying to cleaning up after blanket sprays as well as relieving the burden on the sole spray unit are some of the factors that influence overall profit.

Some of the barriers that Robin believes may impact others implementing this technology are mainly around the cost of the technology and being able to leverage from the investment effectively. Robin considers it is important to buy a WEEDit according to the size of the farm to help manage the capital investment.

In the environment of the Mallee, the machine did have mechanical issues that have largely been worked through and fixed. Some of the ongoing problems include dust on the lenses or struggling to detect weeds that are stressed and have low chlorophyll levels. There can also be problems with false sensing due to infrared light from sunlight causing "miss fires".

Robin suggested that through much of the post harvest summer, a full time labour unit is employed on the WEEDit to keep up, which he admits they didn't realise and fully take account of. This is also due to the speed at which the WEEDit can operate, generally at a much slower 18kph than usual blanket sprays at 28 to 32kph.

There has also been an increase in the amount of complexity involved with running the WEEDit. Determining the differing weed spectrums, applying different mixes of chemicals and rates, and being able to draw the line between using the WEEDit and applying a blanket spray is the key to overcoming some of this complexity.

Despite the high capital costs and economic variability year to year, the WEEDit is "a no-brainer economically" as a profit driver for Bulla Burra when integrated alongside the self propelled sprayer.

Resources *(not an exhaustive list).* *(Web addresses were accessible as of 30 September 2016)*

- Optical Sprayers
    - WEEDit www.weed-it.com
        - WEEDit have also produced an online calculator to determine the time required to pay the machine off based on the original cost and annual spray savings www.weed-it.com/calculator.
    - Weedseeker www.trimble.com/agriculture/weedseeker.aspx
    - Case Studies and comparisons
        - SANTFA published a case study review of both units operated in the South Australian Mallee: http://www.santfa.com.au/wp-content/uploads/Santfa-TCE-Spring-12-Selective-spray-units-help-war-on-weeds.pdf

- In-Crop sprayer
    - The H sensor: a weed ID and mapping system - SPAA Projects.
        - The H Sensor project conducted for SPAA by Sam Trengove, Trengove Consulting, 0428 262 057 samtrenny34@hotmail.com

- NDVI equipment or maps can be obtained from a number of sources,
    - Tractor mounted sensors Greenseeker (Trimble – GreenSeeker | Trimble Agriculture), N-Sensor (,Yara N-Sensor™ | Yara), Crop Circle (Holland Scientific) and Crop Spec (CropSpec | Topcon Precision Agriculture)
    - Satellite (precision agriculture Satamap)

- Satellite images, mapping services and data handling and processing
    - precision agriculture
    - Aerometrex
    - Satamap
    - Wisdom Data and Mapping
    - DroneDeploy
    - PCT – Precision Cropping Technologies Pty Ltd

Acknowledgements: