

# MANAGING SOIL MOISTURE



**GRDC**<sup>™</sup>

REGIONAL CROPPING  
SOLUTIONS NETWORK

**WESTERN REGION**



## **CASE STUDIES OF GROWERS IN WESTERN AUSTRALIA**

AN INITIATIVE OF THE KWINANA EAST REGIONAL CROPPING SOLUTIONS NETWORK

## Acknowledgements

Grateful acknowledgement is made for the information and time committed by the following growers in this case study booklet: Mick Caughey, Campbell Jones, Darren Kilminster, Nick Priest, Callum Wesley, Andrew Crook, Doug McGinniss, Kim Creagh and Deane Aynsley. Acknowledgement also extends to advisers Frank D'Emden, David Stead and a range of researchers from the Department of Agriculture and Food Western Australia.

### Managing soil moisture

Case studies of growers in Western Australia  
An initiative of the Kwinana East Regional Cropping Solutions Network

**Project:** Case studies of growers using novel techniques to use available moisture in the Kwinana East port zone

**Cover Photo:** ©GRDC

**GRDC Project Code:** CIC00033-A

**ISBN:** 978-1-921779-39-8 (online) | 978-1-921779-40-4 (printed)

**Published February 2017**

©Grains Research Development Corporation. This publication is copyright. Apart from any use as permitted under the Copyright Act 1968, no part may be reproduced in any form without written permission from the GRDC.

#### **Disclaimer:**

Any recommendations, suggestions or opinions contained in this publication do not necessarily represent the policy or views of the Grains Research and Development Corporation. No person should act on the basis of the contents of this publication without first obtaining specific, independent professional advice.

The Grains Research and Development Corporation will not be liable for any loss, damage, cost or expense incurred or arising by reason of any person using or relying on the information in this publication.

---

# Table of Contents

<b>Introduction</b>	<b>4</b>
Mick Caughey, Merredin	5
Campbell Jones, Wyalkatchem	8
Doug McGinniss, Merredin	12
Kim Creagh, Nungarin	16
Andrew Crook, Merredin	19
Darren Kilminster, Bruce Rock	23
Deane Aynsley, East Beverley	26
David Stead, Brookton	30
Nick Priest, Bonnie Rock	34
Callum Wesley, Southern Cross	36
<b>Useful resources</b>	<b>39</b>

# Introduction

Soil moisture is vital for crop germination and emergence, especially for canola that needs to absorb a high percentage of its weight in water before germination begins.

Low moisture content in soils will reduce plant germination rates and slow emergence.

In Western Australia's lower rainfall areas of the eastern grainbelt, this makes soil moisture conservation a key strategy for grain growers to optimise productivity and returns.

The Grains Research and Development Corporation's Regional Cropping Solutions Network (RCSN) in the Kwinana East port zone has identified soil water conservation, crop water use efficiency and managing variable rainfall as a high priority in this region.

The group is part of a network of RCSNs set up by the GRDC in each of WA's five port zones, with the primary role of identifying the top locally-specific grains issues to improve grower profitability.

Since its inception in 2011, the Kwinana East group's members have consistently identified soil moisture management as one of the top two priorities in this region (along with business management).

GRDC has significant investments in soils, water use efficiency and soil moisture conservation and the Kwinana East group was interested in identifying and extending information about practical methods that could be employed to address these issues under local conditions and on local soil types.

Through this project, a range of techniques being used by 10 growers are profiled in case studies that explore how they are optimising production and reducing risks in an environment of increasingly fluctuating rainfall and highly variable soil types.

Their tactics include summer weed control; methods and models to measure soil water holding capacity; use of real-time data to quantify change and help with decision-making during the growing season; paddock preparation and crop management to increase the soil water 'bucket'; and use of fallow periods.

Across the Kwinana East region, there has also been increasing interest in trialling new soil technologies, such as soil moisture probes (SMPs), crop modelling and prediction tools such as Yield Prophet® and alternative summer weed control options. This booklet explores some of these developments.

Many of the case study growers have experienced consecutive years of drought or low growing season rainfall. In the Merredin area, for example, five of the lowest rainfall years in the past century occurred in the decade to 2015 – with 2016 being a welcome above-average rainfall year and 2017 looking promising on the back of record summer rainfall.

This RCSN Kwinana East case study publication is designed to be a practical resource and will be available to all growers in this port zone and right across the WA grainbelt.

We would like to sincerely thank all of the growers who have consented to being included as case study participants in this booklet.



For further information – or to receive a copy of this booklet – contact:

Julianne Hill  
Western Region RCSN Coordinator  
regionalcroppingsolutions@gmail.com  
0447 261 607

Case study – soil moisture | Mick Caughey, Merredin

# Summer spraying boosts soil moisture

## SNAPSHOT

**OWNERS:** Mick and Kate Caughey

**LOCATION:** Merredin, Western Australia

**FARM SIZE:** 5000 hectares (cropped)

**ANNUAL AVERAGE RAINFALL:** 200-300 millimetres (declining and variable)

**SOIL TYPES:** Light sand to high pH loam (4 to high 8)

**CROP PROGRAM (2017):** 2400ha wheat, 2200ha barley, 600ha oats

**TYPICAL ROTATION:** Cereals-fallow



Merredin grower Mick Caughey concentrates on summer weed control as a key plank of soil moisture conservation for cropping.  
 PHOTO: Cox Inall Communications

Summer spraying to control weeds and conserve stored soil moisture has proven to be an effective strategy in boosting crop productivity for Mick and Kate Caughey in their low rainfall cropping country at Merredin in WA's eastern grainbelt.

With annual rainfall declining each year, soil moisture and its management are paramount to optimising their winter cereal production from 5000 hectares. But strategies also have to be cost effective in this marginal environment.

During the past 10 years, Mick – a third generation grower – has seen annual rainfall drop by between 10 and 20 percent compared to long-term averages. At the same time, end-of-season ambient temperatures are rising.

“We sometimes have just 100 millimetres of rain falling in the growing season and winter rainfall is definitely decreasing,” he says.

“That makes it critical to set up the soil moisture profile for the following crop using strategies such as stubble retention, sowing into the same furrows to chase the moisture band and spraying summer weeds straight away – which can be during harvest if necessary.”

To ensure cropping remains a viable enterprise has meant reducing risk, which essentially means better managing the moisture that is available to crops.

The Caugheys spray summer weeds with residual and knockdown herbicides, using a combination of products, including glyphosate and triclopyr, to control African lovegrass (*Eragrostis curvula*), paddy melon (*Cucumis myriocarpus*), Afghan melon (*Citrullus lanatus*) and caltrop (*Tribulus terrestris*).

In recent years, the pressure has mounted to treat these weeds quickly, while they are still small.

“I suppose we weren't always as confident as we are now about knowing the amount of damage that summer weeds can do,” Mick says.

“We have realised how much harder it is to kill them if you leave them that bit longer before spraying.”

His confidence comes from taking part in RCSN Kwinana East-initiated trials conducted in 2013 on nine local farms in the eastern grainbelt that found a harvest-time knockdown of weeds conserved significant soil moisture.

When the major weeds of African lovegrass and caltrop were controlled on the Caugheys' calcareous loam site in December 2012, an extra 25mm of soil moisture to a depth of 40 centimetres was recorded in the following February – compared with an unsprayed area.

The subsequent harvest resulted in a doubling of wheat yields on the sprayed paddocks – at an average 3.2 tonnes per hectare – compared to an average of 1.6t/ha on unsprayed paddocks.

Mick says the trial validated the cost of summer spraying (about \$15/ha) but, importantly, demonstrated a clear yield penalty from not spraying weeds at this time.

“The trial was on a very weedy site, so the yield difference was huge,” he says.

“But even on a less weedy paddock, our own trials showed the yield difference was considerable.

“We recorded an average wheat yield of 1.6t/ha on an unsprayed paddock compared with 2.6t/ha on a sprayed paddock.”

The trick is in the timing of spraying, particularly when the summer is wet like it was in 2015, according to Mick.

Herbicide application that year required carrying out one lap of spraying on cropping country of glyphosate, triclopyr, metsulfuron and 2,4-D ester 680, before going over half of the farm again with another herbicide application due to a second weed germination in the wet conditions.



**“ We weren’t always as confident as we are now about the amount of damage summer weeds do...we’ve realised how much harder it is to kill them if you leave them that bit longer before spraying.**

*Mick Caughey, Merredin*

“The bigger weeds take-up more soil moisture, so you have to decide whether it’s better to spray early and then spray again,” Mick says.

“This might end up being a cheaper option than losing that moisture.”

That is one reason why Mick uses residual herbicides and Clearfield® technology, but Mick urges caution in planting the country back to legumes and canola, which can be susceptible to herbicide residues.

Another effective method for conserving moisture is to avoid cropping the weedier or ‘problem’ paddocks and, instead, leaving these in a spray fallow.

The Caughey’s paddock sizes range from 50 to 250ha, which Mick says enables them to opportunistically target parts – or zones – of the paddock with seeding rates and fertilisers, rather than whole paddock areas.

“If we have a dry summer, it doesn’t give us much confidence going into a winter cropping program because we don’t typically get much moisture in winter,” he says.

“After checking grain prices before seeding, we might take out 20 percent of the paddock affected by weeds and leave it in a spray fallow for a couple of years.”

Other benefits of summer spraying include the ease of seeding into clean paddocks and in negating potential problems with allelopathy, the biological process where weeds can produce biochemicals that negatively affect crop growth.



Crop yields have improved on the Caughey's property as a result of concentrated summer weed control programs designed to optimise the soil water 'bucket'.  
PHOTO: Cox Inall Communications

The Caugheys have used contract herbicide sprayers since 2002, which Mick says frees them up to get on with harvesting, grain marketing or effective crop monitoring.

"It gives me more time in the paddock to assess things," he says.

"Sometimes I think growers are too quick to take advice without checking the situation themselves and relying on their own experience and knowledge.

"No one knows the farm better than the owner or manager."

The Caughey's 2016 harvest yields were slightly above average, although spring frosts reduced barley and wheat production.

Because it was such a wet season, there was not a significant increase in yields that could be attributed to summer weed spraying and the challenge was more about 'traffic-ability', or getting through stubbles at seeding.

Sourcing a new John Deere 1910 Air Cart will enable further fine tuning of the cropping operation in 2017.

Mick says he expects to face the same fertiliser bill, but crop nutrients will be more efficiently targeted through variable rate applications (VRT) in the coming year.



## MORE INFORMATION

Mick Caughey  
0429 441 067  
micksea22@gmail.com

## USEFUL RESOURCES

- **GRDC Summer Fallow Weed Management Guide**  
[www.grdc.com.au/GRDC-Manual-SummerFallowWeedManagement](http://www.grdc.com.au/GRDC-Manual-SummerFallowWeedManagement)
- **GRDC Hot Topic 'Summer fallow weed management'**  
[www.grdc.com.au/Media-Centre/Hot-Topics/Summer-fallow-weed-management](http://www.grdc.com.au/Media-Centre/Hot-Topics/Summer-fallow-weed-management)
- **WeedSmart**  
[www.weedsmart.org.au](http://www.weedsmart.org.au)
- **WeedSmart App**  
<https://grdc.com.au/apps>
- **DAFWA 'Crop weeds'**  
<https://www.agric.wa.gov.au/pests-weeds-diseases/weeds/crop-weeds>

Case study – soil moisture | Campbell Jones, Wyalkatchem

# Spray fallow key to crop boost

## SNAPSHOT

**OWNERS:** Campbell and Amanda, Brian and Lyn Jones

**LOCATION:** Wyalkatchem, Western Australia

**FARM SIZE:** 3300 hectares (owned), 2000ha (leased), 1500ha (share farmed)

**ENTERPRISES:** 100 percent cropping

**ANNUAL AVERAGE RAINFALL:** 260 millimetres (2010-2015)

**SOIL TYPES:** Red clay, morrel, loam, sand over gravel

**CROP PROGRAM (2017):** 600ha canola, 3000ha wheat, 600ha barley, 300ha spray fallow



Using spray fallows is proving to be profitable at the Wyalkatchem property of Campbell Jones, who has been involved in RCSN Kwinana East research with agronomist Bernie Quade, of Quade AgriServices Landmark.

Two years of trials culminating in an exceptional 2016 canola harvest have convinced Campbell Jones that a spray fallow is vital to maximising soil moisture and boosting cropping returns on his Wyalkatchem property.

Campbell is among a new wave of growers in WA's eastern grainbelt who are using a strategic spray fallow to reduce the risks associated with seasonal variability, herbicide-resistant weeds and growing non-profitable crops in low rainfall years.

He farms with his wife Amanda and parents Brian and Lyn and their farm hosts one of three RCSN Kwinana East and Geraldton group-initiated trial sites investigating ways to improve a spray fallow in WA's eastern and northern cropping areas.

The trials at Wyalkatchem, Mingenew and Mullewa are assessing the use of a range of herbicides – including residual options – and new crop technologies, including two-gene Clearfield® wheat, imidazolinone-tolerant barley and Clearfield® dual-tolerant triazine-tolerant (TT)/Roundup Ready® (RR) canola.

Early in 2016, the Jones' 360 hectares of fallow area was sprayed with a knockdown of 2 litres/ha of glyphosate, 1L/ha of propyzamide and 1.5L/ha of trifluralin and sown to canola straight away after 45 millimetres of rain fell at the end of March.

In what was an exceptional year, Campbell says canola in the fallow yielded an average of 1.8 tonnes/ha, which was double the typical average of 0.9t/ha for the local area. This crop produced 44 percent oil, which was also above average.

Crops sown on non-fallow country also yielded remarkably well in that season, with barley averaging 2.6t/ha and wheat more than 2.2t/ha across the property. The Jones' 10-year average yields are 1.5t/ha for barley and 1.4t/ha for wheat.

But while 2016 was a stand-out season for rainfall and winter growing conditions, Campbell attributes most of the increased crop yields directly to the addition of spray fallows in the rotation.

“My initial thought was that we'd take a cash flow 'hit' by taking paddocks out of wheat production for a season, but that hasn't been the case,” he says.

“Certainly you take that hit from the first fallow year but, if we consider yields for the past two years, we're probably averaging 1.8t/ha for canola and 1.4t/ha for the wheat.

“We're also getting better grain quality from the second year of crops post-fallow and breaking the cycle of cereal root diseases, such as crown rot and nematodes.”

A typical spray fallow involves:

- Strategic knockdown of weeds in fallow paddocks at seeding
- Keeping these clean from weeds until the next sowing
- Conserving vital soil moisture for the subsequent crop
- A subsequent crop that should be healthier, cleaner of weeds and potentially produces a better two-year gross margin compared to two low yielding cereal crops.

Campbell first trialled a spray fallow in 2014 on 15ha situated next to a medic pasture and a paddock sown to wheat-on-wheat crops.

Soil testing in summer 2014-15 showed the fallow area had a full 'bucket' of water down the soil profile and higher mineralised nitrogen (N) levels compared to the medic and consecutively cropped wheat areas.

**“ My initial thought was that we'd take a cash flow hit by taking paddocks out of wheat production for a season, but that hasn't been the case – we've lifted average yields and we're getting better grain quality.**

*Campbell Jones, Wyalkatchem*

These early findings prompted Campbell to add a fallow of 360ha to his cropping program in 2015, which subsequently produced last season's record canola crop and high cereal yields.

The only fertiliser treatment used for these crops was 60 kilograms/ha of CSBP Agstar and 10L/ha of CSBP Flexi-N – with further applications curtailed by rainfall events amounting to 60mm in April and 62mm in May.



The Jones' Wyalkatchem farm is one of three sites being evaluated for more effective spray fallows in lower rainfall areas of WA, including this site at Mingenev. PHOTO: Crop Circle Consulting

Late in May, the Jones family called in contractors to spray their lighter country with a first and only application of glyphosate. The contractors arrived at lunch time, just as it started to rain, but further falls of 37.5mm overnight put a stop to any spraying for the rest of the growing season, due to continuing damp conditions.

Another 400ha was put to fallow at the end of 2015, but Campbell says it wasn't sprayed after summer rain and the subsequent weed burden early in 2016 made it unprofitable to plant this area to crops.

"That's the only downside – because you're storing all that moisture, the summer weeds just come up," he says.

"I think we just need to learn to keep the fallow area clean from weeds and not go over it so many times."

The Jones' ensured the 400ha of fallow area was kept clean from weeds during summer 2016-17 so that it would be ready to be planted to Roundup Ready® canola or a cereal crop in the case of a good early break this year.



Spray fallow is boosting cereal crop productivity in parts of the eastern grainbelt. PHOTO: GRDC

Campbell says he achieved good control of the property's main winter weeds – annual ryegrass (*Lolium rigidum*), wild oats (*Avena fatua*) and wild radish (*Raphanus raphanistrum*) – in the first year of fallow and the key is to not let them get away and grow too big.

During the 2016-17 summer, he closely monitored the residual effectiveness of the winter herbicide system for controlling kerosene grass (*Aristida holathera*), button grass (*Dactyloctenium radulans*), windmill grass (*Chloris truncate*), caltrop (*Tribulus terrestris*) and paddy melon (*Cucumis myriocarpus*).

The family recently invested in a Case IH Patriot boomspray with an AIM Command® system to ensure timely spraying. Campbell says it made economic sense to invest in their own machine as the planned spray fallow area increases in size.

He says another season of fallow trials and experience will provide more accurate and valuable local data about the effectiveness of summer and winter weed control from a range of herbicides, as well as crop tolerances to residual herbicides in the treated soil.

“At this stage, atrazine seems to be working the best for us but you don't get much residual carry-over through to summer, which is the tricky part,” he says.

Campbell applied atrazine and glyphosate at the start of the 2016 season, with a second spray of atrazine and glyphosate in the hope this would carry through and keep the fallow paddocks clean from major weeds. (Note, it is always recommended to read the herbicide label and follow label instructions).

He says the theory is good, but 2016 turned out to be an exceptionally wet year.

“We probably sprayed a bit earlier than we would have anticipated, but the wet meant the weeds used up the atrazine fairly quickly,” he says.

“In future, if we did that final spray in spring a bit later, it may carry through further into summer.”

Campbell conducts soil tests in the spray fallow area during summer and applies lime and gypsum as required. Whole paddocks are treated with gypsum and 'patched' with lime where necessary.

Another benefit has come from the Jones' integrated Harrington Seed Destructor (iHSD), which sits under the back of the header at harvest and takes weed seeds off the sieve, pulverizes them and spreads them finely over the paddock.

It's a marvelous system for harvest weed seed control to lower paddock weed burdens, according to Campbell.

“Everything that comes out the back is smashed up and spread out, so it's going to save us so much time and money in not having to carry out windrow burning,” he says.

“It's also chopping up the straw quite short, so hopefully that will break down and give us a better chance of getting herbicide into the ground and help to store soil moisture by preventing evaporation.”



#### MORE INFORMATION

Campbell Jones  
0428 885 603  
modestyfarm@gmail.com

#### USEFUL RESOURCES

- See Campbell in a GRDC video explaining more about the RCSN spray fallow trials at [www.grdc.com.au/FallowSprayTechniques](http://www.grdc.com.au/FallowSprayTechniques)

Case study – soil moisture | Doug McGinniss, Merredin

# Fast and timely weed control conserves moisture

## SNAPSHOT

**OWNERS:** : Doug and Vanessa, Mick and Christine McGinniss

**LOCATION:** Merredin, Western Australia

**FARM SIZE:** 5500 hectares (cropped)

**ANNUAL AVERAGE RAINFALL:** 300 millimetres (declining in winter, increasing in summer)

**SOIL TYPES:** Mainly sandy duplex, some mallee

**ENTERPRISES:** 100 percent cropping

**TYPICAL ROTATION:** Seasonal – typically 70 percent wheat/20 percent barley/10 percent canola



Doug McGinniss with sons John and Sam during the 2016 season.

Doug McGinniss describes his cropping strategy as ‘pretty straightforward’, but places a high priority on fast and timely summer weed control as a key tactic to maximise available soil moisture for wheat, barley and canola crops.

He crops 5500 hectares north-west of Merredin with his wife Vanessa and parents, Mick and Christine.

“We want to be more tactical in managing our crops and costs and if we can keep our paddocks weed-free, we can manage soil moisture, disease and fertility,” he says.

Doug accesses Yield Prophet® information and data from local soil moisture probes (SMP), set up through a project supported by the Merredin and District Farm Improvement Group (MADFIG), to help predict crop inputs and yields and monitor moisture. But he says he relies first on his ‘gut instinct’ when making farming decisions.

“Timeliness of operation is critical to what we do,” he says.

“We only have a very small window to spray, seed and harvest and, while it can be a logistical nightmare, it’s important to get to these tasks at the right time to do the job well.”

Weeds are sprayed when they are reasonably small, at a size of about 5-10 centimetres, with a tank mix of (label rate) knockdown including glyphosate, 2,4-D and triclopyr.

This mix is followed up with paraquat in a double-knock in paddocks where weed numbers are starting to build-up and glyphosate resistance is a risk. Knockdown is likely to be a mix of glyphosate, pyraflufen-ethyl (Ecopar) and trifluralin prior to seeding wheat.

Cases of herbicide resistance in annual ryegrass (*Lolium rigidum*) are resolved through a chemical rotation, healthy crops, concentrating stubble into header rows at harvest and burning of crop residues. If monitoring indicates resistance is increasing, the paddock is sown to canola or left out of the rotation.

Doug uses his own standard boomspray and says attention to detail and timeliness is critical when spraying.

“We use high water rates – up to 100 litres/ha at times – to get good contact on the leaf of the plant and air-induced nozzles that allow us to operate to ensure we minimise spray drift,” he says.

“In summer, it is more about timing in that window of two to three weeks after germination – where weeds are fresh, actively growing and easy to kill.”

Doug says he is not worried about the cost of spraying caltrop (*Tribulus terrestris*), paddy melon (*Cucumis myriocarpus*) and Afghan melon (*Citrullus lanatus*) in summer and wild radish (*Raphanus raphanistrum*), annual ryegrass, barley grass (*Hordeum leporinum*) and brome grass (*Bromus diandrus*) in winter.

“We get our money back quickly in terms of available moisture in the ground, no allelopathic effect of summer weeds, avoiding the situation of weeds using stored nitrogen (N) and nutrients and the paddock is then easy to traffic through – with no vines,” he says.

In 2016, the family sprayed all cropping country twice on the back of big numbers of weeds germinating from good rain in late summer and early autumn.



Harvesting in 2016 at the McGinniss property, where conserving soil moisture is key to improving grain yields.

Doug says 2016 was a fantastic year in terms of soil moisture, although eight frost events took their toll on the anticipated wheat yield of 2.5t/hectare.

He says crops recovered, though, and yields were above average at 1.8t/ha across the varieties Trojan<sup>®</sup>, Calingiri, Magenta<sup>®</sup>, Mace<sup>®</sup> and Scepter<sup>®</sup>. The Hindmarsh<sup>®</sup> barley grain yield at harvest averaged 1.8t/ha (in part due to the type of country it was on) and ATR Bonito<sup>®</sup> canola yielded 1.5t/ha.

“Every year we try to adapt to what’s in front of us and we keep most paddocks clean (of weeds) and ready to go, so that if one area gets wet, we can change the rotation around,” Doug explains.

“If we have a dry year, we will leave paddocks out where weed numbers are starting to build-up, or where there may be disease concerns.

**“ We want to be more tactical in managing our crops and costs and if we can keep our paddocks weed-free, we can manage soil moisture, disease and fertility.**

*Doug McGinniss, Merredin*

“We will use that year to target these problem paddocks so they’re ready to go in a good year.”

Doug uses all available local information to inform his cropping strategy, including data from Yield Prophet<sup>®</sup> stations which have been established for several on-farm sites through MADFIG and the Department of Agriculture and Food Western Australia’s (DAFWA) Merredin Research Station.



Coming to the end of the summer weed spraying program

“The data from a number of local sites gives a good indication about how the crop is travelling in a poor year or in a good year, so we can make better tactical decisions to manage production and costs,” he says.

“A lot of things contribute to the season and Yield Prophet® is just one tool.

“But it has improved now that we have calibrated responses to the different soil types in the eastern grainbelt.

“If not for the frost last season, it would have been fairly spot-on because it was 80 percent accurate in terms of when to best apply N and actual resulting yields.”

In the past two years, through the RCSN, DAFWA’s e-Connect project and MADFIG members, there were six SMPs set up within a 100km radius of Merredin. This probe information is more technical, Doug says, and requires more interpretation than computer models, such as Yield Prophet®.

“Learning how to operate a Yield Prophet® site and SMP together is a work in progress – you can get lost in the data and struggle to get a message from it,” he says.

“I receive data through our local group once a month or I can pick up the phone and ask for it, but I probably don’t look directly at the SMP information as much yet.”

In terms of fertiliser needs, Yield Prophet® has proven to be a good guide, although the reasonably fertile soil on the family’s property means there is not much requirement for adding micronutrients/trace elements, Doug says.

“Last year was a pretty good year, with plenty of plant available moisture at the start of the season, and we probably put on enough N to achieve a 2t/ha yield,” he says.



“But each season we stay flexible and use soil tests and Yield Prophet® information to make our decisions.”

Doug uses a DBS bar at seeding to place N under the seed and a presswheel system to place the seed and compound fertiliser close together and establish the crop.

This year Doug will be looking closely at the family’s canola program, as the crop seemed to weather the 2016 frosts better than the cereals.

“Canola was a winner for us, as the cool spring conditions seemed to help its recovery from the frost and it kept flowering and made grain on the later plants,” he says.

After three or four good years with cereals, he says he will be carefully considering paddock selection for field peas, lupins and canola in 2017. Rotation, sequence and variety decisions will be based on available moisture at seeding.



## MORE INFORMATION

Doug McGinniss  
0428 441 024  
dougness3@bigpond.com

## Case study – soil moisture | Kim Creagh, Nungarin

# Grower balances grazing and cropping to conserve moisture

### SNAPSHOT

**OWNERS:** Kim and Shay Creagh

**LOCATION:** Nungarin, Western Australia

**FARM SIZE:** 12,500 hectares

**ENTERPRISES:** Cropping, Merino sheep

**ANNUAL AVERAGE RAINFALL:** 325 millimetres (declining in winter)

**SOIL TYPES:** Loamy sand, sandy loam to clay loam

**CROP PROGRAM (2017):** 8000ha wheat, 1000ha barley, 250ha canola, 250ha lupins

**TYPICAL ROTATION:** Wheat-wheat-wheat, followed by either barley-canola-lupins or sheep pasture



Kim Creagh runs a mixed sheep and cropping system at Nungarin, where soil moisture conservation is a high priority each year.  
PHOTO: Creagh family

Balancing the mix of a large Merino flock with 9500 hectares of cropping has enabled Kim and Shay Creagh to maximise returns and adjust to diminishing winter rainfall on their family property at Nungarin.

At the start of 2016, Kim took over the management of the 12,500ha property that was settled by his great grandparents in 1909. It was challenging, with unprecedented rainfall early in the year, followed by crippling frosts through August and no spring rain to finish the crop.

But the 80:20 ratio between cropping and livestock enterprises enabled him to weather the season, keep lambing percentages high and achieve average long-term harvest yields of 1.5 tonnes per hectare for Mace<sup>®</sup> and Calingiri wheat and 1.7t/ha for Scope<sup>®</sup> barley.

Kim estimates the family lost about a third of its crop production as a result of 15 frost events that struck in August and September, when temperatures in undulating country dropped as low as -3°C.

“The biggest challenges in 2016 were the frosts and high weed burdens – but we also had a wet start to the season with two falls of 30-odd millimetres each,” Kim says.

“We probably had more than 200mm of rain in total for the season, but at seeding time it was so wet and the wheat was so waterlogged that the weeds got away before the crop and reduced its competitiveness.

“Later in the growing period, we tried to spray in-crop to control annual ryegrass (*Lolium rigidum*) but it didn’t work, as the crop was already frosted and couldn’t compete with the grass weeds.”

Kim says he was unfazed by the weather, though, using the experiences of the year to underpin strategies for the 2017 growing season.

If it is another wet summer, he plans to graze sheep on crop stubbles directly after harvest and spray early – if necessary – to control summer weeds and keep the soil moisture profile high.

He has found one pass with a Miller NITRO boomspray, delivering glyphosate, 2-4-D ester 800 and metsulfuron (at a cost of about \$7/ha), will provide enough weed control when combined with high-pressure grazing at about two-to-three dry sheep equivalent (DSE) across the bulk of cropping paddocks.

Kim is targeting paddy melon (*Cucumis myriocarpus*), Afghan melon (*Citrullus lanatus*), caltrop (*Tribulus terrestris*) and small-burr grass (*Tragus australianus*) in summer and annual ryegrass, brome grass (*Bromus diandrus*), barley grass (*Hordeum leporinum*), wild radish (*Raphanus raphanistrum*) and capeweed (*Arctotheca calendula*) in winter.

He says he is confident in his ability to manage weed pressures and maximise soil moisture retention for winter crops without implementing technology such as soil moisture probes (SMP) and weather stations or using complicated forecasting programs.

“I do make use of at least five online weather sites – or apps – to monitor local and global conditions,” he says.

“I also use precision seeding technology that places the seed deep enough in the subsurface to access the available soil moisture and enable the crop to emerge as quickly as possible.

“Basically, without high-tech soil moisture monitoring equipment, I have an idea of how much moisture is down the soil profile because if we have summer rain it’s there and if there’s no rain, it’s not.”

During 2016, Kim’s fertiliser program included 50 kilograms per hectare of CSBP Agras and 30kg/ha of urea, followed by 30-50L/ha of Flexi-N. But he says leaching from the high amount of annual rainfall meant there was little effect on grain protein or yields.

Kim has had to constantly tweak his crop management program to adapt to seasonal changes and fluctuations in rainfall during the past decade, particularly the shorter winter.

“The long-term typical start of the sowing window on ANZAC day has now shifted and planting tends to get underway about 25 days earlier, right at the start of April,” he says.

**“It makes economic sense to me to have sheep because, in any given year, we don’t have to treat the whole farm with herbicides for weed control to conserve valuable moisture that is crucial for cropping success in this district.”**

*Kim Creagh, Nungarin*

“If April is ‘the new May’, the tactic will be to sow crops earlier and graze crops off early in the growing season.

“This will let pastures get away and growing well for sheep feed and conserve as much soil moisture as possible for crops, through heavy grazing or spraying for weed control.”

Kim says he would not have done anything differently in season 2016 to deal with the frosts that hit in spring, which were a one-in-10-year event, but he was glad of the above average annual rainfall.

“Our frost management system is to basically start sowing at one end of the farm and alternate short and long season cereal varieties, from one end to another, to create variability in the flowering windows,” he says.

“Then, if one part gets frosted, hopefully it won’t affect the whole cereal cropping area.”

Last year Kim says he was glad he had the back-up of running a self-replacing Merino flock of 9500 head, which has some Dohne bloodlines to ensure good quality wool and plain bodies to reduce incidence of flystrike.

He planned to shear in February and join 4000 ewes off the board. These will have access to April-planted barley and canola crops, which will be grazed at the three-leaf stage for a period of three to four weeks. This will give pastures a chance to regenerate.



A mixed enterprise with crops and sheep is helping to conserve moisture and boost soil health at the Creagh family farm. PHOTO: GRDC

Kim's aim is to ensure the ewes are on a rising plane of nutrition and the first lambs are dropped when there is green feed in mid-July.

The strategy of early joining in mid to late summer has increased lambing percentages from 85 to between 90 and 92 percent in the past few years. Wool is sold in Perth and prime wether lambs are sold into the export trade.

"Livestock is becoming a major part of our system now, whereas many growers in this district went out of sheep years ago," Kim says

"Much of the sheep infrastructure isn't around here anymore.

"Yet, it makes economic sense to me to have sheep because, in any given year, we don't have to treat the whole farm with herbicides for weed control to conserve valuable moisture that is crucial for cropping success in this district.

"Typically we are just spraying half to two thirds of the cropped area, which we calculate saves around \$50,000 a year."



#### MORE INFORMATION

Kim Creagh  
0428 465 086  
kscreagh@bigpond.com

Case study – soil moisture | Andrew Crook, Merredin

## Early sowing success at Merredin

### SNAPSHOT

**OWNERS:** Andrew, Stephen, Jayden and Callan Crook

**LOCATION:** Merredin, Western Australia

**FARM SIZE:** 6200 hectares

**ENTERPRISES:** 75-80 percent cropping, 1500-1600 Merinos

**ANNUAL AVERAGE RAINFALL:** 300-325 millimetres

**PREDOMINANT SOIL TYPES:** Light-medium mallee

**CROPPING PROGRAM (2016):** 2800ha wheat, 1400ha canola, 100ha lupins, 100ha oats, 350-400ha barley

**TYPICAL ROTATION:** Fallow-canola-cereal-cereal-fallow/canola or lupins



Merredin farmer Andrew Crook, left, with sons Callan and Jayden and brother Stephen, are focused on soil moisture conservation to boost crop productivity. PHOTO: Crook family

The eastern grainbelt's 'May drought' trend in recent years has allowed Merredin growers Andrew and Stephen Crook to bring their seeding program forward to capitalise on subsoil moisture left over from summer.

If conditions are right, sowing canola as early as March in some years has enabled the Crook family to lift crop yields and spread production risks over a longer seeding period.

"The seasons have changed quite dramatically," Andrew says.

"We are getting more summer rain and less traditional cropping season rainfall.

"The moisture from these earlier rainfall events can be lost rapidly, so it is important to be able to act swiftly and make the most of any opportunities to sow early.

"In farming, timing is for free. While we don't always get it right, dry years can make you farm smarter and grow grain on less rain."

The Crooks first experimented with early sowing in 2012 when oats were dry sown in early April following good summer rain.

"We got those oats out of the ground in early April and it was the only green to be seen in the district," Andrew says.

"The oats survived on subsoil moisture and that really opened our eyes to the potential of early sowing other crops, such as canola."

For the Crook family, early sowing is only an option when the opportunity arises in the low rainfall zone.

The season has to be right and the earliest they have sown canola was in 2016, when seeding started on March 26.

This occurred on the back of excellent summer rainfall of 150 millimetres between December and March and led to Yield Prophet® site indications that there was 70-80mm of stored soil moisture at the time of sowing. This meant only a very small risk of the crop dying before there was additional rainfall.

**“While we don’t always get it right, dry years can make you farm smarter and grow grain on less rain.”**

*Andrew Crook, Merredin*

The Crook family use the mid to long season variety ATR Bonito<sup>®</sup> and mid to short season variety ATR-Stingray<sup>®</sup>, which are both triazine tolerant (TT), and provide flexibility for their cropping system.

“These varieties flower in winter, which can heighten the risk of frost damage in susceptible areas, but will avoid a lot of the risk of late season heat stress,” Andrew says.

“By sowing these varieties early in 2016, our yields were 0.7 tonnes per hectare above our long-term average and we attribute this to the season and early sowing.

“It was an exceptional year for canola in WA last year, with the crop handling the frost conditions better than most other crops.

“While early sowing can increase the frost risk, this is outweighed by the benefits of crop establishment and a longer growing season for canola.”

Paddock preparation is key to the success of early sowing. Summer weed control is vital to conserve moisture and it is important to be prepared for pest and disease management issues that arise from early plantings.

Part of the Crook family’s strategy is sowing canola into a stand of oats that has served as a forage crop in the previous year.

“The oats double as a forage crop and a cover crop, so we don’t let the paddocks get too bare if we’re going to be sowing canola the following year,” Andrew says.

“We find that once the sheep have grazed the oats over summer, we are left with woody stems that stand about nine inches (23cm) high and the amount of plant cover helps to conserve soil moisture. They are also easy to sow into.”

These paddocks have also been treated with a double-knock herbicide application for weed control in the pasture phase.

“So the cleanliness of the paddock, coupled with applying pre-emergent herbicides as the canola goes in, gives us a bit of confidence that we’re going to get a reasonably clean crop of canola out of the ground with a low weed burden,” Andrew says.

The Crook family hosted trials run by WA consultancy group ConsultAg in 2015 on early sown and grazed canola in the low rainfall zone. It was the first time the Crooks had dabbled in grazing canola.

The trials found that early sowing canola proved to be most beneficial if planted in paddocks subjected to a 10-month fallow.

This reduces production risks, as the stored soil moisture after a fallow allows the crop to survive a dry spell – typically experienced in April and May in these areas.

The research showed there was also a significant benefit associated with achieving two years of weed control that allows wheat or barley to be grown with confidence in the subsequent years.

For the Crook family, the benefits of early sowing outweigh any downsides – if the conditions are right.

“The early sown canola flowers and produces oil in the cooler months of the year,” Andrew says.

“Canola is quite heat sensitive when it’s flowering, so if you plant it in early April, it’s flowering in July/August.

“That’s a huge advantage because the higher the oil content, the more valuable the canola.”

Andrew says the canola maturing early allows for timely crop-topping, which helps mature the crop and provide harvest efficiency.

Other benefits include time management efficiencies, particularly with intensive cropping programs, and being able to make the most of valuable moisture and warm sowing conditions.

Andrew says tools such as having a Yield Prophet® site can help growers make better informed decisions and reduce the risks associated with big production decisions.

“We have several Yield Prophet® sites on our farm and in the next couple of years we hope to progress to soil moisture probes (SMPs), which will give us even greater insights into and better accuracy of measuring stored soil moisture,” he says.

Since moving the cropping program forward to earlier in the year, Andrew says there have been very few disadvantages, apart from the more lengthy sowing season – which can be a drain on resources.

“Last year, to spread our frost and heat stress risks, we started sowing on March 26 and didn’t finish until May 18,” he says.

“While it drives you nuts at the time, it is a risk management tool when you’re spreading it out over that length of time.

“Other downsides to sowing so early include the risks of a false break; that the crop bolts; more disease potential; and frost worries during the season.”



Canola planting has started as early as March 26 at the Crook family property. PHOTO: GRDC

Depending on the rainfall zone, canola growers also need to factor in the likelihood of crop pests such as Diamondback moth (*Plutella xylostella*) and diseases such as Sclerotinia (*Sclerotinia sclerotiorum*).

Andrew says, in his experience, there can also be more reliance on pre-emergent herbicides, hence the need for sowing canola into an oat fallow.

He says the upside is there is more confidence in getting a competitive, low weed burden crop out of the ground.

One of the major advantages of early sown canola is its high levels of biomass early in the season – which allows an opportunity for livestock grazing. This can reduce the sheep feed gap in early winter

Geoff Fosbury, of ConsultAg, has previously conducted crop grazing trials instigated by WA's RCSN groups.

He says grazing crops allows growers to give pastures a spell and enables them to control grass and broadleaf weeds, without compromising sheep feed.

"It will also delay crop flowering and reduces frost risks associated with early sowing," he says.

"WA trials in recent years have shown that if crop grazing is carried out within recommended guidelines, the maximum yield penalty incurred is about 8 percent, although any yield loss is usually negligible."

Geoff's main message to growers is not to put sheep on to crops too late, not to leave them there too long and to only graze long-season varieties.

"Graze canola crops at the three to five-leaf stage to allow the maximum amount of time for the crop to recover," he says.

While this research is good news for mixed farming operations, Andrew and Stephen prefer to keep the cropping and sheep enterprises very separate on their farm.

"As a business, we have made a decision to do everything we can to ensure sheep don't interfere with our cropping strategy," Andrew says.

"Sheep have a valuable place in the system, particularly in the paddocks we want to spell and that are not suitable for cropping.

"But, in our experience, when sheep compromise our cropping strategy, our overall profitability is reduced."

To keep the two enterprises separate, lambing takes place in July and shearing starts prior to Christmas.

The sheep are allocated to paddocks and up to two years of fodder is retained for any hand-feeding.

The Crooks have a couple of very basic feedlots on the farm, enabling them to lock-up mobs of sheep and allow pastures to get away.

Early sown forage oats also play a huge part in keeping sheep off the other crops.

"Timing has become so critical for the success of our cropping strategy, particularly with the limited rainfall we get, that we can't afford to let sheep interfere with that process," Andrew says.

"We have developed flexible systems to take advantage of opportunities like summer rain and this strategy is working for us."



#### MORE INFORMATION

Andrew Crook  
0429 412 141  
[scaj@westnet.com.au](mailto:scaj@westnet.com.au)

Case study – soil moisture | Darren Kilminster, Bruce Rock

## Probe plus Prophet proving a handy tool

### SNAPSHOT

**OWNERS:** Darren and Tracy Kilminster

**LOCATION:** Bruce Rock, Western Australia

**FARM SIZE:** 3500 hectares (cropped)

**ENTERPRISES:** Cropping, Merino sheep

**ANNUAL AVERAGE RAINFALL:** 350 millimetres

**SOIL TYPES:** Light to red loams

**TYPICAL ROTATION:** Crop pasture-wheat-barley-canola, or wheat-barley-pasture, or pasture-canola-wheat-wheat-canola-wheat-pasture.



Bruce Rock grain grower Darren Kilminster is using new technologies to monitor and measure soil water. PHOTO: GRDC

Two years after installing a continuously-logging soil moisture (or capacitance) probe (SMP) and weather station on his Bruce Rock property, Darren Kilminster says these are proving to be ‘very handy tools’ for fine-tuning cropping decisions when used in conjunction with the Yield Prophet® model.

Darren and his wife Tracy crop 3500 hectares with wheat, barley, canola and lupins and run Merino sheep in an area where the annual average rainfall is 350 millimetres – but this is declining in winter and sometimes increasing during summer.

Darren says he put his hand up for a SMP, along with a weather station and Yield Prophet® site, in 2015 to trial this soil moisture measuring technology in his district.

Yield Prophet® simulates the effects of environmental variables and management decisions on crop yields, using local information provided by the grower about soil types and crop sowing dates, types and varieties – combined with data about growing season rainfall-to-date from the on-farm weather station.

By modelling the crop’s growth from sowing date until harvest, it predicts the most likely yield range and maturity dates.

Prior to installation of the SMP, the Kilminsters used an electromagnetic induction (EMI) – known as dual-EM or EM38 – mapping machine to get an indication of subsurface salt and moisture content. EM38 measures bulk electrical conductivity in the plant root zone and can provide valuable data about soil variation.

An 80 centimetre Enviropro capacitance probe was then buried to a depth of about 25cm in a low-lying area of the landscape and its sensors were spaced at 10cm intervals. This system is designed to provide estimates of soil water content to 95cm, indicating how much moisture – or plant available water (PAW) – is left in the soil water profile ‘bucket’.

This information, combined with real-time weather data and periodic Yield Prophet® reports, using paddock-specific soil, crop and climate data, generates information about the likely outcomes of Darren’s farming decisions.

Darren says he considers the system a helpful decision-making ‘tool’, not an ‘answer’ and uses all available information to underpin his planning and development of strategies for nitrogen (N) applications, grain marketing and risk management.

“It took us until 2016 to get accurate information from the SMP because a slurry is used when it is installed (to ensure correct contact between the soil and the probe sensors) and it takes 12 months to set,” he explains.

**“The probe is a handy tool, not an answer...together with Yield Prophet®, it predicted we would harvest 1 tonne per hectare of canola in 2016 and we achieved 1.2t/ha – so it was close.**

*Darren Kilminster, Bruce Rock*

“Usually there is an initial 20 to 30 percent discrepancy in predicted yields from this system and actual yield results at harvest.

“But, along with the probe information, Yield Prophet® wasn’t far off predicting canola yields that year.

“The program indicated we would harvest one tonne per hectare of canola and our actual average result was 1.2t/ha.”

To boost the accuracy of Yield Prophet®, Darren emails his cropping information – such as seeding dates, rates, fertiliser application and yields – to Caroline Peek from the Department of Agriculture and Food Western Australia (DAFWA) at Merredin. She correlates their local information by remotely accessing the Kilminsters’ site.

In 2016, monitoring showed the farm’s soil moisture bucket was full all year.

Despite the wet season, the harvest was on track to yield more than 2.8t/ha for wheat. But unfortunately frost hit and potential wheat yield was halved, barley yields were down by 30 percent from long-term averages and canola yielded an average 1.4t/ha.

The weather station at the Kilminsters’ property showed a record 25 frost events in 2016, during which temperatures dropped as low as -2°C in August.

In September, temperatures fell to -1.8°C for six hours during one frost event and the following night were down at -1.9°C for five hours.

Darren says the information being provided from his SMP and Yield Prophet® site could be useful to local growers as far as 20 kilometres away who may be in the same rain strip and who are farming similar soil types.

To further conserve moisture for his cropping system, he has been experimenting with spraying summer weeds and grazing these areas with livestock.

“We’ve been finding in recent years that we have been going too early with our summer spraying and I don’t think we get the full benefit from spraying before Christmas as it’s more of a cost,” he says.

“If you get a big rain event, of course you have to spray.

“But if it’s only 20-30mm, we can hold off and run a few livestock over the weeds when they’re small and it is easier to knock them down.

“Then if there’s rain in February and they freshen up, we can spray them then.”

The main summer weeds on the Kilminster property are caltrop (*Tribulis terrestris*), paddy melon (*Cucumis myriocarpus*) and Afghan melon (*Citrullus lanatus*), which can be up to 0.75m in diameter by the time they are sprayed.

With rainfall increasing in summer, Darren says kerosene grass (*Aristida holathera*) is also becoming more of a problem and annual ryegrass (*Lolium rigidum*) on the property is showing signs of increasing herbicide resistance.

“We only seem to get two years of pretty clean country before it gets dirty with weeds and we put it out to pasture,” he says.

“But that is paddock-specific and we mainly follow an opportunity cropping program.

“We’ve used triazine tolerant (TT) and Roundup Ready® canola that we can crop-top to take out as much weed underneath the canopy as we can before the annual ryegrass sets seed.”

Darren has a range of strategies to reduce weeds and keep his below ground soil moisture bucket full as well as his ‘feed bucket’ for livestock topped-up.

In the past, he has used herbicides costing about \$3/ha to control barley grass (*Hordeum leporinum*) and brome grass (*Bromus diandrus*) early in the pasture phase, as these weeds are not palatable to sheep.

He can also plant oats in a weedy paddock and hay freeze it with 1.5 litres/ha of Roundup® (at a cost of about \$7/ha) as a ‘cheap fix’. This maintains the sugars in the dead oats, but kills weeds before they seed.

“You are still conserving the moisture because when you spray the oats, it is still in the ground but it’s not using moisture, so you effectively have a feed bucket on top and a moisture bucket below the ground,” Darren says.

“It doesn’t work 100 percent of the time, but it means the bucket is still full going into spring when we crop-top.

“And the oaten hay provides a good amount of feed for the sheep that will see them through harvest and bridge the gap until we have stubble.”

Darren says in the future he would like to try other soil moisture conservation strategies, including deep ripping of patches of lighter soils, and yield mapping technology that would enable variable rate fertiliser treatments.



Cereal yields are optimised with moisture conservation at the Kilminster property. PHOTO: GRDC

## USEFUL RESOURCES

- **Yield Prophet®**  
[www.yieldprophet.com.au](http://www.yieldprophet.com.au)
- **DAFWA Soil water maps and graphs, forecasting service at**  
[www.agric.wa.gov.au](http://www.agric.wa.gov.au)  
(click on the weather station points on the base map)
- **GRDC Ground Cover TV ‘Managing summer fallow’**  
<http://www.grdc.com.au/GCTV5-SummerFallow>



## MORE INFORMATION

Darren Kilminster  
 0429 611 778  
[dttkilminster@bigpond.com](mailto:dttkilminster@bigpond.com)

Case study – soil moisture | Deane Aynsley, East Beverley

## Quest to fix WUE on questionable soils

### SNAPSHOT

**OWNERS:** Deane and Sarah Aynsley

**LOCATION:** Beverley, Western Australia

**FARM SIZE:** 2500 hectares (cropped)

**ANNUAL AVERAGE RAINFALL:** 350 millimetres (variable)

**SOIL TYPES:** Highly variable, sandy loam, gravels, deep sands

**CROP PROGRAM (2017):** 1250ha wheat, 450ha canola, 400ha lupins, 400ha barley

**TYPICAL ROTATION:** Two cereals-break crop (canola or lupins)



Beverley grain grower Deane Aynsley is focused on soil improvements to lift crop yields. PHOTO: GRDC

Unlocking the key reasons why crops sown on some soil types under-perform in some years compared to those planted on others is the Holy Grail for many eastern and central grainbelt growers striving to optimise water use efficiency (WUE).

Beverley grain producer Deane Aynsley says less than optimal production from crops sown on deep sands and heavy gravels can be relatively straightforward to diagnose, compared to those on other soil types. This can be due to a range of factors that include:

- Acidity/low pH
- Low water holding capacity
- Low organic matter
- Water repellency/non-wetting factors.

But more puzzling is why some crops planted on sandy duplex and loams can yield up to one tonne per hectare less than those grown on similar soil types in different parts of the farm (when obvious agronomic factors are removed).

Deane and his wife Sarah crop 2500 hectares in the medium rainfall zone east of Beverley and grapple with highly variable soil types across the property, but have predominantly sandy loams.

“In the past few years we have noticed, even in seasons with good growing season rainfall, our crops don’t seem to be taking full advantage of the moisture in the soil,” Deane says.

“This is also being reflected in our harvest yield mapping, which is showing areas of under-performance that we can’t really attribute to weed burdens, disease or pests.

“We are thinking it is more about the soil properties, including water holding capacity and plant WUE, and this is now a big focus for us.”

To address this issue, the Aynsleys employed a dedicated soils adviser in 2016 to complement the services of their agronomist.

“Instead of looking at whole paddocks, we are now taking more of a ‘zone’ approach across the farm when investigating our soils,” Deane says.

“Similar soil types in different areas of the farm appear to be producing consistent yield results in many instances, which is enabling us to target equivalent soil types with inputs and treatments – rather than taking a blanket paddock-by-paddock approach.

**“ (Soil moisture probes) might make it easier to track the water use of plants during the season and I think there is significant potential to do this in those areas where the reasons behind crop yield responses are not certain or obvious.**

*Deane Aynsley, East Beverley*

“The plan is to hone-in on weaknesses in these specific soil types and then develop tactics to address the issues and improve our crop production.”

To help identify these potential soil weaknesses, the couple is comparing yield mapping results with results from extensive soil testing – targeting areas where low yields are identified but the underlying reasons are baffling.

Deane says soil testing helps to highlight any nutrient or micronutrient deficiencies and acidity issues.

He says paying attention to crops while harvesting can help to identify if there were factors such as high weed burdens, missed herbicide applications or other management decisions that affected crop production.

“Where we have gone through this process and pinpointed some of the areas we want to improve, we have then dug down deep into the soil to see what’s happening underground,” he says.

“In some cases, we noticed the crop roots had not penetrated below a depth of about 20 centimetres – which might indicate a hard pan or acid layer.

“This may mean we need to apply lime or undertake lime incorporation, or it could be something different affecting soil water holding capacity.”

Deane says in future it may be practical and advantageous to use technologies such as soil moisture (or capacitance) probes (SMP) to indicate how far into the soil profile crops are ‘pulling-up’ moisture.



Identification of soil properties and issues are a focus for Deane and Sarah Aynsley. PHOTO: GRDC



Soil moisture probe systems, similar to these, are set up on the Aynsley's property to help characterise soil types. PHOTO: GRDC

“It might make it easier to track the water use of plants during the season and I think there is significant potential to do this in those areas where the reasons behind yield responses are not certain or obvious,” he says.

The Aynsleys have three SMPs set up on their property through a private adviser – two on soils that tend to consistently produce good crop yields and a third on a sandy soil type that tends to be under-performing.

Deane says the probes are helping to characterise these soil types to improve the accuracy of crop yield prediction models, such as Yield Prophet®.

He says the first year after the SMP installation on the farm was wetter than average and data was not highly useful to him to underpin crop input and grain marketing decisions.

In 2014 and 2015 he used Yield Prophet® with his agronomist and, while it was accurate in predicting final yields for most crops in 2014, the results were skewed in 2015 due to the effects of frost and a big heat shock late in that season.

“The SMPs and Yield Prophet® are producing interesting data, but at this stage it is an inexact science and our soils are so variable that it is hard to use it in practice for making major agronomy decisions,” he says.

“Mostly we base our crop program and input planning on how the season is unfolding, our budget for fertiliser and our experience.

“I am still cautious, but certainly watching with interest.”

Precision Agronomics Australia (PAA) technology development manager Frank D’Emden says while many growers share Deane’s apprehension, technologies such as SMPs and yield prediction models are getting more advanced and useful for agriculture in WA.

He says new tools are likely to come on-stream in soil moisture mapping and SMPs across the grainbelt could have a vital role in ‘ground-truthing’ the data stemming from these.

PAA and the Department of Agriculture and Food Western Australia (DAFWA) have been involved in SMP research supported by GRDC and its RCSN groups across WA for several years and actively monitor many of the 33 probes that are now publicly accessible to the State’s growers and advisers.

Frank says the wet season in 2016 had provided good opportunities for researchers to ‘recalibrate’ some ideas and theories about soil water ‘bucket size’ and upper drained limits at many of these SMP sites.

“This is valuable information that can be used to help underpin in-crop decisions, especially about whether or not to apply top-up nitrogen (N),” he says.

Frank says across the SMP sites that were incorporated with Yield Prophet® modelling in 2016, 70 percent produced predicted final yields at wheat Zadoks Growth Scale 30 – which was in June-July – that were within 0.3t/ha of actual yield results at harvest.

And, at harvest time, half of the SMP sites produced yield predictions that were within 0.35t/ha of actual yield results.

Frank says in 2017, the SMP network will continue to operate across the grainbelt to improve understanding about: how data from SMPs and Yield Prophet® complement each other; the range of soil type selections in Yield Prophet®; and cross-validation of SMP data with Yield Prophet® soil moisture modelling.

“The end-goal is to better understand what is happening in our soils and give growers access to real-time soil moisture and weather data – and periodic Yield Prophet® reports – to help with their key decision-making for boosting cropping profitability,” he says.

Growers can access data from the bulk of the 33 public SMP sites set up by GRDC/DAFWA at: [http://tiny.cc/WA\\_SMP\\_Network](http://tiny.cc/WA_SMP_Network) and: <http://precisionag.com.au/services/moisture-probes-project/>

## MORE INFORMATION



Deane Aynsley  
0428 466 246  
[deaneaynsley@bigpond.com](mailto:deaneaynsley@bigpond.com)

Frank D’Emden  
0488 917 871  
[frank.demden@precisionag.com.au](mailto:frank.demden@precisionag.com.au)

## USEFUL RESOURCES

- **GRDC / DAFWA Soil Moisture Probes sites in WA**  
[http://tiny.cc/WA\\_SMP\\_Network](http://tiny.cc/WA_SMP_Network) and:  
<http://precisionag.com.au/services/moisture-probes-project/>

Case study – soil moisture | David Stead, Brookton

# Soil moisture probes unlock on-farm potential

Growers in the Kwinana East port zone looking for farm-specific data to help make strategic decisions throughout the growing season are starting to turn to continuously-logging soil moisture (or capacitance) probes (SMPs) as awareness of the potential of this technology slowly grows.

Typically, SMPs are permanently located in the soil over a long time period to provide ongoing and real-time data about:

- Subsoil moisture volume
- Subsoil moisture depth
- Where plant roots are active
- Water uptake by crops during the growing season.

Software is then used to analyse and graph the data, which can provide extra confidence for croppers when making agronomic and grain marketing decisions before and during the growing season.

There are about 33 publicly available SMP sites set up across the WA grainbelt in projects supported by GRDC, RCSN groups, the Department of Agriculture and Food Western Australia (DAFWA), grower groups and advisers.

Data from many of these probes are being incorporated with the Yield Prophet® model to improve soil type characterisations and the accuracy of crop yield predictions for the sites – and surrounding local areas/soil types.

Independent farm adviser David Stead, of Anasazi Agronomy based at Brookton, has been using SMPs in his business for more than five years to help growers make better informed agronomy decisions in both dry and wetter years.

He says his work with a grower north of Dowerin, who was one of the first in that region to start using SMPs, was highlighting the benefits of having probe data for strategic weed control decisions.



WA farm adviser David Stead has been working with growers across the grainbelt to get the most out of data stemming from soil moisture probes. PHOTO: Anastazi Agronomy

He says this was especially apparent in 2014, when he and the grower noted an increase in moisture level on the probe in the 24-48 hours after a major rainfall event in early September.

“But from the 20 centimetres level and below, the level wasn’t reducing,” he says.

“The canola looked like it was alive – and it had been the salvaging rain for the crop – but the plants were not drawing down any more moisture from deeper in the soil.

“The season had started off indifferently and then there was a very wet patch in the middle, so paddock accessibility wasn’t great.

“It also got very cold very quickly, so the post-emergent annual ryegrass (*Lolium rigidum*) herbicide didn’t work well.

“There was annual ryegrass coming up through the canopy and we had to make a decision about when to crop-top it, knowing full well we could impact crop yield if we got the timing wrong.

“Data from the SMP helped us decide when to apply herbicide.

“You wouldn’t inherently think, OK, I’ll put a moisture probe in the soil and it’s going to tell me when to crop-top, so this just highlights the opportunity that presented itself that year.

“It didn’t cost us anything in yield and it did a magnificent job in controlling the annual ryegrass.”

That same year, further north in Mingenew, David says another client used data from a SMP to make a key decision about whether to apply more fertiliser to his crops.

“It was a terrible start to the growing season that year – and dry all the way through to the end of July – after which, there was really good rainfall and the crops literally spun on their heels,” he says.

“Overlaying where the soil moisture was in the profile and the physiological stage of the crop enabled the grower to see from his SMP data that there was no real benefit in him putting on his post-emergent nitrogen (N) fertiliser.

“At the same time, his neighbours were out applying N.

“He made that choice based on where the crop was at, what the moisture was telling him and other intuitive data – he wasn’t just being conservative.”

David says this grower was able to leave his 150 tonnes of urea in the shed, whereas many others who had done their N top-ups told him it had made no significant yield difference between paddocks where they had applied it, and where they hadn’t.

“This is a good example of where tools like SMPs can be used to protect what is in the ground and use these resources to be prosperous and profitable as well,” he says.

David says because the application of the SMP technology is still relatively new in WA agriculture, there is a lot of misunderstanding about how it works and what it is best used for.

He says the key to getting the most out of SMPs is generating enough historical data to compare with new data.

“I’ve got growers who have had moisture probes in the soil for four seasons and are now seeing tangible benefits from using that data,” he says.

“The first 12 months of a moisture probe being in the soil are really a data-gathering scenario.

“In terms of the interpretive analysis, there’s a little bit more brainpower that’s got to go behind it.

“You’re not going to instantly get data that will help make decisions.”



CSIRO researcher Yvette Oliver shows the types of soil moisture probes being used to help characterise WA grainbelt soil types and improve crop yield predictions. PHOTO: GRDC

**“You wouldn’t inherently think, OK, I’ll put a moisture probe in the soil and it’s going to tell me when to crop-top, so this just highlights the opportunity that presented itself that year.”**

*David Stead, Brookton*

David says it is only after the second or third year, when there is a reasonable amount of data collated from the SMPs, that tangible and clever decisions can start to be made about a range of issues. These include the impact of soil moisture on crop rotational capacity, all the way through to fine-tuning fertiliser and herbicide applications.

He says entry level costs for probes are falling, which makes them more accessible for growers, who could now expect to get a SMP set-up for about \$2000.

In broadacre dryland farming, there are four or five key ‘big ticket’ decision points in the season, according to David.

He says SMPs add another intrinsic data layer that can underpin objective decision-making at these – and other – times and help to manage risks.

“Other than actually physically knowing how full the soil water ‘bucket’ is, the probes can help to determine the potential water holding capacity of a particular soil type or area of a paddock in a dry or wet year,” he says.

“They can indicate the physical amount of water that’s in the soil at seeding time and midway through the growing season when fertiliser and chemical decisions start being made.

“The probes give a grower the ability to know what their subsoil moisture levels are and then analyse that in comparison to previous cropping data.

“For example, when we’ve had a certain amount of moisture on March 20, we’ve been able to grow canola beyond a ‘break even’ scenario.

“So a SMP can lend itself to rotational changes – as opposed to saying I’m just going with my profit driver and my least-risk option which is wheat – when there could be very good areas to grow break crops, or perhaps barley or niche grains.

“There are a whole host of different things we could look at if we know what it is we’re dealing with, other than just getting the wheels turning on the seeder on April 10.

“I think those days are limited and we are going to get to a point where growers have to recognise the value in not just sticking to the one rate of fertiliser, one rate of seed and the same speed across all different soil types.”

Determining where to locate a SMP is crucial to optimising its potential, with some growers choosing to install at least two on-farm.

When setting up a SMP, David says it is best to take soil cores for analysis and set up self-tipping rain gauges next to the probes.

He says in the past two or three years, he has helped growers isolate zones in paddocks based not only on intrinsic tools – such as EM38 electromagnetic soil mapping surveys and other precision agriculture (PA) systems – but also with yield monitors that have been found to mimic the soil type as well.

“I try to divide the paddock into three zones,” he says.

“There’s the median zone, where the potential yield is plus or minus 20 percent above average; the champagne soil that is above that 20 percent level; and a weaker soil type or soil that has some kind of restriction in terms of keeping it below the average yield that is below that 20 percent level.



Soil moisture probes and weather stations can provide useful in-season data for decision-making. PHOTO: GRDC

“Initially, when I have the discussion with growers about SMP location, I advise them to target an average soil type and know what’s going on there first.

“Some growers ask me why they should not also have at least one probe set up in their champagne soil to compare what’s going on there as well.

“But, although many growers know their paddocks very well, they often don’t fully know the depth of it and a moisture probe will not give them the whole story.”

David says it can also be valuable to hold off from initially focusing on mitigating problems in the restricted soil zone, because it may not be immediately responsive to any treatment and has potential to drain profit margin out of the business.

“You’ve got to mitigate the risks of your average areas dropping any further, but you’ve also got to look after your champagne soil and get your average soil to go better – rather than focusing all your efforts on the under-performing sections in the short term,” he advises.



#### MORE INFORMATION

David Stead  
0429 205 439  
[zim@agronomy-anasazi.com](mailto:zim@agronomy-anasazi.com)

Case study – soil moisture | Nick Priest, Bonnie Rock

# Soil constraint technologies put to the test in Bonnie Rock

## SNAPSHOT

**OWNERS:** Nick Priest and Romina Nicoletti

**LOCATION:** Bonnie Rock, Western Australia

**FARM SIZE:** 10,000 hectares

**ENTERPRISES:** Cropping

**ANNUAL AVERAGE RAINFALL:** 320 millimetres

**SOIL TYPES:** Medium-heavy clay loams

**CROP PROGRAM (2017):** 7100ha wheat, 1200ha barley, 400ha canola, 300ha lupins, 500ha spray fallow

**TYPICAL ROTATION:** Continuous cereal-break crop (canola, lupins)



Nick Priest, of Bonnie Rock, is keen to pursue greater soil knowledge to improve his farming system in a lower rainfall zone. PHOTO: Priest family

Novel technologies and tactics to improve soil biology and function and help mitigate subsurface constraints are showing promise in parts of the eastern grainbelt.

As part of ongoing efforts to boost the capacity of their soils to collect and hold as much moisture as possible for their extensive cropping program at Bonnie Rock, grain growers Nick Priest and Romina Nicoletti are adopting some of these new systems and shifting their focus underground.

The couple has started an ambitious program to undertake soil testing across their 10,000 hectare property in an effort to better understand the composition and structure of their ‘resource base’.

And they are watching with interest trials underway across the eastern grainbelt that are delving into new techniques for capturing and storing more soil water in the sodic and magnesian soil types that are typical in this part of WA.

Nick says improved soil knowledge is the next frontier for he and Romina to tackle in boosting crop productivity.

To the start of 2017, they had sampled soil sites across 3000ha to a depth of 10-15 centimetres and will use the results to help with crop nutrition planning for this year and strategic plans for the longer-term.

“We want to upskill ourselves in better understanding soil biology, the make-up of the bacteria, microbes and fungi in our soils and how this affects water holding capacity and crop production,” Nick says.

He says summer weed control is a mainstay strategy they use every year to conserve soil moisture for crops and new technologies were making this more targeted, affordable and effective.

Two years ago they invested in a WEEDit precision spraying system. This uses near infrared technology to detect the chlorophyll present in living plants and sends a quick response to the nozzles, which release the spray onto the weed.

“It allows us to travel faster over paddocks, cover bigger areas more quickly and control smaller weeds before they become increasingly problematic to kill,” Nick says.

He says without controlling the major problem weeds of paddy melon (*Cucumis myriocarpus*), Afghan melon (*Citrullus lanatus*), caltrop (*Tribulus terrestris*) and windmill grass (*Chloris truncata*), they stand to lose significant cereal yields.

**“ We want to upskill ourselves in better understanding soil biology, the make-up of the bacteria, microbes and fungi in our soils and how this affects water holding capacity and crop production.**

*Nick Priest, Bonnie Rock*

“Two years ago, I missed a 20ha patch of burr grass (*Xanthium spinosum*) when I was spraying and the wheat yield was 0.5 tonnes per hectare less than the adjacent area where the grass was controlled,” he says.

Nick and Romina monitor soil moisture and plant available water during the season using data collected from a nearby soil moisture (or capacitance) probe (SMP) site and a Yield Prophet® site on their property.

Their Yield Prophet® crop yield predictions in 2015 and 2016 proved to be highly accurate when compared to actual results at harvest.

“It has helped us forecast our crop production, which has been highly beneficial in dealing with our bank for finance and just knowing what we might expect as the season unfolds,” Nick says.

He says he is keen to assess and use these types of technologies that are emerging for the agricultural sector if they prove to be economic, practical and effective.



#### MORE INFORMATION

Nick Priest, Bonnie Rock  
0428 470 016  
wairarapafarms@bigpond.com



Technologies such as precision herbicide application using a WEEDit machine are making summer weed control more efficient and affordable in the eastern grainbelt. PHOTO: GRDC

Case study – soil moisture | Callum Wesley, Southern Cross

# Wheels in motion for moisture efficiencies

## SNAPSHOT

**OWNERS:** Callum, John and Adrian Wesley

**LOCATION:** Southern Cross

**FARM SIZE:** 8000 hectares

**ENTERPRISES:** 45 percent cropping, Brahman cattle stud

**ANNUAL AVERAGE RAINFALL:** 315 millimetres

**SOIL TYPES:** Heavy red loam, red sands

**CROP PROGRAM (2016):** 1950ha wheat, 800ha barley, 300ha oats, 150ha lupins

**TYPICAL ROTATION:** Cereal-fallow-cereal-cereal-fallow



Southern Cross grain grower Callum Wesley has investigated tillage tactics as part of his family's efforts to conserve soil moisture in a lower rainfall environment. PHOTO: GRDC

An innovative seeding system for Western Australia's lower rainfall cropping areas – called the Wesley Wheel – has the potential to harvest moisture in inter-row furrows and improve water conservation on-farm.

It is ideally suited to 'eastern fringe' cropping areas, where production is water-limited in most years and growing season rainfall has been variable and declining.

The device's inventor is Callum Wesley, a third-generation Southern Cross farmer who came up with the concept at the age of 16-years-old.

"I went away to boarding school for five years and in my holidays I would return to Southern Cross and see the continuation of prolonged drought – and the heartache it caused – and I knew I wasn't going to settle for that," Callum says.

On one of his breaks at home, he decided to test a 'simple concept' he had thought up as a potential way to deal with those drought years.

This involved creating a 40 square metre plot of land with wide rows and black plastic film covering the inter-rows, generating 100 percent water run-off. The area was sown with 80 kilograms of wheat seed and fertiliser and production was compared to a control plot of conventionally sown wheat.

The result from the black plastic trial area was an average wheat yield equivalent to 4.5 tonnes per hectare, significantly higher than the control crop in a decile 2 drought area that yielded 0.8t/ha.

"While the black plastic concept is not a feasible option for broadacre farming, I thought I could simulate the effect by developing a press wheel that hardened the soil surface on the inter-row to form an apex and increase water harvesting opportunities," Callum says.

With this idea in mind, he designed and produced a prototype of his Wesley Wheel concept with the help of local engineers in 2013.

The specially designed wheel was retro-fitted to pre-existing seeding machinery and sat alongside conventional press wheels.

Better compaction not only allowed for greater flow into the furrow 'trough', but also reduced soil surface area and sun exposure to reduce moisture evaporation out of the paddock.

"Amateur trials I undertook in 2013 at our farm showed this system had potential to triple the length of our sowing window for cereals by capturing early rainfall," Callum says.

**“ I am confident we get enough rainfall to grow a really successful crop in these environments, but the issue is our water use efficiency is not as good as it needs to be for long-term sustainability.**

*Callum Wesley, Southern Cross*

“In that year, the opening season rain was eight millimetres and it came down in five minutes.

“Using conventional seeding with knife-points, that moisture would typically last for four days in the soil.

“But where I used the Wesley Wheel, there was still enough ‘germinating’ moisture in the soil 12 days later.”

Based on this initial success, the Wesley family used the Wesley Wheel system on 800ha of their farm in 2014 and it was tested – on the farm and at the Merredin Research Facility – with assistance from the Department of Agriculture and Food Western Australia (DAFWA).

At both locations, row spacing widths of 220, 300, 375 and 460mm were set up and the trials found wheat yields increased by up to 26 percent where wider rows were used, compared with conventionally sown control plots.

At Southern Cross, Callum says it was a challenging season, where daily rain events in June, July and August did not exceed 5.4mm. This reduced crop water harvesting potential.

“But we did see that the wider row spacing widths of 375 and 460mm produced slightly higher yields of about 0.1 to 0.2t/ha more than the narrower rows – with and without furrows,” he says.

At the Merredin site, there were significantly higher soil water measurements in the Wesley Wheel furrows after two rainfall events of 11mm, compared to conventionally sown plots.

Wheat yields at this site tended to increase (by about 0.3t/ha) with furrow formation, but the trial results were not statistically significant.

“The Merredin trial was the first indication, though, that using wider row spacings could increase yields in a 1t/ha crop, compared with narrower rows,” Callum says.

To further test the Wesley Wheel concept in 2015, Callum’s family used the seeding system with 375mm wide row spacings across 1500ha of their property and the Kwinana East RCSN group members identified that it would be useful to set up more trials at Southern Cross, Merredin and Mullewa.

A 2015 canola trial sown at Merredin and a wheat trial sown at Southern Cross had a range of treatments, including the use of row spacings at widths of 300, 375 and 460mm – with and without Wesley Wheels fitted behind a cone seeder.

Yields at both sites in 2015 were low due to a very dry spring and there was little difference between treatments.

“A large rain event in March 2015 may have reduced the potential impact of water harvesting with the wheels at both sites as the soil water profile would have been fuller than usual at the start of that season,” Callum says.

Although the site with canola had variable crop emergence, the wide row treatments in Merredin had yields similar to the narrow row treatments.

“We faced some challenges with the trial work conducted in 2015,” Callum says.

“Using a limited set of one or two test locations – plus time constraints and seasonal conditions – didn’t give us the data set to critically test wheat grown with and without inter-row compaction.”

Trials were also conducted in 2016, but due to the weather conditions and the full moisture profile for the season, there were no significant yield responses from the Wesley Wheel treatments.

Callum had plans to commercialise the Wesley Wheel and began the patent application process in 2015. But, after careful consideration of the cost and time involved, he has decided instead to focus on the family farm and ramp-up his involvement in the business alongside his father and uncle.

“While cropping is big part of our business and we’re always looking for ways to be more efficient with the limited rainfall we have, there are other areas of our operation that need my focus,” he says.

Callum’s family run a Brahman stud operation selling progeny to extensive pastoral stations across northern WA.

“The cattle have been a valuable asset through consecutive years of drought, with failed cropping programs in some years,” Callum says.

“The stock also have a key role in helping with summer weed control and with fallow/pasture rotations to provide a break for the cropping operation.”

However, as the Wesleys develop a better understanding of their property’s soil constraints and changing rainfall patterns, Callum says he is aware that the cattle operation may also hinder the cropping potential of the business through soil compaction.

“This summer we have conducted a deep ripping trial to alleviate compaction, and I am excited to see the results,” he says.

“My next challenge is to develop a program that segregates the cattle from the paddocks that are cropped.

“In the marginal country that we farm, our livestock are too critical to profitability to get rid of, so figuring out a way that this enterprise can work in unison with cropping is paramount to success and sustainability.”

Despite his new focus, Callum says he certainly is not giving up on the Wesley Wheel concept and believes it still has a really important place in his family’s cropping strategy.

With time, improved technology and more trial work, he hopes the system has potential for growers in the ‘eastern fringe’ of WA’s cropping areas.

“I am confident we get enough rainfall to grow a really successful crop in these environments, but the issue is our efficiency is not as good as it needs to be for long-term sustainability,” he says.



#### MORE INFORMATION

Callum Wesley  
0448 154 888  
cwesley@live.com.au

#### USEFUL RESOURCES

- **Callum Wesley’s 2015 Agribusiness Crop Update paper and presentation**
- **Video of Callum Wesley, designer of the Wesley Wheel**  
<https://www.youtube.com/watch?v=noe1dIN5Kxc&feature=youtu.be>

## USEFUL RESOURCES

- **RCSN**  
[www.rcsn.net.au](http://www.rcsn.net.au)
- **RCSN '2014-15 Annual Report' and '2015-16 Annual Report'**  
<https://grdc.com.au/About-Us/Our-Grains-Industry/Regional-Cropping-Solutions-Networks>
- **GRDC GrowNotes™ western region Wheat, Canola, Oats**  
<https://grdc.com.au/Resources/GrowNotes>
- **GRDC Ground Cover Supplement 'Soil Constraints'**  
<https://grdc.com.au/Media-Centre/Ground-Cover-Supplements/Ground-Cover-Issue-118-Soil-constraints>
- **GRDC Update Paper 'Are Soil Moisture Probes Worth the Investment'**  
<https://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2016/08/Are-soil-moisture-probes-worth-the-investment>
- **GRDC/DAFWA WA Soil Moisture Probes data access**  
[http://tiny.cc/WA\\_SMP\\_Network](http://tiny.cc/WA_SMP_Network) and  
<http://precisionag.com.au/services/moisture-probes-project/>
- **Yield Prophet®**  
[www.yieldprophet.com.au](http://www.yieldprophet.com.au)
- **DAFWA Soil water maps and graphs, forecasting service at**  
[www.agric.wa.gov.au](http://www.agric.wa.gov.au)  
**(click on the weather station points on the base map)**
- **GRDC Ground Cover TV 'Managing summer fallow'**  
<http://www.grdc.com.au/GCTV5-SummerFallow>
- **GRDC video explaining more about the RCSN spray fallow trials at**  
[www.grdc.com.au/FallowSprayTechniques](http://www.grdc.com.au/FallowSprayTechniques)
- **GRDC Summer Fallow Weed Management Guide**  
[www.grdc.com.au/GRDC-Manual-SummerFallowWeedManagement](http://www.grdc.com.au/GRDC-Manual-SummerFallowWeedManagement)
- **GRDC Hot Topic 'Summer fallow weed management'**  
[www.grdc.com.au/Media-Centre/Hot-Topics/Summer-fallow-weed-management](http://www.grdc.com.au/Media-Centre/Hot-Topics/Summer-fallow-weed-management)
- **WeedSmart**  
[www.weedsmart.org.au](http://www.weedsmart.org.au)
- **WeedSmart App**  
<https://grdc.com.au/apps>
- **DAFWA 'Crop weeds'**  
<https://www.agric.wa.gov.au/pests-weeds-diseases/weeds/crop-weeds>
- **Callum Wesley's 2015 Agribusiness Crop Update paper and presentation**  
<https://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2015/02/Furrow-formation-and-Inter-row-Compaction>
- **Video of Callum Wesley, designer of the Wesley Wheel**  
<https://www.youtube.com/watch?v=noe1dIN5Kxc&feature=youtu.be>



**GRDC**<sup>™</sup>

REGIONAL CROPPING  
SOLUTIONS NETWORK