MAXIMISING CROP POTENTIAL IN A DRYING ENVIRONMENT

GRDC
GRAINS RESEARCH & DEVELOPMENT CORPORATION

WESTERN

A REGIONAL CROPPING SOLUTIONS NETWORK INITIATIVE

grdc.com.au

Title: Maximising Crop Potential in a Drying Environment – An Initiative of the Regional Cropping Solutions Network

GRDC Project Code: 9176147

Acknowledgements

Grateful acknowledgement is made for the information and time committed by the following growers in this case study booklet: Piet Diepeveen, Rohan Ford, Karl Suckling, Bill Crabtree, Michael Morrison, Dylan Hirsch, Mark Wilson, Ross Fitzsimons, Ben Strickland, Cathy Cooke, Tony Sachse, Nick Gillett, Jules Alvaro, John Chapman, Robert Miolini, Austin Pascoe, Gary Lang and Paul Hicks. Acknowledgement also extends to Jackie Bucat, Stephen Davies, Bob French and Bindi Isbister from the Department of Primary Industries and Regional Development.

ISBN: 978-1-921779-63-3 (print) 978-1-921779-64-0 (online)

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Design and production: Coretext, www.coretext.com.au

Cover photo: © CussonsMedia

Published February 2019

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Introduction

GRDC invested in the Regional Cropping Solutions Networks (RCSNs) in 2011 with the primary aim to identify local research, development and extension priorities. There are five RCSNs across the western region, which are based on a port zones:

- Albany port zone RCSN
- Esperance port zone RCSN
- Kwinana West port zone RCSN
- Kwinana East port zone RCSN, and
- Geraldton port zone RCSN.

The RCSNs comprise a mix of 60 growers and industry professionals who meet formally twice a year to discuss research, development and extension priorities that will improve profitability for grain growers in Western Australia. One of the issues raised by Geraldton and Kwinana East port zone growers and RCSN members in August 2017 centred around variable crop establishment, especially after the start to the 2017 season where good subsoil moisture was available but crop establishment was poor.

Changing weather patterns in the Western Australian wheatbelt, and in particular in the Geraldton and Kwinana East port zones where the seeding window often experiences warmer and drier conditions than in the past, mean that growers are frequently attempting to sow and establish crops in less-than-favourable conditions. However, these changing weather conditions have also seen more frequent summer rainfall events, often providing a reasonable level of subsoil moisture. This subsoil moisture provides more confidence in earlier seeding and many growers seed deeper to reach this moisture. Deep sowing to chase moisture can be critical in some seasons to getting crops established early.

Geraldton and Kwinana East port zone growers and RCSN members identified that they wanted to know more about improving crop establishment in drying profiles on different soil types, using deeper sowing to achieve this. Maximising Crop Potential in a Drying Environment: An Initiative of the Regional Cropping Solutions Network has been developed to provide growers with access to consolidated information on research and grower experiences. The growers featured in the booklet have outlined what has and has not worked for them, and have provided information on a range of tactics they have employed. This will help to provide confidence to other growers in making decisions to deal with a drying environment.

We would like to acknowledge the support of these growers in sharing this knowledge, as farmer-to-farmer sharing is invaluable and is often the best way to adoption of new practices for other growers. We hope that this booklet can provide growers in the western region with the knowledge to assess the risks and rewards to using tactics such as deeper sowing and other options to manage our more variable climate.

THANK YOU!

Thank you to each of the 18 growers who shared what they do and why they do it, for the broader benefit of grain growers in the northern and eastern wheatbelt of Western Australia.

Julianne Hill, Western Region RCSN Coordinator

How to successfully establish crops in a drying soil profile

As farms and cropping programs become larger, it is commonplace for Western Australian growers to sow early and dry to ensure the potential yield is maximised. Twenty per cent of growers are now starting their seeding programs before 25 April and the average start date of sowing programs is 29 April (Fletcher et al., 2016). More than 50 per cent of growers dry sow (Fletcher et al., 2016) and in the lower rainfall zones this percentage is higher (Minkey et al., 2017). Historically canola and lupins have most commonly been sown dry, and areas of dry sown wheat and barley are increasing.

Unreliable early season rainfall and soils with marginal moisture have motivated an increasing number of growers to sow deeper to access subsoil moisture. Although deeper sowing has the potential to reduce crop germination, the yield gains are thought to offset any yield losses that come with later sowing. This increasing trend among Western Australian growers highlights the need to understand the risks and management of dry deep sowing crops.

SOME OF THE RISKS ASSOCIATED WITH DRY DEEP SOWING INCLUDE:

- reduced/partial germination;
- reduced seedling vigour;
- increases in soil water repellency;
- potential for phytotoxicity from herbicides;
- increased weed burden from weeds emerging with the crop;
- poor performance of soil-applied herbicides; and
- reliance on in-crop herbicides.

Early dry sowing when coupled with sowing at depth can lead to poor crop establishment, particularly in varieties with short coleoptiles. Good crop establishment is critical to the success of Western Australian broadacre cropping programs. It is essential to consider a range of tactics that can be implemented to achieve good crop establishment under these conditions, therefore making the most of the benefits dry sowing can offer.

THESE TACTICS INCLUDE:

- analysing how deep the seed can be placed;
- selecting cultivars with appropriate traits for example, varieties with long coleoptiles, larger seeds and longer seasons;
- practices that allow for accumulation of soil moisture at seeding for example, furrow sowing, application of soil wetter and stubble retention on row sowing;
- practices to improve establishment on water-repellent soils for example, mouldboard ploughing or spading; and
- assessing which equipment provides the best establishment.

How deep can you sow?

Canola

Traditionally canola is best sown into a moist seedbed at 12 to 25 millimetres deep, but recent dry years and good summer rainfall events have prompted growers to sow deeper to access subsoil moisture. Trials by Department of Primary Industries and Regional Development (DPIRD) in Eradu, Mingenew, Dalwallinu and Merredin compared sowing depths and seed size in open pollinated (OP) and hybrid varieties to evaluate the value of chasing moisture in a drying topsoil by sowing deeper.

Depths of 10, 30 and 70mm were used at Mingenew and Eradu, while depths of 15, 30 and 60mm were used at Dalwallinu and Merredin. Soil moisture measurements at Mingenew and Eradu for the three seeding depths, in addition to deeper measurements, showed a trend that moisture in the top 1cm was similar or greater than at depth two weeks following sowing despite hot conditions (Harries et al., 2017). There were reductions in field establishment and yield with deeper sowing across all sites. As depth of sowing increased, plant establishment decreased at all sites (Table 1).

Field establishment (%) and plant density (plants/m^2) reduced by seeding depth at four locations in 2016.

Average yield losses of 18 per cent were incurred by sowing at a depth of 30mm compared with the 10 to 15mm, while reductions of 60 to 65 per cent were observed at depths of 60 to 70mm compared to 10 to 15mm.

Seed was graded into three sizes for the OP variety (ATR Bonito) and the hybrid variety (Hyola 559TT). The hybrid seed was larger than the OP seed, with the largest OP seed being similar in size to the smallest hybrid seed. Seed size did have an impact on establishment. Using small seed (370,000 seeds per kilogram) compared with large seed (230,000 seeds/kg) for the OP variety resulted in reduced establishment, yield and gross margins in the Mingenew trial in 2016. Field establishment of the hybrid was better compared with the OP variety, which was largely attributed to larger seed size. Similar results have also been demonstrated in NSW where large-seeded hybrids established better compared to smaller seeded OP varieties (Brill et al., 2014). Further information for canola establishment can be found in the latest DPIRD Canola Agronomy Research bulletin.

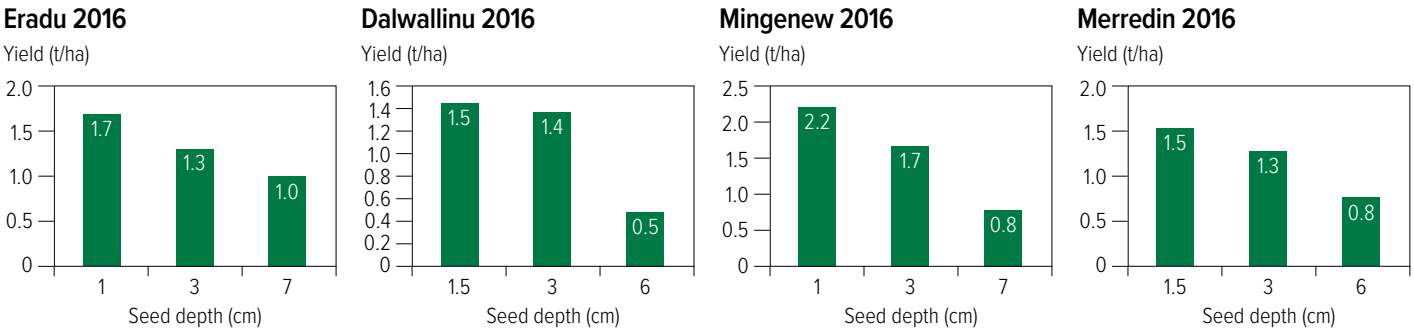
Marty Harries (DPIRD) pictured in the deeper sown plots showing reduced canola establishment. PHOTO: DPIRD

TABLE 1: Decreasing field establishment (FE) and plant density (p/m^2) as sowing depth increases across four WA locations (Harries et al., 2018).

Depth	10 to 15mm		30mm		60 to 70mm	
	FE	p/m^2	FE	p/m^2	FE	p/m^2
Eradu	24	15	11	7	5	3
Mingenew	21	13	8	5	2	1
Merredin	62	33	42	22	15	8
Dalwallinu	58	31	28	15	6	3

Field establishment (%) and plant density (plants/m^2) reduced by seeding depth at four locations in 2016

FIGURE 1: Decreasing canola yields as seeding depth increases across four WA locations (Harries et al., 2018).

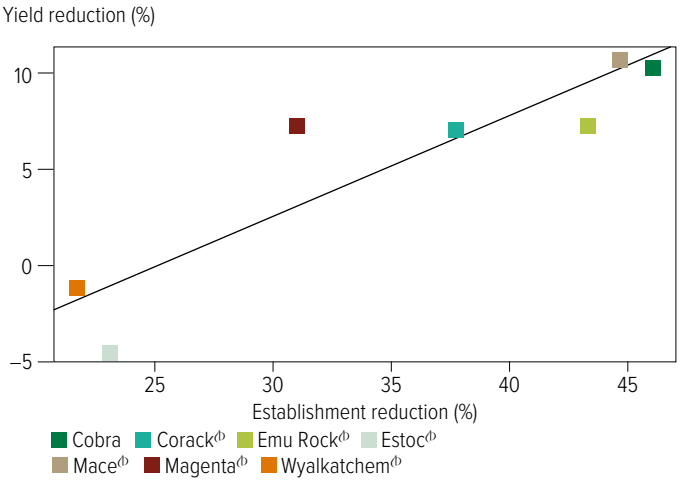


Wheat

Wheat is conventionally sown at a depth of about 20 to 40mm into moist soil. However, it is sometimes necessary to sow wheat deeper at 80 to 120mm in order to place it in moist soil. This is most likely to occur early in the season when the soil surface dries very quickly between rainfall events. Wheat will not generally establish as well when sown this deep. There are several factors that determine how well wheat will establish if planted deep; these include coleoptile length, seed size and grain quality.

Research at Mullewa, Wubin and Merredin in Western Australia (French, 2014) found deep sowing reduced crop establishment by 20 to 80 per cent with the extent of reduction varying between cultivars and sites. Varieties with a longer coleoptile were generally less sensitive to deep sowing than those with short coleoptiles, while wheat sown 120mm deep in sandy soils emerged better than wheat sown 100mm deep in loamy or clay soils. Reduced plant establishment due to deeper sowing did not always lead to lower yields, but it did at Wubin (Figure 2). This has also been noted in trials in NSW (Brill et al., 2012).

FIGURE 2: Relationship between reductions in crop establishment and grain yield due to deep sowing at Wubin.



There is a strong correlation between reductions in establishment and yield, where reductions in establishment from deep sowing resulted in reductions in yields (French, 2014).

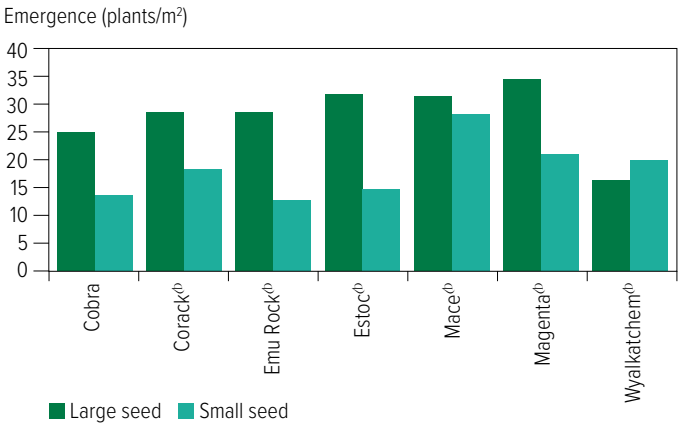
Further trials at Mullewa (French, 2014) showed that small seed was much more sensitive to deep sowing compared with large seed (Figure 3). Seed sizes for each cultivar are shown in Table 2.

TABLE 2: Seed size (thousand seed weight g) for small and large seed for several wheat varieties

Cultivar	Thousand seed weight (g)	
	Small	Large
Cobra	36.7	21.2
Corack(b)	43.0	34.6
Emu Rock(b)	44.4	23.6
Estoc(b)	32.5	21.8
Mace(b)	37.7	30.0
Magenta(b)	40.1	22.4
Wyalkatchem(b)	43.7	32.0

Small and large seed sizes varied among varieties (French, 2014).

FIGURE 3: Wheat plant emergence for several cultivars sown at 80mm with either large or small seed. (Note: the large and small size classes are not all the same size).



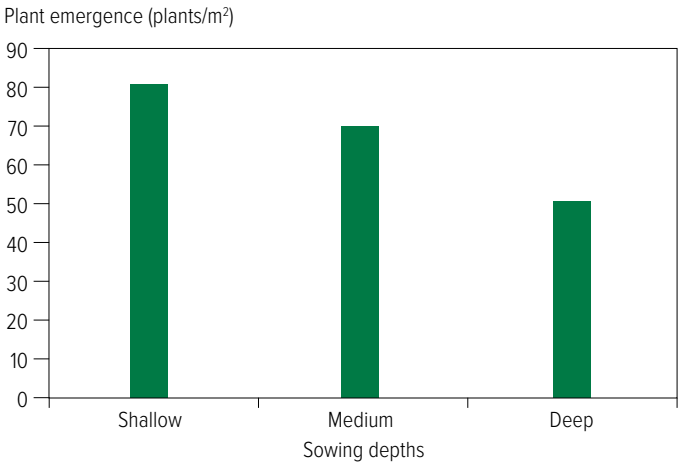
Using large seed generally resulted in increased crop establishment compared with small seed when sown at 80mm (French, 2014).

Emerging wheat seedling sown at depth (left) compared with a wheat seedling sown at depth (right) which is struggling to emerge. PHOTO: BOB FRENCH, DPIRD

Barley

Trial results with barley and depth of sowing in WA are limited, so results from eastern states have been used. Ideally barley is best sown 20 to 30mm into moist soil, and trials (Fettell, 2009) have shown deeper seed placement reduces emergence (Figure 4). Deeper sowing slows emergence, which can be similar to later sowing, and is more problematic for varieties with shorter coleoptiles. Seedlings sown at depth often are weaker and tiller poorly due to much of their energy being expended pushing through from depth.

FIGURE 4: Plant emergence at three sowing depths – shallow (44mm), medium (87mm) and deep (112mm) averaged over 12 varieties in 2009.

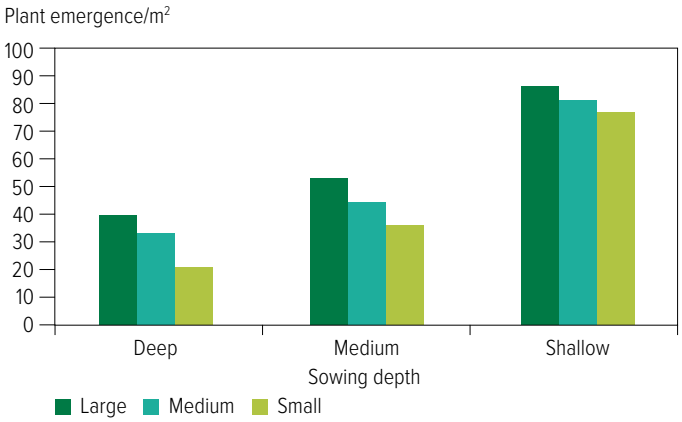


Increasing seeding depth reduces plant emergence in barley, establishment was highest when seed was sown shallow (Fettell, 2009).

Emergence of plants sown at 87mm was 50 to 80 per cent of those sown at 44mm, whereas emergence of plants sown at 112mm was 35 to 60 per cent of those sown at 44mm. Compensation for lower plant densities due to deep sowing through increased tiller numbers has been observed (Fettel et al., 2010), although it is suggested that increased sowing rates should be used when deep sowing to maintain plant densities.

Grain size also influenced emergence rates – grain was separated into small (1.8 to 2.2mm), medium (2.2 to 2.5mm) and large (>2.5mm) categories, with results indicating that plant emergence was greater with large seed for all varieties used (Figure 5).

FIGURE 5: Plant emergence in response to seed size averaged over three sowing depths and nine barley varieties.



Barley emergence was higher when large seed was sown for all three sowing depths (Fettell, 2009).

Similar results have been shown in South Australia (Porker et al., 2013) where two sowing depths, shallow (20mm) and deep (60mm), were used with several barley varieties. Varieties possessing shorter coleoptiles had reduced plant establishment than those with longer coleoptiles when sown deep. There were no differences in yield at deeper sowing, indicating that barley may be able to compensate for less than optimal sowing depths, although caution should still be exercised when varieties with shorter coleoptiles and deep sowing are being used.

Key points

- Retain vigorous larger cereal seed – larger than 35 g/1000 (French, 2015)
- Select varieties with longer coleoptiles – Crop Variety Sowing Guides will indicate the relative coleoptile lengths of available varieties
- Avoid deep sowing on loamy clay soil types
- Increased sowing rates by 20 per cent may compensate for reductions in emergence
- Use seed with a high germination >90 per cent if deep sowing
- Chasing moisture by sowing deeper than 15 to 20mm will reduce field establishment in canola
- Growers retaining TT seed are encouraged to grade seed to biggest size possible, to retain larger seed for sowing programs
- Some seed dressings can shorten coleoptile length, which may lead to crop establishment issues when sown deep (particularly triazole fungicides)
- Varieties possessing shorter coleoptiles are not well suited for deep sowing particularly when certain seed dressings are being used
- Some pre-emergent herbicides can cause shortening of the coleoptile in cereals
- Poor establishment can occur if crops emerge through herbicide-treated soil; in combination with deep sowing, establishment may be further affected
- Deeper sowing can reduce emergence similar to later sowing
- Deeper sown plants may be weaker and tiller poorly
- Barley may be able to compensate and recover yield from less than optimal sowing conditions by increasing tiller numbers

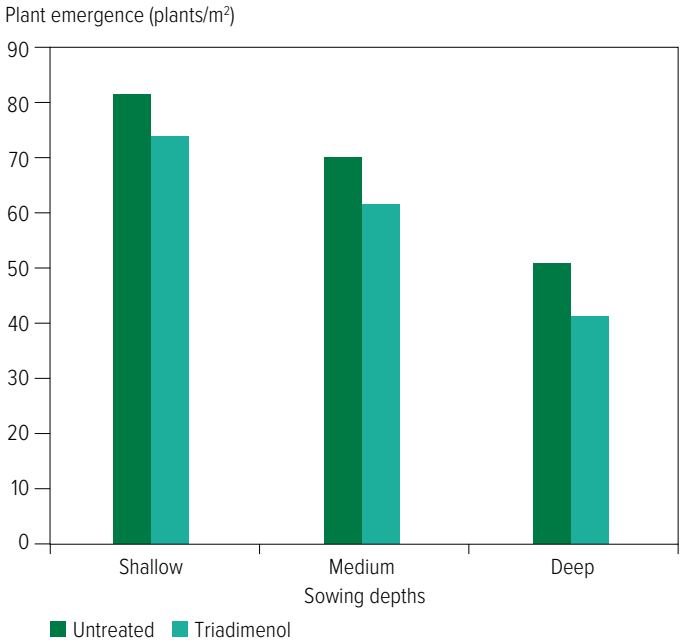
Effect of seed treatments

In some cases, the use of certain seed dressings may reduce coleoptile length, resulting in 'silly seedling' syndrome, which can be exacerbated by deep sowing and the use of short coleoptile varieties. Research (Fettell, 2009) has shown use of seed treatments can delay the emergence in barley by:

- shortening the length of the coleoptile, the first leaf and the sub-crown internode; and
- reducing the rate of germination.

Some seed treatments contain triazole fungicides, which can lead to shortening of the coleoptile. At the highest registered use rate of triadimenol in barley, emergence was reduced particularly in deep sowing situations with varieties exhibiting short coleoptile length (Figure 6). Varieties exhibiting shorter coleoptiles should only be sown at shallow depths to ensure good plant establishment.

FIGURE 6: Plant emergence from untreated and triadimenol-treated seed at three depths, shallow (44mm), medium (87mm), and deep (112mm) averaged over 12 varieties in 2009.



Triadimenol-treated seed reduced barley emergence compared with untreated seed, increasing seeding depth further reduced plant emergence (Fettell, 2009).

A trial in NSW (Brill et al., 2012) also found when triadimenol was applied to wheat, overall establishment was reduced by 25 per cent at 70mm sowing depths, compared with untreated seed sown at the same depth.

The seed dressing Jockey® Stayer® (fluquinconazole) may shorten the hypocotyl length of canola. For canola crop safety, Bayer CropScience includes a warning on the label recommending canola treated with Jockey® Stayer® should not be sown deeper than 20mm or into soils prone to crusting. It is recommended canola should be for sowing in the year of treatment, and where this is not possible treated seed sown in subsequent seasons should be tested for germination and vigour prior to planting to determine if it is still viable.

Effect of herbicides

The use of certain pre-emergent herbicides can cause reduced or poor seedling emergence. The Group D dinitroaniline herbicides (trifluralin, pendimethalin and oryzalin) can cause coleoptile shortening in cereals, while Group J thiocarbamate herbicides (triallate, Avadex®, prosulfocarb and Boxer Gold®) can also affect germination if seed comes into contact with herbicide-treated soil (Peltzer, 2015). Care should be taken when varieties with short coleoptile length in combination with deep sowing are used as this may affect crop germination and establishment.

When the soil is dry at depth, deep sowing offers no special advantage to offset any establishment losses. However, if sowing deep to seek moisture, there are several issues growers should be aware of, summarised below.

Fertiliser strategies for deep sowing

Key points

- Canola seedlings are typically more sensitive to damage from fertiliser than other crops
- Where high amounts of P are required in canola, seed and fertiliser separation are recommended
- Canola is highly sensitive to ammonia N, therefore all N should be banded below seed
- Separation of seed and fertiliser is also recommended in cereals
- Banding below or to the side of seed by 50mm can minimise the risk of toxicity, although some risk remains at high application rates
- Sandy soils and dry conditions at sowing may increase the risk of toxicity
- Assume that in combination with deep sowing, fertiliser toxicity effects may be worse

Canola

Canola seedlings are typically more sensitive to damage from fertiliser than other crops. Research (Brill et al., 2014) has shown that increasing rates of triple super fertiliser placed directly with the seed reduced establishment at Nyngan and Coonamble, translating to yield reductions at both sites. In this trial, increasing phosphorus (P) rate (as triple super) reduced establishment, so it could be safely assumed that in combination with deep sowing, the effect on establishment would be greater. Further research by CSIRO and University of South Australia (Desbiolles et al., 2014) found crop establishment was optimised where seed and fertiliser were separated.

In situations where high amounts of P fertiliser are required, separation of seed and fertiliser is recommended. It is best practice to band all nitrogen (N) when sown with canola due to its high sensitivity to ammonia N (GRDC, 2011).

Cereals

Trials in South Australia (Kleeman et al., 2004) in 2000 and 2001 showed high rates of nitrogen (N) (132kg per hectare) placed with the seed reduced establishment in wheat by 85 per cent and 67 per cent respectively. When banded below or to the side of the seed, high rates of N (66 to 132kg/ha) had no effect on wheat establishment in 2001. In contrast, in 2000 high rates of N banded below or to the side of seed reduced establishment by 27 to 34 per cent. Significant yield reductions occurred where N was placed with seed, caused by toxic levels of ammonia, while separation of seed and fertiliser by 50mm either below or to the side reduced the risk of toxicity. Caution is still needed, despite separation of seed and fertiliser, with high rates of N.

Barley has a higher tolerance than wheat, but caution should still be exercised when applying large amounts of N at sowing. Toxicity will be exacerbated in sandy soils and drier conditions at sowing, in addition to wide row spacings, particularly where the same fertiliser rate is used with different row spacings, resulting in a higher concentration of fertiliser in the row as spacings increase (GRDC, 2011). In combination with deep sowing, it can be assumed that the effects would be worse.

Time of sowing

Key points

- Canola and lupins are well suited to early sowing, particularly in the NAR
- Delaying sowing reduces yields for canola, lupins and wheat and barley
- Barley appears to be well suited to early sowing giving growers another early sowing option
- Sow early, sow long season wheat and consider heat and frost risk

Canola and legumes

Canola is commonly sown dry and early in Western Australia. Research (Harries et al., 2014) has demonstrated that early sowing is the key to maximising canola yields in the Northern Agricultural Region (NAR). Yields were lower for all varieties when sowing was delayed from 14 April to 29 April, with average yield losses of 43kg/ha/day between these two times of sowing. Optimum sowing time in high-rainfall zones is from April to mid-May, dependent on the variety.

Lupins, like canola, benefit from early sowing. They require the warm weather generally experienced in May to establish and are not recommended to be sown in June in the NAR. In some areas of the Southern Agricultural Region it may be viable to sow lupins in early June as yield losses from delayed sowing are not as great as those in the NAR (Pritchard, 2018).

Wheat

Early sowing of wheat crops is becoming common practice, however as farm sizes increase, getting crops established so that they flower in the optimum window is difficult to achieve. Delayed seeding increases the risk of moisture and heat stress and therefore reduced yield, and for this reason trials focus more on yields rather than establishment.

DPIRD trials with co-investment from GRDC have shown that delaying sowing until June compared with sowing in May can reduce average yield potential by 26kg/ha/day in the NAR, 28kg/ha/day in the Central Agricultural Region, 23kg/ha/day in the Great Southern and 13kg/ha/day on the South Coast (Zaicou-Kunesch et al., 2018).

Recent research with co-investment from GRDC (Shackley et al., 2018) investigated four sowing times (mid-April, late April, early May and late May) across several locations including Mullewa and Merredin with a range of wheat varieties including long spring and winter wheats. Trials had various watering regimes to ensure establishment at the four locations.

The results from this series of trials are consistent with results from 2016 (Shackley et al., 2017). At Mullewa the mid-long maturing varieties (i.e. Cutlass[(b)] and Magenta[(b)]) produced the highest yields at the sowing time of early May. At Merredin, early sowing (whether April or early May) did not have a large impact on the yields of the mid-long maturing varieties. Note that frost was not an issue at this site. In general, yields were the lowest across most locations and varieties by delaying sowing until late May. It is important to match the maturity of a variety with sowing date to maximise the yield potential – "If sowing early, sow long" (B. Shackley, 2018, pers comm., September).

Barley

A three-year trial (Malik et al., 2018) found barley to be higher yielding and more profitable than wheat at all sowing times from mid-April to late May in the high to medium-rainfall areas. Further research from a four-year study in NSW (Brill et al., 2013), demonstrated increased yields from sowing barley from late April to early May compared with mid-May to mid-June sowing. Averaged across four years, yield losses of 0.59 tonnes per hectare were seen by delaying sowing until mid-May to mid-June. Reducing the risks from early sowing by choosing varieties that are agronomically suited to regions will assist with this.

Row spacing

Key points

- Canola can be grown on wide row spacings without affecting yield
- Wheat and barley establishment and yields are improved with narrow row spacing
- Lupins grown on wide rows yield similarly to narrow row spacings
- Wide row spacings for canola and lupins appear to be better suited to areas where conditions are warm during grain fill

Canola

Canola is generally grown on narrow row spacings in WA; however, research (Harries et al., 2015) has demonstrated that canola grown on wide rows (50 to 60cm) yields well enough to consider this row spacing as an option. Plants were able to compensate for being sown on wide rows and the research indicates this method may be better suited to shallower soil types in the NAR where water deficits during grain fill can be severe. Advantages include reduced fuel costs, better stubble handling and improved safety from pre-emergent herbicides.

Wheat

As row spacing increases, establishment of wheat tends to decrease as plants compete for water and light within the row. Research has shown wheat crops sown with narrow row spacing produce improved establishment and yield. A trial at Mingenew (Newman, 2014) demonstrated that the percentage of wheat plants that emerged was nearly 100 per cent at 15cm row spacing, but this decreased to under 80 per cent at 30cm. Similar results have been shown in 2006 (Amjad et al., 2006) where increasing row spacings from 18cm to 24cm and 36cm established 9 per cent and 21 per cent fewer wheat plants respectively (Peltzer, 2018).

Barley

Eighteen experiments in WA and the eastern states indicate wheat and barley are similar in their response to changes in row spacing (Scott et al., 2013). In situations where yields were lower (<1.1t/ha) and the row spacing was narrow (18cm), widening the row spacing increased barley yields. However, in higher yielding situations (>2t/ha), widening row spacings to 36cm reduced grain yields. These results are similar to the response of wheat row spacing, indicating that narrow row spacing will improve yields in areas with higher yielding potential.

Lupins

Lupins have traditionally been grown on narrow row spacing in WA, but research (French et al., 2006) has shown lupins grown on wide rows (50cm) yield similar to narrow row spacing. When grown on wide rows, lupins intercept less sunlight and tend to grow slower, using less water, which leaves more water available in the inter-row at grain fill. Wide row spacing is better suited to areas where it is warm and dry during grain fill such as the medium and low-rainfall northern wheatbelt. Narrow row spacing is mostly likely better suited to cooler longer season climates (Pritchard, 2018).

Long coleoptile research

Key points

- Breeding programs are underway to develop wheat varieties with longer coleoptile length
- These new lines are 8 to 10 years away from National Variety Trial testing
- Field testing of the lines with long coleoptiles are showing promising establishment results when sown deep

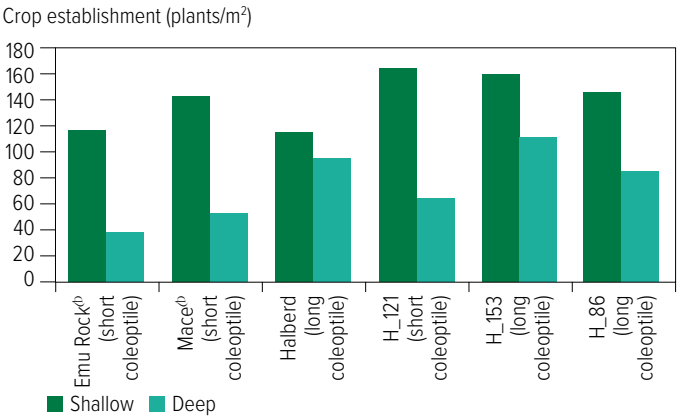
Increased adoption of early and deep sowing has seen a push for wheat breeders to investigate the wheat traits that enable greater seedling vigour and ability to emerge from depth. Greg Rebeztke and his team at CSIRO have been working on selecting genetic material that will help breeders develop varieties that possess longer coleoptiles.

Coleoptile length varies between varieties. Under standard laboratory conditions the coleoptile length of commonly grown varieties varies from about 50mm to 90mm. There are genetics available with coleoptiles as long as 150mm. Semi-dwarf varieties possess dwarfing genes that exhibit shorter coleoptiles and therefore are not suited to deep sowing. The CSIRO team has been investigating alternative dwarfing genes that will allow the development of semi dwarf, long coleoptile wheat varieties allowing sowing depths exceeding 100mm. It is imperative in this process that yield and grain quality traits are maintained.

These lines have been tested at Merredin and Mullewa in Western Australia by Bob French (DPIRD) and Greg Rebetzke (CSIRO) and show considerably better establishment when sown at 100mm than current commercial varieties (Figure 7). Further results from this research will become available in early 2019.

Lines with these selected traits from CSIRO have been distributed to breeding companies, where breeding programs will begin a lengthy process to select suitable varieties. It will take approximately 8 to 10 years to get these varieties through to the GRDC National Variety Testing (NVT) program.

FIGURE 7: Crop establishment comparing two current short coleoptile varieties with lines selected by CSIRO with longer coleoptiles when sown deep (108mm) and shallow (47mm).



Lines with longer coleoptiles show increased crop establishment compared with current short coleoptile varieties Mace(b) and Emu Rock(b) when sown deep at 108mm (French, DPIRD).

Water-repellent soils

Water-repellent soils pose as a major constraint to crop establishment in Western Australia, with up to 10.2 million hectare of arable land at risk, with 3.3 million ha considered high risk and a further 6.9 million ha at moderate risk (van Gool et al., 2008). As a result, the cost of lost production in WA is approximately $251 million per year (Herbert, 2009). Signs of soil water repellence include patchy crop emergence, dry patches of soil even after significant rainfall and staggered crop and weed emergence.

Increases in water-repellent soils have been driven by several factors including (Davies, 2018):

- drier autumns with unreliable early season rainfall events;
- higher concentrations of topsoil organic matter from reduced soil cultivation methods;
- increases in adoption of knife point seeding systems, allowing repellent topsoil to flow into the furrow; and
- increased adoption of dry seeding.

Soil water repellence typically affects sandy-surfaced soils with less than 5 per cent clay, but has also been noted as a problem on gravels in the high-rainfall zone of the south-west. Soil water repellence occurs when waxy hydrophobic organic matter accumulates on the soil surface. Derived mostly from plant material, these hydrophobic compounds accumulate in the topsoil, creating a water-repellent skin around soil particles and rendering them repellent. Water often pools on the soil surface until it finds a point of entry via an old root channel or soil crack, resulting in patchy and delayed emergence.

Consequences from water repellent soils include (Davies et al., 2018):

- patchy crop or pasture establishment;
- increases in water run-off on sloping land;
- reduced weed control from patchy and delayed weed emergence;
- increased reliance on in-crop post-emergent herbicides;
- nutrient unavailability from dry soil; and
- susceptibility to wind and water erosion due to poor ground cover.

Mitigation

Management of water-repellent soils is dependent on several factors, including the severity of the repellency, soil type affected and how widespread it is across the farm. Management can be categorised into mitigation, amelioration or avoidance. Mitigation strategies used to reduce the effects of water repellence are short-term and low-cost, but need to be repeated annually.

Mitigation tactics include:

- furrow sowing;
- on or near-row sowing and stubble retention;
- use of surfactants/wetters;
- delaying sowing on water-repellent soils; and
- higher sowing rates.

Furrow sowing

Furrow sowing has typically been used to manage water repellence on deep sands. This technique creates small ridges and furrows by shifting repellent soils into the ridges, resulting in water being harvested from the sides of the furrow towards the germinating seed placed at the bottom. Furrow sowing with knife points, particularly when dry sowing, has had varying levels of success due to the repellent soil flowing back into the furrow.

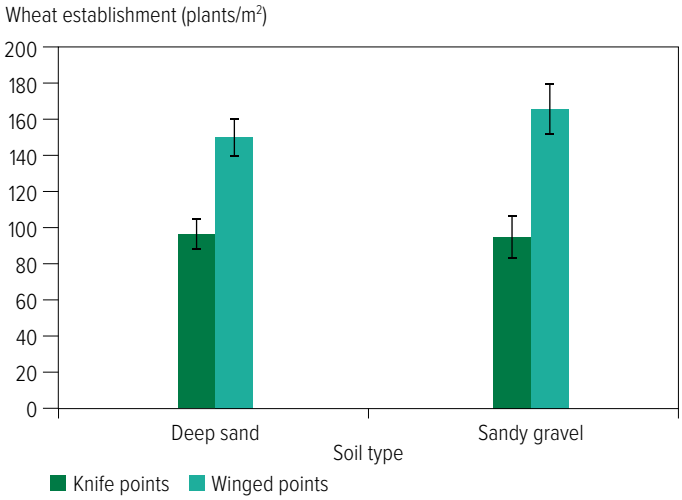
Techniques for improving furrow sowing on repellent soils include:

- use of winged points;
- banding wetting agents;
- use of press wheels;
- paired row or ribbon sowing; and
- sowing on the previous year's crop row.

Winged points

Using winged sowing systems helps grade repellent soil out of the furrow, resulting in improved seedling establishment in water-repellent soils. DPIRD trials in Badgingarra (Roper et al., 2015) show improvements in crop establishment when using winged points compared with narrow points on a moderately repellent deep sand (Figure 8).

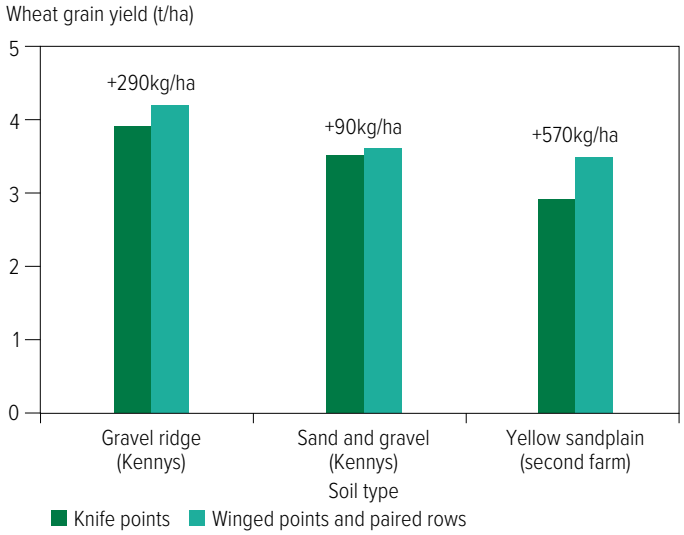
FIGURE 8: Wheat establishment on a moderately repellent pale deep sand and severely repellent sandy gravel in Badgingarra (WA) using knife points or winged points.



Wheat plant establishment is increased using winged points compared to knife points on two repellent soils (Roper et al., 2015).

Seven field trials across a variety of crops and soils in the NAR have shown that winged points increased yields by an average of 140kg/ha compared with knife points on repellent sands (Blackwell et al., 2014). The use of winged sowing boots with twin row seeding in five field trials across WA further improved yields by over 400kg/ha (Blackwell et al., 2014). Grain yields at a DPIRD trial in Badgingarra were increased by using winged points and paired rows across three different soil types (Roper et al., 2015) (Figure 9).

FIGURE 9: Grain yield of wheat on a moderately repellent pale deep sand, severely repellent sandy gravel and a mildly repellent deep yellow sand at Badgingarra (WA) using knife points or a winged point-paired row seeder system.



Wheat yields are increased using winged points and paired rows compared with knife points on three water-repellent soils (Roper et al., 2015).

Yield increases observed with twin row and paired sowing could be attributed to more seed being spread through the soil, therefore increasing the likelihood of seed being positioned near wet soil. This would also provide a competitive advantage over weeds – similar advantages would occur with ribbon sowing.

Wetting agents

BLANKET APPLICATIONS

Blanket wetter applications are advantageous because they can be easily applied through existing machinery, they increase weed germination allowing improved weed control and can result in better crop establishment.

Costs of $50 to $200/ha at use rates of 10 to 50 litres per hectare are quite high, although some products may give two years of benefit on responsive soils (GRDC, 2014). Research has shown results can be variable on different soil types, with loamy (forest) gravels in the south-west responding better than deep sands or sandy gravels, which are typically unresponsive except at uneconomic rates (Davies et al., 2012). Blanket application is best suited to selected areas of loamy gravel paddocks that have high water repellence rather than whole paddock applications, due to the high cost.

BANDING WETTER

Banding soil wetting agents can help improve crop establishment, early crop vigour, nutrient use and weed control. Applied to the furrow at the base of the press wheel at relatively low use rates of 1 to 2L/ha reduces the cost compared with a blanket spray application costing approximately $6 to $12/ha (Davies et al., 2016). Creating a stable furrow is vital when banding wetters and using V-shaped or rounded press wheels helps achieve this. In comparison, rectangular press wheels can interfere with the side wall of the furrow, causing it to fall and bury the banded wetter. Trials across soil types and crops throughout the state have shown average yield increases of 227kg/ha (Blackwell et al., 2014).

Research suggests banding wetting agents is more beneficial with early or dry sowing. Recent trial work on deep sands and sandy duplex soils show the yield response to banded wetters is on average 11 per cent with dry sowing but there is no significant benefit if sowing, after rain on sands (GRDC, 2018). On forest gravels the average increase in yield response to banded wetters is 18 per cent for dry sown and 5 per cent for sowing after rain (GRDC, 2018).

Canola yield increases on loamy repellent gravels in Kojonup have ranged from 0.3 to 0.5t/ha and barley yield increases from 0.3 to 1t/ha (Davies et al., 2016). Yield improvements of 8 to 32 per cent have also been measured on deep sands near Binnu and Badgingarra in low to moderate rainfall seasons (Blackwell et al., 2014). Responsiveness on loamy gravels tends to be higher with the use of banded wetters (Davies et al., 2015) and therefore provides a good short-term option for growers with those soil types where more aggressive soil tillage methods are not feasible.

BANDING NEAR THE SEED

Wetters can also be banded below or near the seed and applied with UAN or other liquids. Typically the wetter needs to be placed within 20mm of the seed to be effective. Trials at Meckering demonstrated soil wetter applied with UAN or on its own below the seed significantly improved wheat plant numbers by 37 to 88 per cent. However, this did not translate through to yield gains, which may have been limited by seasonal conditions and subsoil constraints (Davies et al., 2016). At Kojonup a 1t/ha increase in seed banded wetters was observed in barley (Davies et al., 2016). Banding wetting agents with the seed can help improve seedling establishment equivalent to banding on the furrow surface. It is important to note that variability between seasons has shown this method is not always as effective as banding on top of the furrow and some products will work better than others.

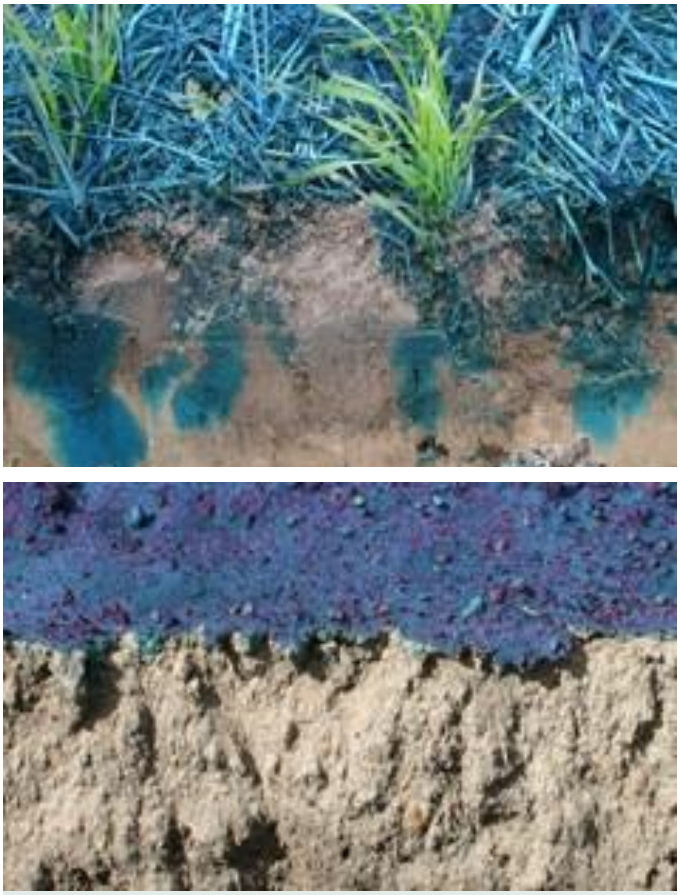
APPLICATION ON THE SEED

Seed coating with wetters is a relatively new area of research being investigated to improve crop establishment on water-repellent soils. Similar techniques have been used to improve native grass establishment in the Pilbara. Trials in 2017 (Anderson et al., 2018) compared varying rates of wetters either banded on top of the furrow, banded 2cm below the seed or as a seed coating at Badgingarra and Darkan. Use rates of wetter coated to the seed ranged from 0.065L to 0.325L/ha while wetters banded on top of the furrow or below seed ranged from 1 to 5L/ha.

Cereal crop establishment was similar to those achieved with furrow-applied banded wetter, suggesting that the use efficiency of wetters is increased when seeds are coated, given similar crop establishment was achieved for seed coating or banding techniques. This method may be advantageous from a product handling point of view, with lower use rates and therefore costs. However, further research is required to adapt seed coating techniques to commercial seed companies and the potential for on-farm application by growers.

Stubble retention

Some growers in WA have been managing water-repellent soils using no-till and full stubble retention. Despite the fact that retention of stubbles increases soil organic matter and consequently increases soil water repellence, growers are having success using this method.

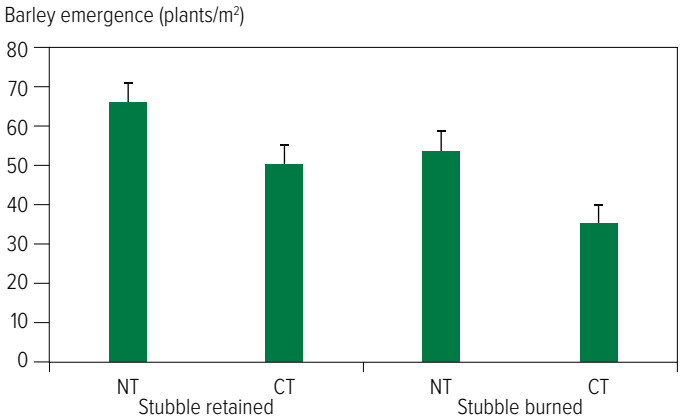


Improved water infiltration shown with blue dye (top) on a soil with no-till and residue retention, compared with minimal water infiltration (above) on a cultivated and burned residue soil treatment. PHOTO: DPIRD

Extensive trial work by Margaret Roper and Phil Ward (CSIRO) involved a four-year study at Munglinup. They are monitoring water infiltration, water repellence, soil carbon and crop performance across treatments comparing zero tillage against annual cultivation and stubble retention versus stubble removal by burning or grazing. Soil water repellence, as expected, was highest in the treatments with stubble retention and zero tillage that had higher soil C levels. Soil water content, however, contradicted these findings with infiltration of water best under zero tillage and stubble retention, resulting in improved crop emergence. Under no tillage, residual roots systems are undisturbed and these provide a preferential pathway for water to infiltrate the soil, bypassing the repellent soil layer.

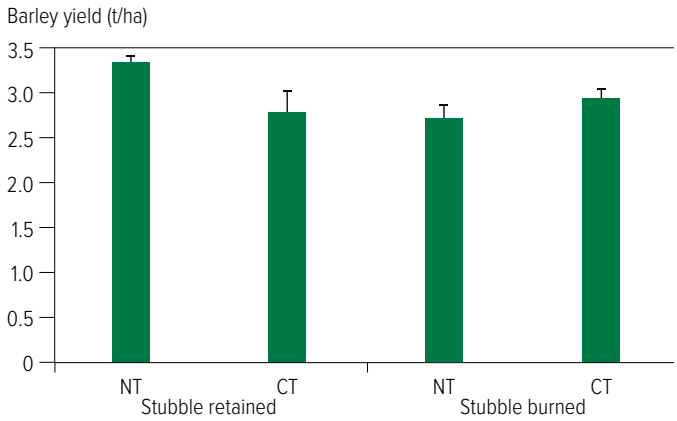
Despite decreases in water repellence and soil carbon in the plots that were cultivated and residue removed, this did not translate through to improved crop establishment and yield. Plots with no-till and residue retained often had better crop establishment and grain yield (Figures 10 and 11).

FIGURE 10: Barley emergence comparing no-till and cultivation under either stubble retained or stubble burned treatments at Munglinup, 2009.



There was a direct benefit of no-till/stubble retention on plant emergence compared with all other treatments (l.s.d = 9.57) (Roper et al., 2015).

FIGURE 11: Barley yield comparing no-till and cultivation under either stubble retained or stubble burned treatments at Munglinup, 2009.

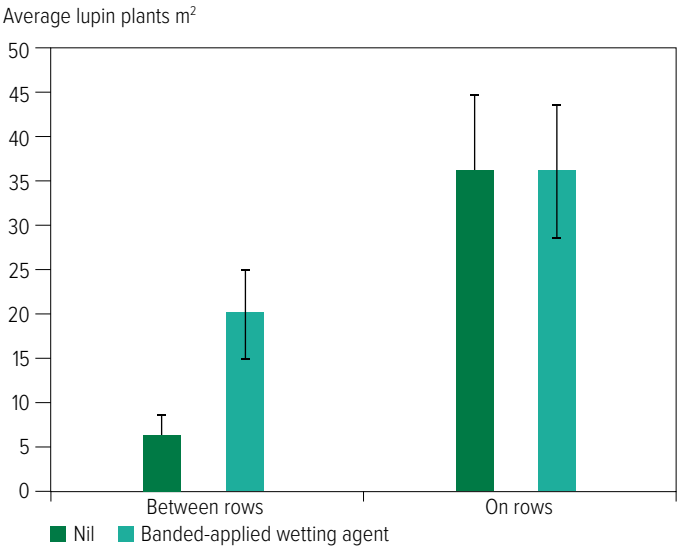


Grain yields were highest under the no-till stubble retained treatment (l.s.d=0.32) (Roper et al., 2015).

On-row sowing

Growers have also observed better crop establishment when they sow on or very close to the previous year's crop row. A trial in Balla in 2011 (Davies et al., 2012), using wetting agents with dry sown lupins demonstrated improved crop establishment when seed was sown between the previous year's wheat rows with banded wetters. However, improvements when sown on the same row as the previous season's wheat crop were much greater in comparison (Figure 12).

FIGURE 12: Dry sown lupin establishment when sown either between or on the previous year's wheat rows and with or without (nil) banded wetting agent at Balla on deep yellow water-repellent sand in 2011.



Lupin establishment is increased significantly by sowing on the same row as the previous year's crop compared with the inter-row in Balla 2011 (Davies et al., 2012).

Similar results from a trial in Calingiri measured up to 4 per cent volume per volume (v/v) more water in the crop row compared with the inter-row with significant differences in crop emergence of 147 plants/m^2 in the row compared with 79 plants/m^2 in the inter-row (Roper et al., 2015). Further trials in Pingrup (Roper et al., 2015) also measured higher water contents of 7 per cent in the furrow compared with 6.2 per cent in the inter-row averaged across nine sampling times in 2015 and 2016. It was hypothesised that wetter furrows promoted microbial decomposition of waxes, resulting in a reduction in soil water repellency. Results from this trial measured numbers of wax-degrading bacteria were 10-fold higher in the furrow than in the inter-row, and further work is being done with this.

To ensure accurate sowing either on or close to (within a few cm) of the previous crop row and therefore into the moisture zone, some growers use a device on their seeders that independently steers the bar to ensure precise placement of the seed onto or as close to the row as possible.

Stubble retention and sowing on or next to the previous crop's row may be a viable tool for improving crop establishment in water-repellent soils. As seen in the photo at the top of the next column, the canola crop sown onto the row (left of the photo) has established, whereas when sown on the inter-row establishment was severely affected (right of the photo).

Significant improvements in canola establishment sown on the row (left of photo) compared with canola sown on the inter-row (right). PHOTO: DPIRD

It should be noted that it does take time to see results, particularly if cultivation and stubble removal methods were previously used. Further research also needs to be conducted to investigate the potential for leaching of nutrients using this method and if fertiliser strategies need to be amended.

Delayed sowing and increased sowing rates

Dry sowing onto repellent soils greatly increases the expression of repellence and should be avoided where possible. In one case where canola was dry sown into a paddock and the remainder was sown following rainfall, the crop sown dry had very poor establishment while the wet-sown establishment was much better.

Canola sown into wet soil had significantly better establishment (left of photo) compared to canola sown into dry non-wetting soil (right of photo). PHOTO: DPIRD

Trials investigated seeding rates and two times of sowing – early and dry, and later and wet – on wheat establishment on water-repellent soils across four different locations (Davies et al., 2015). Increasing sowing rates from 60 to 120kg/ha increased establishment by 73 per cent at Binnu, 56 per cent at Warradarge and 77 per cent at Yealering at the first time of sowing. Visual emergence ratings at Cranbrook also suggested better establishment at higher seeding rates.

In this trial increased sowing rates resulted in better establishment across all sites at early dry sowing; however, yields were not improved in lower rainfall locations, whereas they could be beneficial for higher rainfall areas. Delayed sowing provided an opportunity to control weeds, which is important on water-repellent soils.

If dry sowing in repellent sands is unavoidable, it is recommended to sow as close to the previous crop row as possible to assist crop establishment. Delaying sowing on water-repellent soils until soils have wet up is recommended to ensure better crop establishment.

Key points

Mitigation options are relatively low cost, but they are short-lived in their effect. Growers may begin by testing different seeding points/boots and sowing closer to the row with wetters to find out that method will be most beneficial to their farming system. These methods provide good short-term options which once implemented have few risks, allowing growers to apply them over all their water repellent soils at relatively low cost.

- Winged points improved crop establishment and yields by 140kg/ha compared with knife points on repellent deep sands
- Winged boots with twin row sowing increased yields by 400kg/ha on repellent deep sands
- Blanket applications of wetters are best suited to loamy gravel repellent soils compared with deep sands. It is more cost effective to patch spray problem areas than whole paddocks
- Banding wetters on the furrow improved yields by an average of 227kg/ha. Responses seen were larger when used with early dry sown crops
- Press wheels that are V-shaped or round help improve furrow stability, particularly when banding wetters on top of the furrow
- Wetters can be banded below the seed with UAN, improving crop establishment and yield. Responsiveness tends to be better on loamy gravels than sands
- Seed coating with wetters is a new method that uses lower rates and provides similar improvements to banded wetters
- Retention of stubble and no-till systems have proven to help growers overcome water repellence, increasing crop establishment and yields on the south coast of WA
- Stubble retention and sowing on or next to the previous crop's row may be a viable tool for improving crop establishment in water-repellent soils
- Dry sowing on repellent soils is not recommended and where possible sowing should be left until soil has wet up
- Increased sowing rates have shown improvements in crop establishment when sown dry

Amelioration

Amelioration techniques are long term and have a high cost. They change the properties of the soil surface and therefore remove the water repellence.

Tactics include:

- soil inversion (mouldboard, square or modified one-way ploughs);
- deep soil mixing (rotary spaders, large offset disc ploughs); and
- clay subsoil application by spreading or delving.

A one-off deep cultivation for soil renovation and weed control has continued to increase in popularity across Western Australia. Researchers and growers, particularly in the NAR, have been experimenting with this technique using either a full or partial inversion of the soil.

Soil inversion

This technique involves a full inversion of the soil, burying the repellent topsoil and bringing up wettable subsurface soil. This can be achieved using mouldboard, square or modified one-way ploughs. Initially employed by growers to bury resistant weed seeds, this technique is now being used predominantly to address non-wetting sands, subsoil acidity, subsoil compaction and water and nutrient holding capacity.

Yield improvements following the first year after mouldboard ploughing have shown an average increase of 544kg/ha across 16 comparisons and 338kg/ha three years after (Davies et al., 2012). Costing approximately $100 to $120/ha, this method is more expensive initially, but the benefits can last up to 10 years or more. This has been demonstrated at a trial in Mingenew (Davies et al., 2015), which used mouldboard ploughing and lime treatments to show a long-term benefit on yields. This trial determined that a one-off amelioration can provide long-term benefits (up to eight years) provided multiple soil and agronomic constraints are corrected.

There can be issues with soil inversion on forest gravels as demonstrated by trials in Kojonup (Bakker et al., 2014), whereby crop emergence was reduced. Although the non-wetting issue was removed by soil inversion, poor establishment could reduce grain yield. In contrast, other trials at Kojonup on forest gravels (Davies et al., 2016) demonstrated mouldboard ploughing increased early crop establishment by 24 per cent, leading to yield improvements of 62 per cent. Further research is required to see if this method is suitable for these soil types.

Significant improvements in crop establishment by mouldboard ploughing (right) versus untreated (left) on a repellent sand. PHOTO: STEPHEN DAVIES, DPIRD

Deep soil mixing

Deep soil mixing using a rotary spader or large deep-working offset discs results in partial inversion and mixing of the topsoil while also lifting seams of the subsoil to the surface, which creates more preferred pathways for water to infiltrate, increasing the soil wettability. These techniques are useful for mixing lime or clay into the soil, making it more accessible, unlike a soil inversion which buries the layer of clay or lime at depth.

Yield increases of 603kg/ha have been shown in wheat across 12 comparisons in the first year after spading (Davies et al., 2012). Costing approximately $150/ha, this method also has long-term benefits of three to seven years.

Significant improvements in crop establishment from spading (left) versus untreated (right) on repellent deep sand. PHOTO: STEPHEN DAVIES, DPIRD

Claying

Water repellence can be overcome by spreading or delving clay-rich subsoil that is incorporated into the topsoil, aiming to lift the clay content of the repellent topsoil to 3 to 7 per cent. Research has shown a topsoil clay content of 3 per cent or more can overcome water repellence in a soil with an organic carbon of less than 1 per cent. Soils with higher organic carbon of 1.5 per cent require a topsoil clay content of 5 to 7 per cent (Davies et al., 2017). Yield improvements range from 20 to 100 per cent (Davies et al., 2017) with application rates of 75 to 150t/ha costing between $300 to $900/ha (Davies et al., 2012).

Research (Hall et al., 2010) demonstrated yield increases of 0.3 to 0.6t/ha on repellent sands on the south coast of WA with the addition of 200 to 300t/ha of clay, with significant increases in yield production for eight years after clay was applied.

Similar results have been shown in recent trial work (Betti et al., 2018) on deep pale repellent sands in the West Midlands region of WA. In this trial the addition of 100t/ha of clay in combination with either one-way ploughing or spading increased lupin yields by 0.5t/ha and 0.6t/ha at Badgingarra and Moora respectively. Similar trials with barley on a deep pale sand at Moora achieved yield improvements of 1t/ha by applying 100t/ha of clay in combination with spading. On a water-repellent sandy gravel soil in Moora, the greatest yield benefits came from low rates of clay (50t/ha) in combination with deep tillage using a one-way plough. Clay spreading improved yields in these trials and can be more cost effective when combined with spading or one-way ploughing at low rates (50t/ha sandy gravels and 100t/ha deep sands).

Sandplain topsoils generally have limited nutrient-holding capacity due to low organic carbon and clay content (Hall et al., 2010.)

Amending poorer soils with nutrient-rich clay can improve nutrient availability. Results from seven field sites (Bell et al., 2017) found adding clay rich in potassium (K) was beneficial to crops if the original topsoil was low in K. Similar results were also seen for phosphorus, but it is recommended that testing of the subsoil (if delving) and topsoil be carried out prior to undertaking claying to maximise the returns on investment.

Rotary spading a water-repellent deep yellow sand at Binnu. PHOTO: STEPHEN DAVIES, DPIRD

Delving

Delving of clay subsoil is an option in duplex soils that have clay at depth. Large angled delving tynes penetrate the subsoil clay layer and lift it to the surface. However, as the depth to the clay layer can vary across a paddock, the amount of clay lifted to the surface also varies, so the results from delving are often less consistent than spreading. Recent trials (Edwards et al., 2017) have shown that delving on shallow clay duplex soils of the south coast of WA significantly improved yields by up to 770kg/ha in the first year, even though treatments did not significantly improve crop emergence. The majority of yield benefits are thought to be attributed to a reduction in subsoil strength from delving and greater root density at depth, giving plants access to the clay-rich subsoil, which has higher nutrient and water-holding capacity (Edwards et al., 2017).

Effective incorporation is essential for claying to be successful, as poor incorporation can lead to:

- surface crusting;
- increased run-off; and
- poor crop establishment.

Some issues from claying include (Davies et al., 2017):

- crops can grow large amounts of biomass, making them prone to haying off and poor yields;
- compaction from machinery used to spread the clay; and
- nutrient deficiencies or toxicities from applying high rates of alkaline subsoil with high levels of salt or boron, which can also lead to poor yields although this is rare and is typically only a short-term issue.

Trials in Binnu and Balla (Davies et al., 2012) have shown decreases in yields from claying are likely due to the warmer and shorter growing seasons, whereby keeping moisture at the surface makes it prone to evaporation. Generally claying is better suited to areas with higher rainfall and higher yield potential, providing a good long-term option for amelioration of these soils lasting 10 to 15 years or more.

Other benefits from claying include (Davies et al., 2017):

- reduced wind erosion risk as topsoil is stabilised with higher clay content;
- increased nutrient retention in the topsoil;
- increased capacity to store soil carbon; and
- addition of nutrients, especially potassium and sulfur, and alkalinity from some subsoils.

Amelioration tactics are costly and slow to implement but are long-term, provide significant yield increases and do not need to be repeated each year. Additional benefits include removal of compaction, burial of resistant weed seeds with full soil inversion, and an opportunity to ameliorate subsoil acidity issues through incorporation of lime. Due to the high risk and costs involved it is important that they are implemented carefully, targeting paddocks with good yield potential that mitigation tactics have not improved.

Key points

- Soil inversion is a good long-term option for managing water-repellent sands. Results on forest gravels have been variable
- Deep soil mixing (for example, spading) provides a good medium to long-term option, allowing for lime and clay to be incorporated into the soil
- Claying provides a very long-term option with benefits for 10 to 15 years or more; however, it is costly and good incorporation is essential for it to be successful

Avoidance

Avoidance techniques include alternative land use where it is not economical to implement other strategies.

Alternatives include planting perennial species such as (Roper et al., 2015):

- Kikuyu, which has been popular on the south coast;
- Rhodes and panic grass, which are commonly grown in the NAR; and
- Tagasaste, which is ideal for water-repellent sands.

These provide year-round soil cover, reducing erosion and offering grazing for livestock.

Establishment post amelioration

Although amelioration is needed to improve crop establishment on non-wetting soils, there can be some issues with crop establishment in the first few seasons after inversion or deep soil mixing.

These include:

- seeding depth is difficult to control in soft uneven soils;
- removal of topsoil and burial of stubble leaves the soils exposed and at increased risk for erosion;
- crops sown are at increased risk from sand blasting until well established;
- removal of topsoil organic matter reduces soil nutrient and water holding capacity;
- topsoil can be less fertile;
- increased risk of crop damage from pre-emergent herbicides; and
- lifting of higher clay content subsoils to the surface can result in surface crusting, which can interfere with seedling emergence.

Erosion risk

Complete soil inversion or deep soil mixing removes stubble, leaving topsoil exposed and at risk of erosion. Cereal cover crops should be sown into wet soil as soon as possible after amelioration to help minimise the crops' exposure to sandblasting.

Improving soil surface

The soil surface can be left uneven after deep tillage, which makes seeding depth control difficult, often resulting in poor establishment as crops are sown too deep. Towing a weighted roller or hydraulic cage roller over the paddock can help achieve a firm, even seed bed.

Cloddy soil surfaces are also common, so a prickle chain, disc harrows or offset discs can be used to help break up the clods and even out the surface. Choosing to sow larger-seeded crops such as cereal grains or legumes is an option particularly where seed depth control is an issue.

Some growers have been using the following tactics to help improve establishment (Isbister et al., 2018):

- using lighter seeding bars to sow crops on renovated soils to help minimise the bar sinking, preventing deeper-sown crops;
- broadcasting seed onto wet soil and packing down with coil packers;
- some have had success using shallow seeding points or even worn knife points to help minimise deep sowing; and
- using cross sowing, whereby crops are sown on a 45-degree angle, is thought to help with establishment issues. However, in a controlled traffic system this nearly doubles the trafficked area, so some consideration needs to be given to using this method.

A weighted roller is towed to achieve a firm, even seed bed.

PHOTO: BINDI ISBISTER, DPIRD

Interactions with pre-emergent herbicides

Reductions in soil organic matter after amelioration can change how pre-emergent herbicides work and, in some cases, can increase crop toxicity. Recent research (Edwards et al., 2018) has demonstrated that reductions in organic matter from soil inversion resulted in increased phytotoxicity and leaching of some herbicides. Changes in soil strength and structure can lead to herbicides being more mobile and increases the likelihood of herbicide-treated soil coming into contact with the emerging crop, resulting in crop toxicity.

The aforementioned research showed diuron caused the greatest yield losses in barley, it would be best to avoid using this as a pre-emergent in the first season after soil inversion.

Damage from Boxer Gold® (prosulfocarb and s-metolachlor) was minimal where seed and herbicide separation was achieved, but crop establishment and yield was reduced where this wasn't achieved.

Sakura® (pyroxasulfone) is more mobile in the soil. However, wheat has a high tolerance and minimal damage was seen, so this may be a good option for wheat sown after soil inversion. Trifluralin was tolerated by barley and triasulfuron (Logran®) was tolerated by wheat.

Reducing herbicide rates may be tempting after soil inversion to reduce herbicide toxicity. However, research (Busi et al., 2012) has demonstrated that using sub-lethal herbicide rates will lead to herbicide resistance and is therefore not recommended.

Further research is required to understand herbicide interactions in the soil in subsequent years after soil amelioration to develop a safe and effective herbicide strategy for growers.

Fertiliser strategy post amelioration

It is thought that in the first year after soil inversion, there will be an increase in mineralisation and availability of nutrients to plants. Research trials (Scanlan et al., 2013) in Badgingarra have shown that mouldboard ploughing and spading treatments produced higher soil moisture contents compared with control and banded wetter treatments. Higher nitrogen uptake was also noted for soil inversion treatments, suggesting that higher rates of nitrogen mineralisation had occurred. It is strongly suggested that tissue testing be done on crops grown on soil that has been inverted so growers can apply accurate rates of fertiliser.

Research into this topic is limited and so GRDC has recently invested in a new research project to better understand nutrient distribution and availability in ameliorated soils in WA.

Key points

- Cereal cover crops should be sown as soon as possible into wet soil after inversion to minimise the risk of sandblasting
- Good crop establishment post soil amelioration can be difficult
- Controlling seeding depth on soft soils can be improved by towing a weighted roller or hydraulic cage roller
- Towing a prickle chain, discs harrows or offset discs can assist in breaking up soil clods and smoothing the soil surface
- Lighter seeding bars can prevent sinking
- Seed can be broadcast and packed down with coil packers
- Cross-sowing at 45-degrees may improve establishment but can increase compaction, which is not ideal in a controlled traffic system
- Soil changes can lead to increased crop toxicity from pre-emergent herbicides
- Nitrogen uptake was observed to be higher post amelioration, but further work is required
- Tissue testing is strongly recommended to ensure accurate fertiliser rates are applied

Which seeding system?

Selecting a specific seeding system to suit a grower's needs requires a lot of consideration, but can lead to significant benefits in crop performance. Western Australian cropping regions have a diverse range of soil and environmental conditions to consider and there is no one-size-fits-all answer.

Unfortunately, in Western Australia a large-scale trial looking at different seeding systems has not been conducted. However, Western Australian No-Tillage Farmers Association has just begun a four-year project looking at different seeding systems and establishment in Western Australia, which is part of a larger national project is being led by Glenn McDonald (University of Adelaide). In addition, in early 2019 GRDC will publish a case study booklet featuring the seeding systems 25 WA growers use to successfully achieve optimal crop establishment.

In South Australia at the Hart Field Site (Hart Site Inc, 2016) a trial over 16 years investigated three different seeding systems: strategic (worked up), no-till and disc systems. This trial established that no particular seeding system consistently outperformed the others with yield. Rather the decision about which seeding system to use lies with other factors including:

- weed and pest management;
- speed of sowing;
- stubble management;
- non-wetting soil issues; and
- soil compaction issues.

Machinery demo days organised by grower/farmer groups offer a great opportunity for growers to do their own research, in addition to seeking advice from agronomists/consultants and/or speaking directly with dealerships to make a well-informed decision on what best suits their needs.

Conclusion

As farming enterprises continue to increase in size, early sowing and moisture seeking by deeper sowing will continue to be used as a tool by many growers to establish crops in a timely manner.

As revealed in this publication, there are suite of tools that can be used to help improve crop establishment in a drying soil profile. In summary:

- Using varieties with long coleoptiles when moisture seeking and retain large seed for cropping programs.
- Select seed dressings and pre-emergent herbicide options that do not inhibit crop establishment.
- Separate seed and fertiliser to optimise establishment.
- Match maturity of varieties with sowing date to maximise yield potential.
- Trial narrow row spacing on wheat and wide row spacing on lupins and canola for improved crop establishment.
- On water-repellent soils, mitigation options offer low-cost, short-term solutions.
- Amelioration of water-repellent soils costs more but provides long-term solutions.
- Establishment of crops post soil renovation can be affected, however the long-term benefits outweigh this.
- Research different seeding systems and seek advice to see what best suits needs – there is no 'one size fits all' answer.

It is recommended that growers using early sowing and moisture seeking as a tool to establish crops in a timely manner should explore and trial the options available to them to help improve crop establishment. Often a mix of management tools will be required to achieve this and the optimal mix will differ between farms depending on which factors are limiting.

Locations of growers who feature in the case studies

MAP: WWW.NEILCLARK.COM.AU

Spreading potash is safer than banding in dry times at Binnu

SNAPSHOT

GROWERS: Piet and Dale Diepeveen

LOCATION: Binnu

CROP AREA: 3100ha

ENTERPRISES: 100 per cent cropping

ANNUAL RAINFALL: 300mm

SOIL TYPES: Yellow sand

2018 CROP PROGRAM: 1550ha wheat, 775ha canola and 775ha lupins

Piet Diepeveen believes the key to farming in marginal areas is to conserve any summer rain by summer spraying as often as required.

PHOTO: CUSSONSMEDIA

Twenty years ago, it was not important to conserve summer rain, but for Piet Diepeveen it is now essential. The Diepeveens continuously crop with a set rotation of wheat–canola–wheat–lupins and they grow Roundup Ready® canola as a tool to fight herbicide-resistant radish. Piet says their rotation is also a tool to manage blue lupins, which are becoming more problematic.

"Definitely the key to farming in a marginal area is to look after that summer rain and to spray summer weeds no matter how many times you've got to spray, which gets frustrating but is definitely worth doing," Piet Diepeveen says.

The Diepeveens farm yellow sands and so managing soil compaction is a priority. They run a DBS on 30 centimetre spacings with 23cm points, which Piet believes helps make the soil more friable and aids their deep-ripping program. He also feels the 12-inch spacing is good for trash flow and the crops "hang on a bit better" in the wider rows.

CONTROLLED TRAFFIC FARMING

The Diepeveens began tramlining about 10 years ago, something Piet believes is the way to go on their sandplain soils.

"We didn't start perfectly but as we've changed seeding gear and headers, we're sticking a lot to those tramlines on three-metre wheel spacing and it seems to work for us," Piet says.

"We had to add a long auger on the header which looks crazy long to get to the next tramline and we use a track tractor to pull a 12-metre deep ripper and so the header, boom spray, spreader, all line up on that three-metre wheel track."

DEEP RIPPING

The Diepeveens own an Ausplow Easitill II on 600-millimetre spacings with longer 820mm shanks, which allows them to rip to 500mm.

"We've had some trials with GRDC and DPIRD which have been good with the soil inclusion plates, showing definite benefits there," Piet says.

"We're still working towards that ourselves, but the deep ripping and getting rid of that hard pan is definitely beneficial."

The Diepeveens can rip at six kilometres per hour because of the horsepower available. They rip every four years in front of the wheat crop, with the aim of getting deeper in subsequent years. Piet estimates that in the first year after ripping, they can see a yield improvement of about 0.5 tonnes per hectare.

"You can get deeper if you stick on the same rows and the tynes are in the same place, you could get from 450 to 500mm in four years," Piet says.

"We've played around a bit but generally we deep rip the lupin stubbles pre-wheat, because that's the greatest benefit we've found, and we don't disturb canola stubble, which can be difficult to get through at times – if you pull it all out of the ground and lay it down, it's harder to seed through."

In terms of lessons learnt from deep ripping, the biggest one would be not to leave the soil surface loose.

"We've learnt to pull a roller after the deep ripper, so we aren't leaving the soil loose on top," Piet says.

"The roller is just made of old truck tyres and we don't fill it with

> **"We've had some trials with GRDC and DPIRD which have been good with the soil inclusion plates, showing definite benefits there."**
>
> – PIET DIEPEVEEN

The Diepeveens are focused on removing their hardpan and use an Ausplow Easitill II on 600mm spacings, with longer 820mm shanks, which allows them to rip to 500mm. PHOTO: CUSSONSMEDIA

Pulling an empty tyre roller following the deep ripper firms the soil surface and Piet believes it holds moisture better as it prevents the top 50mm drying out. PHOTO: CUSSONSMEDIA

water as the tyres give enough compaction to firm the surface for a good seed bed – otherwise the top 50mm dries out because it's loose and fluffy, so if you roll it until it's flat and firm, it seems to hold that moisture better."

Depending on summer rain, the Diepeveens will deep rip from February right through to seeding, assuming they have had a minimum of 50mm of rainfall to hold the soil together so it does not blow.

LIMING PROGRAM

Spreading 1000t of lime per season for the last 20 years has improved in the Diepeveens' soil pH. They apply 2t/ha in front of the deep ripper, which does not fully incorporate the lime, but it does help a little bit.

AVOIDING SOWING DEEPER

Without Magenta$^{\phi}$ or a longer coleoptile wheat in their variety line-up, Piet is not comfortable sowing their Scepter$^{\phi}$ wheat more than 50mm deep to chase moisture. He is cautious of furrow fill and burying the seed too deep.

"I'm not using Magenta$^{\phi}$ now but a new, shorter season variety with a long coleoptile would be handy," Piet says.

SPREADING POTASSIUM (K)

The tough start in 2017 had an unexpected consequence for the Diepeveens' fertiliser strategy.

"That year we only had around 5mm of rain to start the season, it was a half-wet and dry sort of seeding and we ran out of compound with K in it, so used some other fertiliser instead," Piet says.

> **"I'm not using Magenta$^{\phi}$ now but a new, shorter season variety with a long coleoptile would be handy."**
>
> **– PIET DIEPEVEEN**

"It ended up being a positive; you could easily see a line in the crop from the positive impact the alternate fertiliser had, and as I didn't like the other one anyway, because of the corrosiveness in bins and things, that prompted a change."

While his agronomist did not agree with his decision, Piet now applies muriate of potash (MOP) with ammonium sulfate in the summer months, and the lupins gets spread with a three-way mix of urea, ammonium sulfate and potash after sowing.

IN SUMMARY

- Tyre roller gives adequate compression for good establishment
- Sowing shallower is a safer strategy than sowing deep
- Potash is spread rather than banded

MORE INFORMATION

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Ameliorating non-wetting soils is the focus in Northampton

SNAPSHOT

GROWERS: Karl, Gemma, Craig and Trin Suckling

LOCATION: Northampton

CROPPING AREA: 6800ha

ENTERPRISES: 100 per cent cropping

SOIL TYPES: Red loams, light sand and good yellow sand

GROWING SEASON RAINFALL: 300mm

2018 CROP PROGRAM: 4200ha wheat and 2600ha canola

Karl Suckling is finding that deep ripping in dry conditions is exacerbating their non-wetting problems. PHOTO: CUSSONSMEDIA

The Sucklings have embarked on a significant deep-ripping program on their sands over the past five years. While it has reduced compaction, it has also made their sands much more non-wetting. As a result, their focus is shifting from removing compaction to ameliorating soils to improve their productivity.

"On our red loams and good yellow sand, where the clay content's high enough in the topsoil, non-wetting is not a problem, but where we drift into sand hills and our lighter sands, we have a lot of problems with non-wetting," Karl Suckling says.

"The more deep ripping we do, the more non-wetting it's becoming and when we till that paddock dry with the deep ripping process, which often happens during summer, the non-wetting issues are quickly getting worse."

Karl is unsure why ripping in dry conditions is having this effect, but he knows it is definitely exacerbating the problem.

"If you can deep rip or seed while the soil's really wet, non-wetting doesn't seem to be an issue, but then timeliness is a problem, because you can't seed 2500ha in one day, so that's our biggest issue," Karl says.

About 60 per cent of the Sucklings' soils are red loams, so they plan to dry seed them first in their program as they do not have any crop establishment issues on that soil type. However, with their sandplain soils, they plan to sow when it is wet, as that reduces non-wetting issues.

DEEP RIPPING

The Sucklings have been focusing on trying to get the pH right on their sandy soils, especially at depth, so for the past two years they have been deep ripping with inclusion plates. Their 12m machine can rip to about 500mm, but with the inclusion plates, 450mm is the maximum and most of the time they are only at 400mm because of horsepower limitations.

"The inclusion plates are definitely better for getting lime through the profile, we see a tenfold better response from the inclusion plates than deep ripping alone," Karl says.

"However, you just don't get as deep, and there's definitely a response to deep ripping.

"In 2018, we deep ripped 600ha without inclusions where we believe the pH is getting to where we want it, whereas for rest of the program, we believe that lime is the limiting factor, so we've used the inclusion plates and not gone as deep, so there is still a hard pan down at around 450mm."

Despite owning the biggest tractor on tracks available, horsepower is still a limitation for digging deeper, so another option is to go to a smaller machine, which would mean a six-metre-wide ripper to keep in-line with their controlled traffic system.

"We've got a trial in this year looking at whether we should change from a 12m machine, which doesn't rip as deep, to a 6m machine which could rip deeper but I think the economics will still stack up with the 12m machine, doing it over time," Karl says.

The Sucklings use a seven board John Deere square plough to speed up lime incorporation by dropping it to a depth of about 350 to 400mm and Karl says it almost acts like a mouldboard plough. PHOTO: KARL SUCKLING

SQUARE PLOUGH

Aside from deep ripping, the Sucklings have a seven board John Deere square plough that achieves two things: it speeds up lime incorporation by dropping it to a depth of about 350 to 400mm, and it acts almost like a mouldboard plough, although it does not quite give the full inversion as a seam of topsoil comes to the top.

"We're not chasing weed control with it, for us it's just a matter of trying to get that lime to the soil it needs to be in contact with, and probably the major positive is we're bringing up clay by doing that," Karl says.

The Sucklings have had good results with the square plough on sand over gravel soils, not only because the machine is robust, but also because of the additional clay that comes up with their gravel. They also use the square plough on light sands, but when they used it on good yellow sand over clays it brought up too much clay to the surface. This had a negative effect on germination, but Karl is not concerned.

"Our plan in 2019 will be to deep rip that country and then probably try and use the coil packers to mix a bit of sand in with the clay behind the deep ripper and seed it dry," Karl says.

"We will be treating it almost like our red country, where we get into it dry, because what we're finding is when we're doing it wet, the press wheel's making the soil set like concrete behind you, so that's our plan – whether or not it works, we'll see."

Karl also says while the plough only covers about 3.5ha an hour, it does not use a lot of fuel and so it is a very cheap machine to run.

WETTERS

As a means of getting around non-wetting issues, the Sucklings trialled the wetters Irrigator™ and SE14™ in 2018 over 1300ha of canola that had been deep ripped. Irrigator™ was applied behind the press wheel and the SE14™ with the seed boot.

"We got our seed placement awfully wrong because we seeded at about 10 to 15mm and then after a little bit of wind and a heavy rain, it went to about 70mm and so the canola didn't come up," Karl says.

"Then we reseeded the paddock and I actually dug a cross section on the wetter, and I wish I'd taken a photo of it, because I believe the wetter worked really, really well.

"If we had used hockey boots, which we normally use when seeding canola, instead of wheat boots, which was recommended because we were using the wetter, then I believe with the wind and the heavy rain, the canola would've ended up about 15mm with the wetter, and it would have been perfect.

"I believe the wetter would have worked really well as a one-off, but the reason we're not pursuing that in the future is because we believe the wetter is a cost we would have to incur every year.

"And if our non-wetting's getting worse, then it's a long-term cost we're going to have to deal with, whereas we're getting a lot of added benefits with square ploughing and spading by putting nutrition that's sitting in that non-wetting band under the ground and making it wet and available again.

"The machines mix up our lime too so there's a lot of added benefits, not just one benefit with the wetters, so we've made a bit of a holistic decision to go that way instead."

SPADER

Their experience with the plough has taught the Sucklings they need to use a specific tool to fix a specific issue on a specific soil. So, after seeing trials on their farm, they have purchased a 4.5m spader at a cost of nearly five times the price of the square plough, which they will use to manage their non-wetting yellow sands.

"On our good yellow sands, we've been dealing with the hard pan first, but we haven't started yet on our non-wetting soils, so that's why we tried wetter," Karl says.

"But we've got to a stage where I think the investment in the spader is going to be a better return on our dollar straight up, by fixing the non-wetting now.

"The spader will do all the good, yellow sand areas because we found in trials this year, it mixes the sand and clay a lot better than the square plough.

"The square plough flips it, and leaves a big layer of clay on top, which is great for the real weak patches where there's not too much clay at depth, and great for the gravel but not really good on our good yellow sand over clay, because that clay then sets like concrete on the surface."

The Sucklings plan to ameliorate their non-wetting soils first and then come back with the deep ripper as both the square plough and spader do not rip deep enough to break the hard pan.

> **"The more deep ripping we do, the more non-wetting it's becoming and once we till that paddock dry with the deep ripping process, which often happens during summer, the non-wetting issues are quickly getting worse."**
>
> **– KARL SUCKLING, NORTHAMPTON**

NUTRITION IN AMELIORATED SOILS

The Sucklings are slowly learning how to manage the nutrition requirements of their newly ameliorated soils. They have noticed the crops are very slow to get going on the square ploughed soils, whereas that is not so much an issue for the spaded soils.

"I think the spader mixes up the nutrition that's already in the soil, and the crop can access it really quickly," Karl says.

"We actually noticed a positive effect on the crop with spading as it was quicker to establish than the crop alongside, whereas with the square plough, the crop was definitely slower, but once the roots reached the old topsoil, it went ballistic."

LESSONS LEARNT

The Sucklings will definitely reduce pre-emergent herbicide rates, particularly on their weaker soils, because the herbicide affected crop emergence. Karl says they will only ameliorate their soils when they are wet, not dry.

"We won't do it – it's simple as that – because there is too big a risk of a blow," Karl says.

"That's a big opportunity cost of having that machinery sitting in the shed for a year, so, there are risks, there's no doubt about that, but the rewards we're seeing at the moment look like they well and truly outweigh those risks."

IN SUMMARY

- Sow non-wetting soils last when they are wet
- Deep ripping is exacerbating non-wetting soils
- Spading and square-ploughing are curbing non-wetting soils

MORE INFORMATION

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Fixing the subsoil pH first before chasing moisture at Morawa

SNAPSHOT

GROWERS: Bill and Monique Crabtree

LOCATION: Morawa

CROPPING AREA: 5500ha

ENTERPRISES: 100 per cent cropping

ANNUAL RAINFALL: 300mm

SOIL TYPES: Mostly York gum loams

2018 CROP PROGRAM: 5000ha wheat and 500ha canola

Bill Crabtree, pictured with his grandson Emmanuel, has focused on improving his subsoil pH, which has now given him the confidence to sow early and deep if there is moisture at depth. PHOTO: CUSSONSMEDIA

Subsoil acidity has been the major constraint on productivity and profitability for Bill and Monique Crabtree since beginning farming north-east of Morawa in 2008. However, with a strong liming program and some pulsating (heavy) rains, Bill is confident his subsoil pH is improving and he can now focus on other tactics to improve crop establishment.

"I thought all of my farm was pretty good for pH because I surfaced tested it, and it was all about five and some of it was 5.8, so I thought it was great," Bill Crabtree says.

SUBSOIL ACIDITY

In 2011, the Crabtrees had 470mm of rain with about 180mm as summer rain. They stored most of that rain because Bill had sprayed all the weeds, so he believed he could have 3t/ha crops from one end of the farm to the other. However, about 30 per cent of the farm yielded from 200 to 400kg/ha.

During that season, Bill noticed some weaker yellowing patches, so applied ammonium sulfate, but after 16mm of rain and three weeks later, there was no improvement in the crop. The following year he decided to do some subsoil pH testing, which determined he had a major subsoil acidity problem.

"I found everywhere that didn't yield, at 10 to 20cm and 20 to 30cm the subsoil pH in calcium chloride was around four, plus or minus 0.1 to 0.2, and then I really knew what the problem was," Bill says.

RAINFALL TO INCORPORATE LIME

Before going farming in 1999, Bill had researched lime incorporation with rainfall and found when 4t/ha of lime was applied and two pulsating rains followed, it lifted the pH at 20 to 30cm by 0.2 of a unit. The same trend also occurred when 2t/ha of lime was applied. So as a result, Bill "poured the lime on". This was despite the conventional wisdom that it would not move down in loamy soils.

"I've since learned that once you get the soil to pH 5.78 on the surface, the bicarbonate ions are free to move through the soil profile, but if you only put 1t/ha on, you'll never get it to move because it will all get tied up in the surface and the pH won't get to 5.78," Bill explains.

However, after first discovering he needed to lift his liming program in 2011, they had three droughts in 2012 to 2014. They did not receive enough pulsating rain to flush the lime to depth, so Bill decided he needed to purchase a plough.

"At the end of 2014, I bought some ploughs and put a backpacker on them and that was the worse combination you could ever possibly have and that paddock actually hasn't yielded well since," Bill says.

"I could only afford cheap ploughs and we took every second disc off and put it down as deep as we could, so we probably got six inches deep.

"We tried to get the lime to move down, but really what we did is we buried our minimal organic matter, caused wind erosion and made the paddock rough as guts.

"The yield there initially was 70 per cent of the rest of the paddock and after ploughing, it was 20 per cent of the rest of the paddock and it had weeds, it was rough and we couldn't spray it – everything just went wrong, so I am glad it was only 30ha."

In 2015, in late February into March, Bill received three 60mm rain events, each in about two hours. About that time, his water use efficiency data was re-evaluated and Bill found that water use efficiency had improved from 7.9 to 12.9kg/ha/mm for the 2015 and 2016 harvests.

"I thought that's the pulsating rain, as patches that didn't yield anything were going well, not 1.8t/ha, but they went 1.2t/ha and they used to go 0.2t/ha," Bill says.

Magenta(Φ) wheat sown at 33kg/ha, 9cm below the furrow on 13 April 2018, taken four weeks after seeding. PHOTO: BILL CRABTREE

Bill is also a firm believer that it is better to apply lime in December when it is warm rather than April because, as he says, "you can dissolve sugar in warm water very easily".

CHASING MOISTURE

Now that Bill has improved his subsoil acidity, he is confident that he can chase moisture at depth with Magenta(Φ) wheat.

"If you put a long coleoptile wheat five inches below the surface you're going to put it into acidity, so you can't can play this long coleoptile game if you haven't fixed your subsoil pH," Bill says.

Bill first tried seeding deep into moisture in 2016 with his Seed Hawk bar on 30cm spacings, with "pretty good" results.

"In 2017 I had about 200mm in February in a couple of events and I knew there was moisture down there but I didn't know exactly where it was, so I scratched around and put it in where I thought the moisture was," Bill says.

"I shifted probably 7cm of soil out of the furrow and then I put my wheat down probably 9cm below that, so it ended up about 16cm below the original surface.

"Everywhere I did that where there was moisture at depth, which was probably 400ha out of 2800ha, it all went between one to 2t/ha.

"However, I had to spray 20 per cent of it out where no wheat germinated due to planting so deep, and there wasn't quite enough moisture there."

His experience in 2017 gave Bill the confidence to sow deep again after receiving about 62mm from a tropical cyclone in January 2018. While he did some scratching around with a shovel to check the moisture initially, he concedes he should have continued to check moisture levels. It did not rain again until 24 May.

> **"I've since learned that once you get to soil the pH 5.78 on the surface, the bicarbonate ions are free to move through the soil profile, but if you only put 1t/ha on, you'll never get it to move because it will all get tied up and the pH won't get to 5.78."** – BILL CRABTREE, MORAWA

"I started sowing Magenta(Φ) at 33kg/ha about 9cm below the furrow on 13 April and it came up beautifully, but I kept going and didn't get the shovel out as much as I should have," Bill says.

"Sixty per cent of what I sowed deep is looking near 3t/ha plus this year (2018), but I have also got 400ha of 10 plants per square metre.

"I've had a real win where I did it right and I've also got a real loss, where the crop is not as good as my late germinating shallow seeded wheat.

"It's taught me a lot and if you don't get a bit bruised then you don't sharpen your axe."

FERTILISER SEPARATION

Bill believes when sowing deep, it is critical to make sure there is good separation between fertiliser and wheat, something he is confident of achieving with his Seed Hawk.

"You've got two openers, one shallow and one deep, so I just put the DAP in the shallow tube and the wheat down deep when I'm going deep and then I switch them back when the soil is wet or I am planting dry and deliberately waiting for the rain," Bill says.

Magenta(D) wheat sown at 33kg/ha, 9cm below the furrow on 13 April 2018, taken five months later. PHOTOS: BILL CRABTREE

TIME OF SOWING

Ideally, Bill would prefer not to put his whole program in dry, but has found that waiting for a germination is just too costly. In addition to growing Magenta(D), Bill also grows Mace(D), Scepter(D), Corack(D) and Longreach Havoc(D).

"I just know that whenever I've gone dry, it yields 1t/ha more than where I've tried to wait because I've had a dirty paddock and so that's why I use Roundup Ready® canola, or TT canola if I believe it is getting too late or the cost of the Roundup Ready® seed is too expensive," Bill says.

Another positive of sowing dry is that Bill believes they cannot apply too much pressure on their loamy soils, so there is no risk of sealing over when dry sowing.

"One year I had no press wheels on one of my bars and I had press wheels on my Seed Hawk and as I had 20mm of rain, I thought that I needed to put some more pressure on it to make sure it germinates," Bill says.

"My loams ended up sealing over due to the press wheels, and where I didn't use a press wheel I had a better germination with a cheap old-fashion bar with an Agmor boot on it.

"Every year's a little bit different and you learn something every year, but what I've now learned is if it does rain, I have to watch the pressure of my press wheels so it doesn't seal over."

FALLOW HAS NOT WORKED FOR BILL

Bill has also tried chemical fallows, but in his experience on heavier loamy soils they did not result in him storing any additional soil moisture.

"In 2014 when I chemically fallowed 140ha, the first 60mm rain in February 2015 that came soaked in beautifully and it looked great," Bill says.

"Then with the next rain three weeks later, probably half of it soaked in and the other half ran off and the third rain, because the first heavy rain had smashed the soil and it had little stubble, the ground turned into concrete and 80 per cent of it ran off, so it didn't store any water over the rest of the farm."

IN SUMMARY

- Pulsating rain can incorporate lime, but is not a reliable option
- Fix subsoil acidity before attempting deep sowing
- When deep sowing, ensure fertiliser and seed separation

MORE INFORMATION

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Deep ripping and one-way ploughing are cost-effective at Three Springs

SNAPSHOT

GROWERS: Michael and Kate Morrison

LOCATION: Three Springs

CROPPING AREA: 1200ha

ENTERPRISES: Cropping and sheep

ANNUAL RAINFALL: 400mm

SOIL TYPES: Red loam, yellow loam, sand over gravel and deep white sand

2018 CROP PROGRAM: 600ha wheat, 300ha canola and 450ha lupins

Michael Morrison believes non-wetting soils are his biggest soil constraint and so for a capital investment of $5000 for a one-way plough, he is impressed by the initial results. PHOTO: CUSSONSMEDIA

When Michael and Kate Morrison first bought their farm in 2004, they originally planned to predominantly run livestock because of their sandy soils. However, they ended up cropping half the farm before deciding to pull back and crop the best 1200ha. Michael says he is confident growing wheat and canola but believes they have not been able to grow lupins well. However, nearly 15 years later, thanks to deep ripping and the use of a self-modified one-way plough, they are making considerable improvements to their soils for both the cropping and pasture enterprise.

"After talking to locals who had been doing deep ripping, and hearing the responses they were getting, we thought we'd give it a go, so we found an Agrowplow deep ripper and paid $10,000 for it," Michael Morrison says.

AGROWPLOW DEEP RIPPER

Originally the ripper was 10.4 metres wide, but the Morrisons took the wings off so they could pull it with their existing tractor and see whether it worked without another capital investment.

"Our soil type is definitely not like a Mingenew yellow sand with 2000 hectares of hardpan – it's going from gravel into white sand into yellow in one paddock," Michael says.

"There was compaction there; using a penetrometer we borrowed you could definitely find it at about 300mm, but now you can get the penetrometer to go down to about a metre quite easily."

To better understand the effect of the deep ripping across varying soil types, they ripped about 20 AB lines across a paddock and then they would leave one out, as a comparison.

"We did a weigh scale on every strip over the paddock and there was an improvement in wheat yield of between 0.6 to 0.8t/ha – it was huge," Michael says.

EMPTY ROCK ROLLER

Michael has also discovered the addition of an empty tow-behind roller is critical for optimal establishment following deep ripping. He feels many of the newer rippers do not compress the soil adequately, resulting in many people sowing too deep.

"We've had a go without a roller and we had the worst germination, whereas where we've had the roller go over it, we had better seed-soil contact and so better germination," Michael says.

COST-EFFECTIVE RIPPING

Due to their size, Michael cannot justify the cost of buying "flash or bigger gear". He believes because he has been able to try deep ripping without needing to purchase a bigger tractor, they are succeeding in improving their country without a significant capital cost.

"It costs us around $25 per hectare, and that's including wages and depreciation, so that is affordable," Michael says.

While the home farm, with its sandy gravel loams, has been deep ripped, Michael plans to deep rip more of his gravel-base country in 2019. He is hoping he will be able to push out the ripping interval, so he is ripping every four years.

"It's probably as simple as going out and buying a penetrometer and looking at the country, so we'll see," Michael says.

While it is a widely held opinion that growers should be doing controlled traffic farming (CTF) before embarking on a ripping program, Michael believes the cost of setup, their farm size and the fact that they run about 50 per cent stock makes it difficult to justify. Instead, they have done as much as they can by putting as many machines as possible on to 3m centres.

Soil profile that was deep ripped in 2016 and one-way ploughed in 2018. PHOTO: CUSSONSMEDIA

ONE-WAY PLOUGH

Michael says he had been mulling over the best way to deal with his non-wetting soils for the past five years and was getting to the point where he really needed something to work, so he decided to try a one-way plough.

"The non-wetting issue was killing us and I'm hoping now with the non-wetting soil buried, if there are weeds in it, we'll get a good germination and a good weed kill too," Michael says.

"The outlay on the plough has been cheap, it cost about $3000 and we have put $2000 worth of discs on to it.

"The only thing that's probably cost us this year (2018) is wages and time because we were doing 14ha every 12 hours as we did straight AB lines because of backpackers and to make it simple.

"As a cost per hour for wages, it was probably a bit expensive, but you've got to try it and see."

The Morrisons' plough can go to a depth of 350 to 400mm and it is operated at 5km an hour to allow for proper inversion. In terms of results, Michael has been really impressed by what they have seen so far.

"We have a paddock that's 34ha and before we deep ripped and ploughed it, we harvested 12 tonnes of lupins off it because it was non-wetting, just atrocious," Michael says.

> **"The outlay on the plough has been cheap; it cost about $3000 and we have put $2000 worth of discs on to it."**
>
> **– MICHAEL MORRISON, THREE SPRINGS**

"2017 was a poor season until spring time, and we took 52t of lupins off it, so if I can get a 1000ha of non-wetting country performing like that, I'll be pretty happy."

In 2018, Michael allowed eight days for ripping at seeding time and focused on ploughing lighter soil seams in paddocks with the idea to bring that soil up to the same level as the rest of the paddock, therefore increasing his paddock yields.

LESSONS LEARNT

Michael was advised not to apply pre-emergent chemicals on his newly ploughed paddocks because of the risk of chemical damage. He also thought because the paddocks were green when they were ploughed that they had a really good mechanical weed kill. However, in one of his weedier paddocks, he has had a huge ryegrass germination and believes he should have applied some pre-emergent herbicide.

The rooting depth of the lupins was visually about 10 to 15cm deeper in the ripped section of the paddock (left) compared with the unripped headland (right).

PHOTOS: CUSSONSMEDIA

AMELIORATING PASTURE PADDOCKS

Over the years, the Morrisons have focused on planting perennial pastures, which have performed well on their lesser soil types. However, now with deep ripping and one-way ploughing as tools, they are considering planting more annual pastures and even putting some of that pasture country back into crop.

"Basically, the pasture country that is not in crop is not the best quality country," Michael says.

"I am now looking at that country and saying right, instead of spending $70 per hectare on clover and serradella or something and sowing it into non-wetting white sand, instead we could go and plough it, and then sow it into pasture.

"Walking around with a shovel digging a few holes, there's also probably quite a bit of other country that could be brought into cropping too."

In addition, they plan to ameliorate any long-term perennial pastures that have been overgrazed after seeing another local grower have good results.

"James Dempster did a trial in 2017 where he deep ripped a perennial paddock before it was sowed and the establishment out of that was incredible," Michael says.

IN SUMMARY

- Run an empty roller behind the ripper for optimum establishment
- Modifying gear allowed amelioration to be tried without significant cost
- With amelioration, some pasture country may now be cropped

MORE INFORMATION

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Having the confidence to take calculated risks is the key at Latham

SNAPSHOT

GROWERS: Dylan Hirsch and Kirraly Thompson, Bradley and Joanne Hirsch

LOCATION: Latham

CROPPING AREA: 6000ha

ENTERPRISES: 100 per cent cropping

GROWING SEASON RAINFALL: 180mm

SOIL TYPES: Majority sandplain, minority red loams and gravels

2018 CROP PROGRAM: 3000ha wheat, 1500ha barley and 1500ha canola

Nuffield scholar Dylan Hirsch is focused on capitalising on subsoil moisture by early sowing into warm soils. PHOTO: CUSSONSMEDIA

With the majority of their country being sandplain soils, the Hirschs embarked on a deep ripping program in 2016 that has now given them the confidence to try seeding wheat about 100mm deep into warm soils to capitalise on summer rains. While they are in the low rainfall zone, with a growing season rainfall of around 180mm, they commonly receive between 70 to 100mm of rain from the end of harvest into early February.

"Our adventure into deep ripping and keeping that subsoil loose opened up the idea of being able to plant earlier, knowing that the plants are less likely to stress and are able to tolerate a lot longer periods without rainfall," Dylan Hirsch says.

"That was definitely proven in 2017, where at one farm we had a 10mm rainfall event in April and we sowed that farm with canola, lupins and wheat, and without the deep ripping I'd say a lot of those crops would've fallen over because we didn't get another follow-up rainfall until July.

"Some of those areas did die because we couldn't deep rip everything, but some of those crops actually really did surprise us with how long they were able to hang on with subsoil moisture."

DEEP SOWING INTO WARM SOILS

While the Hirschs sowed canola and lupins shallow in 2017, they chased moisture with Mace(Φ) and Zen(Φ) wheat, knowing they had moisture at about 75mm below the surface on their heavier soils.

"We decided to try and sow the seed 25mm under the moisture layer because we know even with our narrow tynes, it will still dry out so we decided to try and seed it about 90 to 100mm deep to get into that moisture layer," Dylan says.

"While we had some patchy areas, we largely had success as 90 per cent of the paddock came up and where we were able to get that crop up and going it went 1.3t/ha, so that led us to have another go in 2018 in similar conditions."

With confidence from 2017, in 2018 the Hirschs decided to sow deep again into a paddock with sandplain soils that had been deep ripped. The paddock had 100mm of summer rain in January and February and it also had an 8mm rainfall event at the end of March. While initially they thought they might be able to establish canola, they found the moisture was too deep, so they decided to plant wheat between 6 and 8 April.

"We looked up some trial data on early sown wheat and unfortunately we only had our mid to short-season wheats in the silo, so we bought some Magenta(Φ), because the trial data indicated it had the most potential for early sowing and a longer coleoptile making it more suitable for sowing down into moisture," Dylan says.

"We were trying to target about a 100mm depth again but because it was deep ripped, it left the soil surface a little bit wavy so each tyne was probably getting anywhere between 75 to 125mm deep and the moisture varied between about 50 to 100mm deep.

"So, it was quite variable – a few rows came up straight away and looked a million dollars, a few rows took a month actually to come out of the ground but a few rows just didn't come up, so we had to reseed in the end for weed competition and to make sure we hit some potential yield."

WIDE PRESS WHEELS

While furrow fill has been a widespread problem in 2018, particularly for growers who chased moisture and sowed deep, the Hirschs sow their program with a John Deere Air Hoe drill with 14cm press wheels, so furrow fill is not commonly an issue for them.

"I guess if we had a different bar with narrower press wheels or a parallelogram type bar, we'd still be trying deep sowing but we'd have to be more careful on our softer sand plain because very quickly a 75 to 80mm seed depth can become 120mm, and that could be the difference between germination and not," Dylan says.

LESSONS LEARNT

According to Dylan, mistakes are critical to learning and they have learnt from both their 2017 and 2018 experiences.

"The successes in 2017 was when we sowed in April and the failure was when we tried a little bit again in May," Dylan says.

"It was very similar conditions in terms of the amount of moisture but I think the soil temperature was five degrees cooler and if the soil is warm, the grain certainly seems to be able to come up from depth.

"Basically, my lesson is, if the soil is warm, plant deeper rather than shallower because certainly the rows that didn't come up were probably the ones that were on the shallower side of the four inches, not the deeper side."

Dylan says 2018 taught him about the importance of having retained stubble to help keep soil moisture closer to the surface. He also thinks it will give them another week in their seeding window, rather than having to sow earlier because they are worried that the soil surface may dry out.

"Because the canola was sprayed out and the paddock was deep ripped, there was very minimal residue there and so I think when we try it again, we need to make sure we have some residue, either one or two years of big barley or wheat stubble to hopefully keep that subsoil moisture layer a bit higher," Dylan says.

"So that will be sitting on the top of my mind because I think having that moisture layer one inch higher could be probably the difference between success and failure.

"I think having these mistakes and sharing and talking about them will get us closer to the successes that we're after."

FROST

While frost is a concern for the Hirschs, Dylan believes heat stress and heat shock in late August or September is a bigger issue for them, so it is important to get wheat out of the ground early.

"If we were farming further south in the central wheatbelt, I probably wouldn't sow early and deep, but for us frost will certainly be a risk but the trials say that earlier sowing is still better," Dylan says.

> **"The guys that are using insurance products well are using them to take calculated risks and ensure that they are being the most profitable farmer they can rather than trying to protect their losses."**
>
> **– DYLAN HIRSCH, LATHAM**

FUTURE PLANS

In terms of improving crop establishment on ripped paddocks, the Hirschs plan to change the engineering of their crumble roller behind the ripper and to try seeding at an angle to the ripping lines.

"Even though it looked like the surface was nice and even behind our ripping job, it wasn't really truly even, because some rows were a lot firmer or looser than others and that changed the summer moisture profile level in the soil," Dylan says.

"I think seeding on an angle to your ripping lines, while you might only still get the same percentage of plants established, it's more likely to be two out of three plants in a row rather than being two out of every three rows.

Dylan Hirsch is investigating multi-peril type insurance products as part of his GRDC sponsored Nuffield Scholarship because he believes having the confidence to sow early is the biggest opportunity cost of the Hirsch family's business. PHOTO: CUSSONSMEDIA

"For weed competition, having rows that don't come up is a big problem for us and if we can try something simple like that in a marginal start, I think that will pay big dividends."

Dylan will also consider near or on-row sowing to capitalise on summer moisture if they have "a nice furrow", particularly at the start of the seeding program where they are happier to slow down and get that accuracy.

MULTIPERIL PRODUCTS

Aside from implementing tactics in the paddock to improve crop establishment, Dylan Hirsch is also a 2018 Nuffield Scholar, supported by GRDC. He is investigating financial risk management systems in variable climates, including multiperil crop insurance.

"The reason I am investigating multiperil type products or any sort of risk management product is because I think opportunity cost and having the confidence to seed early is probably our biggest cost as a business and I dare say is probably for most farmers in WA," Dylan says.

"The guys that are using insurance products well are using it to take calculated risks and ensure that they are being the most profitable farmer they can, rather than trying to protect their losses.

This paddock had a failed canola crop in 2017, so was sprayed out and deep ripped, which meant there was very little residue on the soil surface to hold the 100mm of rain that fell in January and February. Dylan Hirsch believes this contributed to the patchy germination of the wheat that was sown between 75 to 125mm deep.

PHOTO: CUSSONSMEDIA

"I'd say a typical Australian farmer is very resilient and we can survive droughts because we can protect our losses, but I think taking more calculated risks and being more profitable is just as, if not more, important than protecting our costs."

For the Hirschs, taking more calculated risks with the goal of improving their gross margin could mean trying earlier sowing with longer coleoptile wheats or trying a few more pulses, but Dylan is certainly not afraid of making mistakes.

"I would like to have the confidence to make mistakes because I think some of the best farmers I ran into on my Nuffield trips were still making probably more mistakes than the guys farming more conservatively, and they felt like they are going forward by making mistakes."

IN SUMMARY

- Sow deep into warm soils for best results
- Soil cover is important to keep moisture close to the surface
- Multiperil crop insurance gives confidence to take calculated risks

MORE INFORMATION

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Setting the crop up to maximise potential is crucial at Latham

SNAPSHOT

GROWERS: Mark and Suzanne Wilson

LOCATION: Latham and Dalwallinu

CROPPING AREA: 4800ha

ENTERPRISES: 100 per cent cropping

GROWING SEASON RAINFALL: 200mm (Dalwallinu)

SOIL TYPES: Medium soils (Dalwallinu) and wodjil soils (Latham)

2018 CROP PROGRAM: 4200ha wheat, 230ha lupins, 165ha canola and 230ha chickpeas

Mark Wilson is focused on setting his crops up to maximise their potential rather than reducing costs to protect against dry seasons. PHOTO: CUSSONSMEDIA

The past 20 years has taught Mark Wilson the value of setting crops up to capitalise on good years, rather than restricting their potential to protect against dry seasons. He believes the financial cost of lost opportunities is greater when the crop hasn't got adequate nutrients, compared with savings made by cutting back on those nutrients in a dry year. The Wilsons run two farms at Latham and Dalwallinu, both of which have had some very difficult years.

"I think from a nutrition perspective, we have to basically make sure the plant's got everything it needs when it starts growing," Mark says.

"If you've cut back on base P fertiliser, trace elements and nitrogen because it was a late season, when the plant finally germinates it's struggling from the start because you haven't put any fertiliser on, or half the fertiliser, or whatever it might be.

"We need to remove the thought that it's going to be a bad year, because I actually don't believe that when we go into seeding we can determine if it's going to be a bad year or a good year."

This approach was again proven to Mark in 2017, when they only had 125mm of growing season rainfall at their Dalwallinu farm. They applied a nitrogen top-up of 20 to 30L/ha urea ammonium nitrate (UAN) with the belief that if it was not used by the crop that year, it would be in the following year.

"Last year, we had a 1.8t/ha average on our farm here (Dalwallinu), yet we only had 125mm growing season rainfall," Mark says.

"Only 60 per cent of our growing season rainfall, and we achieved 1.8t/ha, so when the seasons are better, we can achieve more than 1.8t/ha, because 125mm of rain is barely enough to grow a crop on.

"I think last year was a classic because we achieved a lot of hard wheat and our Calingiri went into noodles at very good prices, whereas there was a lot of low protein wheat around because many people didn't put the nitrogen on because it was a dry year."

DEEP RIPPING

After digging into the soil profile in the paddocks of some of his failed crops at Latham in 2017, Mark was convinced that he needed to provide better access for the plant roots to find water at depth. While they only had half of their average growing season rainfall (92mm) at their Latham farm, they averaged 0.4t/ha. Mark believes that if the soil had been deep ripped, their yields could have been at least 200 to 300kg/ha better.

"Last year when we dug down on our failed crops, when we got to 300mm the ground was dry, and then from 300 to 600mm the ground was soaking wet, and those crops had died on top," Mark says.

"Basically, their roots couldn't access that water, and we thought we've got to make it accessible for them so, with inclusion plates and deep ripping, we can now provide channels down to 500mm, which would enable the plants to get that water.

"This year we had early rains again, so we now know that at least half that farm is deep ripped and the roots do have access to that deep moisture."

While the need to deep rip was obvious to Mark, he believed deep ripping 1300ha in 2018 was risky. However, he knew the benefits to the soil would far exceed the negatives. His wodjil soils were deep ripped to nearly 500mm while some were to nearly 600mm, with a hired Nufab Tilco deep ripper.

"Because we had drought conditions in 2017, it made it a high-risk proposition, but after seeing what we saw, we thought about the risk of the wind blowing versus what we were going to gain out of it, and we thought that the gain was way better than the risk was," Mark says.

"At the end of the day, I would say that yes, we got our worst-case scenario in terms of winds, and with a less than 5 per cent blow over some of the dirt, that was a good result because we've got plants now that can access water down to 600mm, whereas before they were only accessing water up to 300mm."

Rather than sowing deeper, the Wilsons will rip as deep as possible beneath the seed with their DBS bar to improve capillary rise and crop rooting depth.

PHOTO: CUSSONSMEDIA

KEEP SOWING DEPTH AT 15 TO 20MM

Rather than sowing their seed deeper to access moisture at depth, the Wilsons focus on trying to rip the soil deeper with the point below the seed to get improved capillary rise and rooting depth. In addition, they find the loose soil provides a pathway for the rain to move into the soil profile and away from the soil surface where it can evaporate.

"Generally, we will go as deep as we can with the point, not with the seed depth, and I will just keep pushing my tractor until it hits 10 per cent wheel slip, and then I'm not prepared to go any more than that," Mark says.

While some choose to sow their canola as close to the surface as possible, Mark believes it is a better strategy to sow it at 10 to 15mm to reduce the chance of a false start.

"We've seen it happen some years when you get one or two millimetres of rain, and then if you've seeded the canola shallow, you can actually get a start, and then if you don't get any rain for three or four weeks, it dies, and then you get a failure of the crop," Mark says.

"Basically, we've found that if we sow 10 to 15mm deep, generally you have to get a rain of three or four millimetres to actually kick the canola into gear and then after that it should stay alive."

In 2018, Mark decided with his lupins to chase the moisture and seeded them deeper than usual; however, being planted in sandier soil, strong winds produced some furrow fill, causing a delay in lupin establishment. As a result, Mark will not be so inclined to sow his lupins deeper in the future.

LONGER COLEOPTILE WHEATS

The availability of longer coleoptile wheats would be beneficial, Mark believes, to give growers more confidence to seed deeper without worrying about furrow fill. He also believes there will be benefits in terms of reducing the impact of pre-emergent herbicides on wheat germination and establishment.

"When you start putting trifluralin and triallate with the seed, that's when you shorten the coleoptile and some years it can be worse than others," Mark says.

"We have found our DBS does a good job keeping that chemical away from the seed, so we're effectively getting a better coleoptile length just by making sure that there's no chemical with the seed."

TIME OF SOWING

For the Wilsons, to maximise their yield potential the majority of their crop will often be sown dry, with the aim of finishing their seeding program by the end of May.

"I do know farmers that don't start until it rains, but the window of opportunity for us is way before that time," Mark says.

If Mark is concerned about having all of the crop in dry and having it germinate at the same time, he will slow the pace of seeding down rather than stop.

"Generally, what we do is we slow the pace down, so this year (2018), we were only seeding for around 16 hours a day but if we end up getting a situation where we've had the early rain, then we'll make sure we're seeding for 24 hours a day," Mark says.

> **"We need to remove the thought that it's going to be a bad year, because I actually don't believe that when we go into seeding, we can determine if it's going to be a bad year or a good year."**
>
> – MARK WILSON, LATHAM

Also, as the break of the season is getting later, the Wilsons will increase their sowing rate from 40 to 50kg/ha.

"We've found that if you've got less numbers, your plant has to tiller more to get the same amount of grain per metre, whereas if we put more seed there, then effectively each particular seed doesn't need to put up as many tillers to get the same amount of grain to maturity," Mark says.

IN SUMMARY

- Do not limit the crop potential by skimping on nutrition
- Deep ripping increases access to stored moisture
- Use knife points to rip deeper rather than sowing deeper

MORE INFORMATION

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DBS is preferred over Morris C2 for hard soils at Buntine

SNAPSHOT

GROWERS: Ross, Lyn and Shaun Fitzsimons

LOCATION: Buntine

FARM SIZE: 6000ha (arable)

ENTERPRISES: Cropping and sheep

GROWING SEASON RAINFALL: 210mm

SOIL TYPES: Mixed, including deep yellow sands, heavy red and shallow sand-over-gravel and sand-over-granite

2018 CROP PROGRAM: 3360ha wheat, 500ha barley, 125ha canola and 105ha lupins

After attempting to chase moisture with their lupins, a patchy germination means in future Ross Fitzsimons will stick to sowing at their normal depth rather than sowing deeper .

PHOTO: CUSSONSMEDIA

Over the past few years, the Fitzsimons have been very happy with the crop establishment from their 18.3-metre Morris C2 bar. However, in 2018 their establishment was not as good as they had expected as they experienced trouble getting into hard soils. Canola and lupins were sown too deep and their establishment was patchy.

"There was no seed in those gaps in the rows, so I don't know whether it's a seed flow issue through the tynes or using too much air and bouncing some seed out. We just haven't worked it out, so we'll try a few things next year and we'll keep a better eye on it," Ross Fitzsimons says.

HARD SOILS

In 2018, the Fitzsimons had to stop seeding twice because they were trying to seed into paddocks that had been in pasture for two years, and the ground was too hard. Ross says that sheep did not add to the compaction in those paddocks because in 2017 they were agisted. He also believes the wet year of 2016 contributed more to those soils packing down.

"That's the only fault with the Morris bar is that if the tynes kick back at all, you lose your depth of seeding and it's like shooting the seed into the air rather than into the ground, so that's something we've just got to be aware of," Ross says.

"Unfortunately, you can't see it from the tractor, and I've been wracking my brain, trying to work out how to solve that – if I could work out which tyne was the first to let go, I could put a camera or a sensor on it."

The Fitzsimons have run their 60-foot Morris for the past five seasons after changing over from a smaller 44-foot (13.4m) second hand DBS. They believe they would not have been able to pull a 60-foot DBS with their existing tractor, so an additional capital investment would have been required, which became cost prohibitive. However, after struggling to get into hard soils this year, Ross believes the DBS would be a better way to go.

"I'd still like to go back to the DBS system because after coming out of it and doing something else, I think it's probably a lot more bulletproof system than what we're using now and it gives us the option of digging a little bit deeper at West Buntine where our current system is only an inch at best below the seed," Ross says.

"I think our biggest point we've had was seven-inch points and I know people that go nine-inch, but they can adjust their depths – they've really improved them now."

SEEDING SHALLOW IS BETTER

Normally the Fitzsimons start their seeding program sowing lupins dry, aiming to place them about 25mm deep. In 2018, they sowed the lupins just under 50mm to try and place them into moist soil.

"The first time we checked the depth of the lupins, the soil was quite wet and it was sticking together so I thought I might as well go for it, but I probably should have checked more of the paddock because it was very patchy," Ross says.

Ross says they also had problems with canola being too deep as well, so the plan in 2019 is to sow at their normal depth and not be tempted to chase moisture.

"At this stage I think we'll go back to shallower again, although from last year to this year, I think we were consistently deeper this year, on the same setting," Ross says.

"The press wheels were going in, because they were at higher pressures and especially on the deep-ripped paddocks, I think the trenches are deeper, so that could be part of the problem, but we did try on the deep-ripped soil to back off the pressure."

SHEEP

While Ross says he doesn't love sheep, he does believe they do offer some benefits to their farm. They tend to use more Gramoxone and less glyphosate than others because they spray-top with

Sheep still have a fit for several reasons for the Fitzsimons including allowing them to better use paddocks that do not lend themselves to cropping because they have shallow soils that do notstore moisture if fallowed. PHOTO: CUSSONSMEDIA

> **"I'd still like to go back to the DBS system because after coming out of it and doing something else, I think it's probably a lot more bulletproof system than what we're using now..."** – ROSS FITZSIMONS, BUNTINE

Gramoxone. Also, the Fitzsimons have paddocks that don't lend themselves to 100 per cent cropping because they have shallow soils, which also don't store moisture if they were fallowed. Stock also allows the Fitzsimons to have a permanent employee, who they otherwise couldn't maintain. In 2017, stock allowed them to more easily decide to make the call to stop sowing.

"We stopped seeding because we'd run out of stubbles to sow into and so we made the decision to pull up then, and then when it didn't rain by a certain date, which was quite late, we said no way, and packed up," Ross says.

"It was easier to stop because we had stock, so if it did start to grow it wouldn't have mattered, we could've used up the paddocks with sheep.

"Our last paddocks yielded 0.3t/ha, so if we had kept going like the 100 per cent croppers, then we would have lost more money."

AMELIORATION

The Fitzsimons have been deep ripping mainly their lighter soil types with a Yeoman deep ripper with shear pins. They have also had an extensive liming program over the past 15 or so years and have seen their pH increase into the fives on those soils. As the ripper follows the lime application, they have had some mechanical incorporation.

"Unfortunately, the shear pins on our deep ripper do limit us to where we go because if we hit rock, we break the shear pins and that's a real pain and I don't think we've got one paddock where we can confidently do the whole area," Ross says.

To get around this, in 2018 they used a set of Tiny offset discs to incorporate lime between 200 to 250mm on three paddocks.

"While we don't have the results yet, I think that by correcting the pH in the top 200mm of those shallow soils, it will improve the size of our bucket," Ross says.

IN SUMMARY

- DBS is more bulletproof than Morris C2
- Sow shallow rather than chasing moisture
- Sheep have a fit in the system

MORE INFORMATION

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Horsch Tiger offers one-pass renovation at East Pithara

SNAPSHOT

GROWERS: Ben, Kirsten and Robert Strickland

LOCATION: East Pithara

CROPPING AREA: 5500ha

ENTERPRISES: 100 per cent cropping

GROWING SEASON RAINFALL: 175mm

SOIL TYPES: Mixed – including wodjil sands, heavy reds, red loams and gravels

2018 CROP PROGRAM: 2500ha wheat, 3000ha barley and 1500ha fallow

Acidity and toxic aluminium soils have been a big focus for Ben Strickland, pictured with his family. He is now looking to ameliorate the farm's compacted soils. PHOTO: CUSSONSMEDIA

Correcting aluminium levels and low pH soil have been significant focuses for the Strickland family. Now they are turning their attention to dealing with compaction layers to make sure their crops can access soil moisture, particularly at the end of the season.

"Up until about two years ago the biggest constraint was, by far, acidity and aluminium toxic soils, so we've had a big push to try and fix that and are getting quite good results, with our yields and soil tests improving," Ben Strickland says.

"Now we've found the next issue is trying to break through hard pans as my father stopped deep ripping in the mid-'90s."

ACIDITY AND ALUMINIUM TOXIC SOILS

The Stricklands soil sampled and mapped all of their soil types and then applied the base rate of lime required to fix them. They have made subsequent applications as required, often in multiple passes.

"Over the past seven or eight years, the lighter better soils would have had 2t/ha of lime and the worst would be more like 8t/ha," Ben says.

"We've done a couple of trials that were just over 10t/ha, just to see if we can get a response to those levels.

"But ultimately we really didn't make a difference to our soils until we started ploughing the lime in."

INCORPORATING LIME

Ben first tried a set of one-way ploughs to skim "quite shallow" but found them frustrating as they had to be used "around and around". He then borrowed some offset discs from neighbours and was pleased with the results.

"Offsets are quite good because we can get big areas done very quickly, turning it in 10 to 15cm and leaving a nice finish, so while the establishment is always down, it wasn't to the point that we were really damaging our yield," Ben says.

TRIAL AND ERROR

Once the lime was incorporated with the offset discs, the Stricklands began trialling various machines to tackle subsoil compaction. They struggled to find a machine that did what they needed it to do as well as leaving a soil surface that did not cause establishment issues.

"Everything we looked at was doing a really nice job, but there was something physically or agronomically missing out of the system," Ben says.

"If we deep-ripped, often it was leaving big lumps in the paddock that we couldn't seed through or caused establishment issues, and if we one-way ploughed, then we left a very fluffy soil that we were struggling to prevent our airseeder bar collapsing into and we'd have the furrows collapse afterwards.

"We were also having a lot of trouble with the light soils blowing away or making the soils incredibly rough, if they had clay.

"We promised ourselves it would only take couple of seasons of seeding through it, and it would even itself out.

"But, even after three years on some areas, it was still at a point where you virtually couldn't spray it at the speed you wanted to, so you had to slow right down."

HORSCH TIGER MAXIMUM TILLAGE

The Stricklands had finally decided to purchase a deep ripper when they saw a machine the Liebe Group were trialling that made them rethink their plans.

"When we came across the maximum tillage machine about 12 months ago initially we considered it to be completely inappropriate," explains Ben.

Originally designed to mix in heavy stubbles in Europe, Ben Strickland purchased a Horsch Tiger to mix their lime and corrected pH soils, which are now just in that topsoil, as well as breaking the hard pan and mixing the organic matter. PHOTO: CUSSONSMEDIA

"We thought it was a European machine that wouldn't fit here at all, but then we saw it in a live demo and in trials. We realised it actually had a massive fit for what we're trying to do."

The Horsch Tiger is manufactured in Germany and was designed to turn in big stubbles, so the soil is easy to sow into the following year. Although big stubbles are not the reason why the Stricklands bought the 6m machine, they felt its capacity to mix the soils offered real potential.

"We knew we had a pH problem below 15cm that we couldn't address with the offset discs or one-way ploughs, so rather than using it as a stubble-mixer tool, we are actually using it to do the same mixing, but with the lime and corrected pH soils, which are now just in that topsoil, as well as breaking the hard pan, mixing the organic matter," Ben says.

While 2018 is the first year the Stricklands have used the Horsch Tiger, they are really pleased with what they have seen so far.

"It has physically done exactly what we wanted it to do – it took us quite a few hundred hectares of figuring out how to make it work for our scenario but, once we got there, we love what we're seeing," Ben says.

LESSONS LEARNT

Initially concerned by the narrow width of the machine, they have since found their 550-horsepower track tractor is at capacity, as the discs on the front of the machine drop about 200mm into the ground and the tynes that follow rip to about 400mm, if the conditions are wet enough.

> **"Everything we looked at was doing a really nice job, but there was something physically or agronomically missing out of the system."** – BEN STRICKLAND, EAST PITHARA

They have also found that slower is not better, with the Horsch Tiger needing to be operated at about 8 to 9km an hour to work as it was designed.

In their first season with the machine, Ben notes establishment has been variable, adding the delving function of the machine seems to have had the biggest impact. While they were not initially fussed by its delving capacity, they were impressed by how well the machine bought up some of the heavier clays from depth, which reduced wind erosion.

"It also made a channel for a lot of that topsoil to fall down into, so we got a little bit of an inclusion plate type effect," Ben says. "Not quite as well as an inclusion plate, but it's something, so we left the delving tynes on.

"Where we were getting the full depth of the machine, and where it was working very well, we were able to get a lot of what would be quite sour, yellow clay soil to land on the surface and that seems to be our worst result for establishment, which makes sense because we've added a bunch of clay without much organic matter to the surface."

Sowing shallower will be a strategy in these areas, as Ben believes the crop will need to maximise its vigour to grow through a potentially acidic, low organic carbon, crusting soil. While Ben acknowledges they have reduced their establishment in some areas, he believes the rewards far outweigh the risks.

"It is more important to be dropping topsoil down in a slot, to give the root matter somewhere to chase the moisture that so often we never reach," Ben says.

"We get to the end of the year with a dry finish and wish we would have had another 10mm, but then we dig into the subsoil and find it's wet still at 25cm.

"We never got the roots there to access it, so it's more about finding a way to get the roots to depth. Just as a bonus, bringing that clay from down deeper to the surface holds the soil, stopping it from blowing away after you've basically removed all the stubble from the topsoil, which is scary for us."

ESTABLISHMENT FOLLOWING RENOVATION

When first sowing the very light fluffy soils, the Stricklands discovered while they were getting the seed placed at the right depth, the press wheels were dropping too deep where the tractor had not driven over and not deep enough where it had. So they opted for wider closer tools and press wheels on their modified DBS.

They also have further refined the system by making the spring that holds the press wheel also hold some of the tension, which they found worked well on their renovated soils but had the opposite effect on their standard soils, which needed more pressure to get good seed–soil contact.

"Wherever we'd been through with the maximum tillage, we moved the press wheel pressures back up to the light as possible setting but given the Horsch actually has a roller as part of it, it was nowhere near as much of a problem as what we'd seen with one-way ploughing but it still seemed to give us a better result," Ben says.

"It didn't make big, deep trenches where the press wheels had been through, which we were worried about collapsing."

MORE LIME?

Given the ability of their new machine to mix the soil profile effectively, Ben thinks he may need to let the soils settle for a few years before they can take meaningful soil samples. He would not be surprised if he needs to apply more than maintenance levels of lime, because the soil has been changed so much.

IN SUMMARY

- Horsch Tiger is a one-pass renovation tool
- Optimum speed with the Tiger is 8 to 9km an hour
- Use wider press wheels and closer plates, with light pressure on treated soils

MORE INFORMATION

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In the first year of using the Horsch, the Stricklands have found optimal soil mixing occurs at 9km an hour rather than at slower speeds.

PHOTOS: BEN STRICKLAND

Budget reviews, bank managers and Farm Management Deposits are handy tools at Mollerin

SNAPSHOT

GROWERS: Peter and Cathy Cooke

LOCATION: Mollerin

CROPPING AREA: 7450ha

ENTERPRISES: Cropping and sheep

GROWING SEASON RAINFALL: 200mm

SOIL TYPES: Red sandy lake country and wodjil soils

2018 CROP PROGRAM: 4900ha wheat, 1000ha barley, 500ha canola, 200ha oats, 150ha lupins and 700ha triticale

Cathy and Peter Cooke have successfully used Farm Management Deposits to provide security in tough years. PHOTO: CUSSONSMEDIA

Using business tools to deal with dry seasons is just as important to first-generation Mollerin farmers Cathy and Peter Cooke as tactics used in the paddocks. For example, while for some people budgets can be set-and-forget, Cathy is constantly reviewing their numbers and knows when to shut the cheque book.

"I put pluses and minuses against things on our budget, so for example, how we've had a bit of a win on some sheep sales, so great, we've got a bit extra in the kitty and we can afford to do something else," Cathy says.

Farm Management Deposits (FMD) have also been a very handy tool for the Cookes, allowing them to put money away in the good times for the tougher seasons, like 2017.

"Farm Management Deposits in a marginal area are incredibly valuable for security rather than the tax planning side of it for us," Cathy says.

"Financially we're not knocking on doors looking for extra money, because we had FMDs, so they're hugely important for our business."

Like many farmers the Cookes use a range of paid professionals for guidance and they also have forged a good relationship with their bank manager, which Cathy says is really valuable.

"There's no surprises for our bank manager when something goes wrong, she's the first person to know," Cathy says.

"I think it is a huge asset to have someone that you can work closely with who can reassure you if times are tough and when times aren't so tough, they're the first person there to help you expand your business."

FEED MARKETS

While 80 per cent of their cropping program is wheat, growing some feed barley and triticale is good agronomically and allows the Cookes to provide grain into the domestic market, reducing handling fees and creating other opportunities including back loading. In addition, they grow lupins and oats generally for their sheep enterprise.

"We are growing Berkshire triticale on our poorest wodjil soils where we could grow maybe a 1t/ha wheat crop and instead on a normal year, you might get 1.4 to 1.5t/ha of triticale," Cathy says.

"It harvests just like wheat, weighs just like wheat, handles just like wheat and is priced in line with wheat."

As triticale does not tiller like wheat, the Cookes increase their standard cereal sowing rate from 50kg/ha to 80kg/ha and generally sow it with 40kg/ha of compound fertiliser and 30kg/ha of urea and will do a nitrogen top-up, if they believe the potential is there.

"Generally, we don't feed it up as much as wheat, as being on poorer country we expect poorer yields, but in 2018, we're going to have a crack at putting a bit more nitrogen on, and see what happens with a couple of test strips," Cathy says.

The Cookes now grow 1000ha of barley, consisting of Scope CL(b) and feed varieties. They believe it is fast to establish and it is well suited to their conditions.

"Barley takes off and it's tough, really tough, and it often seems to yield better than wheat," Cathy says.

FIT FOR CANOLA?

While the Cookes are confident with their cereal production, they are less comfortable with their ability to grow canola, as their average is 0.6t/ha despite growing it on reasonable country. They are growing canola as a weed management tool and to break up their heavier soils. With the right prices and in the right season, it can be a good earner.

The canola is all sown dry, but Cathy is wondering if they should be taking climate forecasts into better account. In 2017, their

canola crop failed but it was not disastrous, as they were able to graze it off with ewes and lambs. In 2018, the canola germination was patchy.

"We don't know if it was sown deeper or shallower, because I'm assuming what's happened is the guys have stopped mid run to check something, so I don't know whether they've left the bar out, or if they've gone back in deeper," Cathy says.

"Or perhaps they were going too fast and should have slowed down – I've got all these questions and I can't get answers because they're backpackers, so that's the problem with having seasonal staff on your machines."

LESSONS LEARNT

While 2017 was a very tough year, the Cookes have learnt seed can sit in the ground for up to six weeks and still germinate. This gave them confidence in 2018 with the late break that their crops would germinate once the rain came.

Sheep, in particular prime lambs, are an important part of the Cookes' business, which was highlighted again in 2017.

"We were fortunate we had the grain and hay on hand from 2016 and the income from the prime lambs is definitely what kept us going," Cathy says.

"Having said that, I spent a huge amount of time on sheep, and it was an opportunity cost, because I could have actually gone and worked off farm and generated income that way.

"I don't think it would have made as much as the sheep, but there are costs associated with them and I don't put a cost on my time as such."

The Cookes lamb at the beginning of March and while this often coincides with hot temperatures and no green feed, they are generally one of the first lamb producers in their area to send lambs to market and so receive a good premium.

"I reckon maybe seven in 10 years we lamb on green feed; after a good cyclone up north they get going on the green feed and when that dries up, they have got stubbles," Cathy says.

Generally, the lambs are supplementary fed and put onto the best stubbles in small mobs of about 400. Cathy does acknowledge she spends a significant amount of time shifting and managing their sheep.

"We count sheep as another string in our bow, so we might as well run sheep and we've got our own stock crate, so that makes it easier, too," Cathy says.

FUTURE PLANS

While the Cookes have embarked on a significant liming and gypsum program to bring their poorer paddocks up to a base level, they are just beginning to explore deep ripping after initially thinking that given the cost, it might not be worthwhile.

"We tried two paddocks in 2017 about 20km apart and both paddocks yielded 1.2t/ha, which was double the yield of the neighbouring paddocks, and ripping was the only difference," Cathy says.

The Cookes are not yet confident of choosing the right paddocks with the right soils to deep rip and so are planning on using a penetrometer and soil consultant to formulate a plan.

Through her involvement with GRDC, Cathy was pleased to learn of the long coleoptile variety development in wheat and believes it has a huge fit.

The Cookes have a very close relationship with their bank manager, who is the first person they let know when things go wrong and is there to help them expand their business when opportunities arise. PHOTO: CUSSONSMEDIA

> **"I think it is a huge asset to have someone that you can work closely with who can reassure you if times are tough and when times aren't so tough, they're the first person there to help you expand your business."**
> **– CATHY COOKE, MOLLERIN**

"I jokingly said to them, 'you could put any fool on the machine and still know you're going to get something' and then you really could chase moisture, but at the moment, we're really only confident going to four or five centimetres," Cathy says.

IN SUMMARY

- Use business tools as well in challenging conditions
- Triticale performs better than wheat in wodjil soils
- Prime lambs receive a premium for March lambing

MORE INFORMATION

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Multiple benefits from Grizzly disc machine at Bencubbin

SNAPSHOT

GROWER: Tony Sachse

LOCATION: Bencubbin

CROPPING AREA: 7450ha

ENTERPRISES: Cropping and livestock

2018 CROP PROGRAM: Cereals, pulses and canola

Tony Sachse purchased a Grizzly XL Tiny in 2015 after on-property trials in 2014 to aid lime incorporation to at least 30cm deep. PHOTO: CUSSONSMEDIA

Aside from his focus on the importance of managing soil compaction, Tony Sachse says a major constraint to good crop yields on some areas of his farm is soil acidity at depth. Having historically conducted soil sampling to 10cm, and then 30cm, soil sampling is now done down to 50cm in 10cm increments. Soil testing at depth is for pH (in calcium chloride) and aluminium levels, and by testing to 50cm Tony finds he can get excellent information on what lime needs to be applied and in what timeframe.

"Although we didn't lime enough early enough, generally the surface pH has been kept from 5.3 to 6, with some areas over six," Tony says.

"However, a decline in the subsurface levels has taken place, and with no-till planting and surface pH levels at six or below, no movement of lime into the subsoil has occurred.

"It's not all over the paddocks, and it's certainly not all over the farm, but it is in some of the higher-production paddocks.

"The decline in pH over time has seen subsoil pH levels of 4.8 to 5 fall to 4.3 or even lower and I am concerned if subsoil pH is below 4.8 and very concerned if it is below 4.5.

"If the pH levels have associated high aluminium toxicity, which they probably will, then root growth of different crops are affected because high aluminium levels can have a very severe impact on sensitive crops and pastures.

"Unless the surface is above 6.2 then it's unlikely that any significant downward movement in pH will occur, so you need significant lime applications and a very long period of time for the lime to move down naturally.

"Significant rainfall events can help in this regard but it can still take a long time, depending on soil type and location."

GRIZZLY XL TINY

To help rectify their low subsoil pH, the Sachses purchased a Grizzly XL Tiny with 107cm discs in 2015, after on-property trials in 2014. A variable rate liming program was completed based on soil test data, with applications up to 6t/ha of lime applied before incorporation with the Grizzly. The XL model was chosen because the larger discs allow deeper tillage to at least 300mm. Tony believes if this can be done properly, then a major tillage event may not need to occur for up to 15 years in a no-till system. He also finds it can help to apply lime to pasture paddocks in late winter and early spring to benefit from some rainfall incorporation prior to any mechanical incorporation.

"We like to apply lime and then allow some time to pass and/or some rainfall for it to actually be moved into the soil – it's nice if it was a few months with a few significant rain events before mechanical incorporation."

The working width of the Grizzly can be varied slightly, depending on how much aggression is required, and while the initial setup was on the third strongest setting, they have now settled on the second strongest, which is about 5.8m and a travel speed of 4.5 to 5km/h. Tony says they try to operate the machine when the soil is moist at depth to minimise the wear on the discs.

"If you inadvertently go over rocks it will ride over them, but it can chip the discs, which is disappointing, but it's not like the machine's going to be inherently damaged in any way – if you've

> "In the first year the establishment was perfect, however year two saw a poor establishment due to a very heavy rain event post sowing in combination with deeper sown grain due to dry soil at sowing."
>
> – TONY SACHSE, BENCUBBIN

got mixed country and some rocks, that's an advantage over perhaps a spader," Tony says.

"If it's very dry, there's higher wear on the discs and as well it's more prone to erosion, so it's important to get the timing right. We did have a reasonable weight package on our 530 horsepower Caterpillar tractor, but we've added a bit extra just to help with the Grizzly and keeping the wheel slip at less than 5 per cent.

"Under good conditions the wheel slip should be around 2 per cent."

INCREASED NUTRIENT AVAILABILITY

Another benefit of mechanical incorporation following liming is increased availability of nutrients, including nitrogen and phosphorus. However, Tony cautions that the majority of the nitrogen effect is in the season of incorporation, meaning additional nutrients may be required in subsequent years to cover for the already released organic nitrogen.

Tony says those planting crops following a Grizzly might need to adjust inputs, suggesting with better soil conditions they should be able to achieve increased yields. He believes with increased available nitrogen, better soil structure and improved root growth, if good establishment is achieved then a yield response of up to 20 per cent in year one with perhaps 10 per cent yield responses in future years is possible. He attributes the yield increases to the lime itself, the incorporation of the lime to depth and a reduction in compaction to at least 300mm.

"I think that in average seasons, it shouldn't take too long for the extra variable and capital costs to be returned," Tony says.

"In more challenging rainfall years with extended dry spells, the ability of crops to have deeper and greater root growth should enable yields to be maximised with rainfall."

ESTABLISHMENT FOLLOWING THE GRIZZLY

Tony says there have been some issues with levelling paddocks following the Grizzly, which is not uncommon with any ploughing treatment. Despite focusing on setting the machine up correctly, he has found the paddock finish can still be compromised.

"Depending on the soil moisture levels and subsequent rainfall events, the establishment can vary significantly," Tony says.

"In the first year the establishment was perfect, however year two saw a poor establishment due to a very heavy rain event post-sowing in combination with deeper grain placement due to dry soil at sowing.

"In 2018 the germination was a little lower than the non-Grizzly, but with good weed control the crop is looking very good and it's expected that a yield increase will occur."

Tony believes the keys to successful emergence following lime incorporation are shallow seed placement and a high sowing rate, light compaction rolling if needed, and good chemical choices that will not overly compromise coleoptile length of the seedlings.

"Using an Ausplow DBS planter, we sow with a zero-depth setting with the lightest press wheel pressure available," Tony says.

"We reduce speed as well, sometimes going as slow as 6 to 7km/h to create good furrow definition while minimising soil throw, which is made easier when the soil profile is wet."

In addition, they increase sowing rates in those treated areas, from a traditional rate of around 60kg/ha for cereals up to 80 to 90kg/ha after the Grizzly treatment.

"Ideally a depth of 10mm for wheat is preferred but if it is drier on the surface with moisture at depth, then obviously we'd go deeper than that, as long as the coleoptile length of that variety can handle it," Tony says.

Tony has not tried sowing smaller seeds such as canola on country which has been recently covered by the Grizzly, saying he would be cautious with that approach after seeing even cereals struggle. However, he knows of growers who have successfully established canola in year one.

CAGE ROLLERS

The Grizzly already has cage rollers on the back of it, that leave an imprint after the treatment, which Tony thinks helps reduce the erosion risk.

"They were an option available, engineered and integrated into the machine and they work and fold well, which I believe is a good addition," Tony says.

However, the Sachses are working together with the manufacturer to better level the tilled soil. Tony is also planning to use a smudge bar in a separate operation with a tyre roller to aid levelling and establishment. He believes this extra operation, which would be done while the soil is still loose and easily moved, will be worthwhile.

IN SUMMARY

- Soil acidity at depth is the key challenge
- Grizzly is aiding incorporation of up to 6t/ha of lime using variable rate spreading
- Establishment following Grizzly treatment can be variable

MORE INFORMATION

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The width of the Grizzly varies slightly, depending on how much aggression is required, and while the initial setup was on the third strongest setting, the Sachses have now settled on the second strongest, which is about 5.8m and a travel speed of 4.5 to 5km/h. PHOTO: TONY SACHSE

Managing soil health a priority at Bencubbin

SNAPSHOT

GROWER: Nick and Tryphena Gillett

LOCATION: Bencubbin

FARM SIZE: 11,000ha (arable)

ENTERPRISES: 100 per cent cropping

GROWING SEASON RAINFALL: 170mm

SOIL TYPES: Mallee, salmon gum and lighter sands and gravel soils

2018 CROP PROGRAM: 6000ha wheat, 2000ha barley and 1500ha canola

Nick Gillett is focusing on the factors he can improve such as the friability, moisture-holding capacity and rooting depth of his soils to improve the bucket of water available to his crops. PHOTO: CUSSONSMEDIA

While annual rainfall of around 300mm has not changed too much over the years on the Gillett property at Bencubbin, what has changed is the distribution. The challenge of a lower growing season rainfall, according to Nick Gillett, is to manage available moisture well while ensuring a friable soil structure. It is for this reason that even though he likes sheep, he has removed livestock from the property as they compromise the soil structure and other management decisions.

"We really need to have soil cover and stubble retention to maintain moisture, and sheep have always got this uncanny knack of camping on the barest part of the paddock, making it worse," Nick says.

"It meant we could actually never fix up some of the problematic soils that we had, so that's been the premise behind it."

ANALYSING THE NUMBERS

Before making the decision to shift out of sheep, the Gilletts analysed their numbers. Despite the fact they could make quite good returns on sheep there were several issues that ultimately led to their removal.

"To get the best return out of our sheep enterprise, we needed more food on offer, and that meant that we would spray-top late, which would mean more carry over weeds, which also caused issues with dry seeding, because obviously the weed burden is a problem," Nick says.

"We tried higher stocking rates, but that meant supplementary feeding, feed lotting and at the start of the season, because the feed just wasn't established, we were grazing crops as well.

"We tried everything we could to really make it work and, in the end, I just thought it was just too much of a compromise."

HEDGING BETS WITH DEEP SEEDING

Nick has also been focused on setting up a solid seeding system that uses available moisture effectively. Using an RTK system, they have been on 2cm accuracy from 2005, which meant in dry years such as 2006 they could seed back into the slot and chase moisture at depth.

However, the addition of another tractor in the system without the same autosteer unit means they cannot continue with that system until the guidance equipment is standardised. An additional tactic in seasons with a dry outlook has been using deep-seeding to access moisture by sowing wheat to 75 to 100mm.

"Obviously if you deep-seed and then get 50mm of rain on top, that would seal things over, but we have had good results," Nick says.

"We hedge our bets, so we might put 50 per cent deep banded and 50 per cent on top, or we might increase the sowing rates and combined with the ability to seed in-between the rows if you had high stubble loads, that was working extremely well."

The deep-seeding tactics also meant a change in fertiliser and seeding rate tactics as well. Initially they deep-banded Flexi-N, before turning more recently to deep-banded urea.

"Basically, if we're chasing germination and we're seeding deep, we'll pull nitrogen out of the system and just go compound split 50/50, so there's no risk of toxicity or anything like that," Nick says.

"In terms of seeding rates, we generally aim for 55 to 65kg/ha, which we increase when seeding deeper, depending on the soil types – if it was a really heavy clay soil, we probably wouldn't push things too high.

"But obviously on the lighter medium soils I certainly wouldn't have an issue going to 80kg/ha or similar to compensate for the depth, increasing the rate by 10 to 20 per cent."

IS SEEDING SHALLOW BETTER?

Despite the success of deep sowing tactics previously, the 2018 season is the first time Nick Gillett has seen a significant amount of moulted wheat when deep sowing. Fifty per cent of their wheat was sown at 75 to 100mm and 50 per cent was around 50mm.

"It's not worth the issues – this year on anything that was deep-seeded, or even was just sown at 40 to 50mm, we had moulting issues, while where we sowed it at 10 to 20mm there were very little problems," Nick reports.

"It was really bad and so I'm sort of second guessing our operation now and I'm wondering whether we'd just seed shallow – if we have the same start in 2019 as in 2018, I'll think I'll seed everything shallow.

"You will get capillary rise in the slots as well, but generally if you just get a small amount of rain you harvest the moisture with the press wheel slot anyway, so maybe I'm morphing away from the deep-seeding."

LONG COLEOPTILE WHEATS

Although in 2018 the Gilletts are exclusively growing Scepter(ϕ) wheat, Nick says being able to grow particularly short season wheat varieties with a long coleoptile would be beneficial when deep-seeding.

"Because we do get a lot of out-of-season rainfall, a lot of times we'll have moisture at depth going into April but generally we'd just sow shallow and ignore it because we just don't have the ability to get the seed in and get it up.

"Having said that, when we first deep seeded, we actually had Wyalkatchem(ϕ) coming up from 100mm because there was no rain following, it was warm conditions in late May and it still came through quite well – but obviously we won't rely on Wyalkatchem(ϕ) coming through on that sort of depth normally."

MAXIMISING SOIL HEALTH

Another big focus for Nick Gillett has been soil health, particularly through management of soil pH through liming. The decision to pursue an intensive liming program came after he realised the importance of targeting the factors he could control.

"We can't change the rainfall, we can't change the rainfall patterns, so we've just got to improve friability and the moisture-holding content of the soil and also, the rooting depth of the soil to improve the bucket of water available to the crop," Nick says.

"Our heavier country contains strong fertile soils and they're traditionally early cleared wheatbelt soils but they don't handle dry conditions too well, so we're purchasing more lighter sands and mallee soils and inherently they have a lot of pH issues which, certainly at depth, can cause yield limitations."

LOCAL LIME

This means the Gilletts have always had quite a big liming program, carting limesand from the coast. Nick says that was a costly exercise, particularly due to the freight costs. However, they have since found sources of high-neutralising Morrell lime on their farm, with Nick describing the ability to convert a hectare's worth of lime from a paddock into improving 3000 to 4000ha as a "game changer".

"The neutralising value of our lime is around 30 per cent, so it's probably, give-or-take, a third of lime sand from the coast," Nick says.

> **"We can't change the rainfall, we can't change the rainfall patterns, so we've just got to improve friability and the moisture holding content of the soil and also, the rooting depth of the soil to improve the bucket of water available to the crop."**
>
> **– NICK GILLETT, BENCUBBIN**

"However, there's still some trials coming out of DPIRD showing our Morrell lime is a lot finer than limesand; they're actually getting good responses."

PLOZZA PLOUGH

Incorporating the lime effectively has been a work in progress for the Gilletts, who have used a Plozza Plough on deep sands to mix it in.

"We used the Plozza Plough on extremely deep sand on a new farm which was highly acidic, so we hit it with four tonne of limesand and a tonne of gypsum the year before and then we put up to 12t/ha of Morrell lime on it in 2018, but that was always just going to fizz around on top," Nick says.

"So, the best thing to do was to get in the root zone and the Plozza Plough definitely did that – it was working down to 250mm depth and folding it in, so I think it would have done a great job.

"On certain soil types the lime is probably doing enough to buffer the change and the issues, but certainly some of those wodjil deep sand soil types that have bad aluminium toxicity and also really poor pH, I think the Plozza Plough is just the only way you can get a quick result."

While the performance of the Plozza Plough is good, Nick admits it is quite fiddly to use and operates at very low hectares per hour. He is considering something simpler such as offset discs in the future, if he can get the depth to at least 200mm.

The Gilletts also have a deep ripper, which Nick says is good in theory for incorporating lime, but says in heavier soils with rocks, the machine can make a huge mess in their paddocks.

IN SUMMARY

- Sheep are no longer worth the compromise
- Shallow seeding might be less risky than deeper sowing
- Local lime source showing great potential

MORE INFORMATION

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Capitalising on the 'middle years' is the key at Merredin

SNAPSHOT

GROWERS: Jules and Pep Alvaro

LOCATION: Merredin

CROPPING AREA: 6000ha

ENTERPRISES: Cropping and sheep

GROWING SEASON RAINFALL: 184mm

SOIL TYPES: Heavy clay to sandy wodjil

2018 CROP PROGRAM: 3300ha wheat, 1600ha barley, 220ha lupins and 800ha chemical fallow

Jules and Pep Alvaro first tried using a weather derivative product in 2017 to protect against a dry start to the season on their higher risk, heavy clays.

PHOTO: JULES ALVARO

After a run of average to below-average years, Jules and Pep Alvaro were keen to try a weather derivative product that would allow them to farm with more confidence, knowing they were protected against big losses in drought years on their higher-risk heavy clays. In 2017 they used a weather put, after having both their own rainfall data and some Bureau of Meteorology (BOM) gridded data professionally analysed. The Alvaros successfully applied for a grant that covered 50 per cent of this cost.

"The weather put works on rainfall received in between specific dates, so our dates in 2017 ran from 11 April until 16 June, and we insured against receiving less than 39mm in that period," Jules says.

The Alvaros have a BOM weather station site close to them that is used as the official rainfall measurement station and Jules is confident it accurately reflects their rainfall received.

With the dry start to 2017, the Alvaros lodged a claim and received a payout of $23/ha after a spend of $7.26/ha. In 2018, they insured against receiving less than 39mm between 3 April and 20 June. However, pleasingly, they received more rain in this period.

ANALYSING DATA

With the aim of minimising premium costs, the Alvaros use their rainfall data with the help of their consultant to determine the time period and rainfall amount they would like to insure for.

"We're obviously trying to pay the cheapest premium we can, so sometimes if you widen the dates out with less rain, you're looking at a cheaper premium, so we are using the data to try and work out where the best bang for our dollar is premium-wise," Jules says.

The Alvaros also learnt from analysing their data that there really was not an overall pattern with their rainfall and that while their annual rainfall was not declining, more of it was falling in the summer months. Before the analysis the Alvaros believed that September was their 'money month'; but they now understand that July is, because if they have good July rainfall then a reasonable season follows.

INSURING AN APPLICATION

Since learning July is their money month, in 2018 the Alvaros insured their nitrogen application across the farm for the month of August.

"We insured basically the cost of our nitrogen that we were going to apply and if we ended up with decile one rainfall for August, we would have been able to make a claim," Jules says.

"We're so cautious because our rainfall can just cut off so quickly and so the insurance gave us the confidence to spread that N out and we think in the season of 2018 it's going to pay off."

The real benefit of the weather insurance products for the Alvaros is the confidence it gives them to maximise the potential of their 'middle years' by better understanding the weather in those years.

"We're not farming for that bottom season, but a drought is a drought and then you get probably one to two really good seasons in a decade but then there's probably another six that we can squeeze more profit out of.

"I think the main effect the insurance has had is on our attitude to spending that little bit more on our crop during the season instead of having so much of a defensive role because we've had some fairly harsh seasons.

"We're farming more like we were in our younger days, not being silly, but just putting that little bit of extra N where we think that it's going to have value."

> "You learn to understand that it's not all about farming for those high highs and low lows; there's a lot of average seasons that we can squeeze more profit out of."
>
> – JULES ALVARO, MERREDIN

FUTURE PLANS

With weather derivative products being so new, they are always changing and as more growers use them, Jules believes they are getting better. As a result, the Alvaros will continue to evaluate the products available to determine the fit for their business. For those considering trying a weather derivative product, Jules believes it is an opportunity for growers to learn a lot about their weather.

"You learn to understand that it's not all about farming for those high highs and low lows; there's a lot of average seasons that we can squeeze more profit out of," Jules says.

IN SUMMARY

- Analysed 100 years of weather data, determining July is their 'money month'
- 2018 insured against a decile 1 rainfall event from 3 April to 20 June
- 2018 insured against a decile 1 rainfall event in August to cover nitrogen application

MORE INFORMATION

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Doing the big things well at Bruce Rock

SNAPSHOT

GROWERS: John, Steph, Chris and Maureen Chapman

LOCATION: Bruce Rock, Ardath and Shackleton

CROPPING AREA: 6200ha

ENTERPRISES: Cropping and sheep

GROWING SEASON RAINFALL: 200mm

SOIL TYPES: Mostly medium, with some light and some heavy

2018 CROP PROGRAM: 2800ha wheat, 1400ha canola, 900ha barley, 300ha lupins and 130ha chickpeas

John Chapman runs a 50-foot (15.3m) DBS after switching from a Morris to give the operation the capacity to chase moisture. PHOTO: CUSSONSMEDIA

It is all about focusing on doing the big things right for John Chapman rather than worrying about the little things. So, at his Bruce Rock and Shackleton farms, that means focusing on doing the right job at the right time, such as summer weed control, timely sowing, providing adequate nutrition, applying lime or deep ripping. If the family gets these things right, then John believes their crops stand the best chance to maximise their potential, whether it is in ideal conditions or otherwise.

DBS CHASES MOISTURE

The Chapmans have run a 15.3-metre DBS on 30cm spacings for nine seasons after switching across from a Morris because they wanted more tyne break-out pressure to allow them to chase moisture at depth.

"There are a lot of systems, and it'd be nice to have one of everything, but for us having a bar that doesn't break, covers the ground, and can dig a hole in a fairly consistent and reliable manner – we're happy with the DBS," John says.

Generally, the Chapmans try and rip as deep as possible with their points, as determined by the tractor's capacity. However, John has found changing the sowing depth on the DBS can be hard.

"Digging depth control is pretty easy, it's just donuts on hydraulic rams, whereas the seed depth is more difficult to change," John says.

"Historically it was a closer that you had to unbolt and move it and then bolt it back on, which was a good system, but it just took time to change.

"Sometimes you didn't want to change it because you didn't want to undo all the bolts, and you didn't want to stop, but we learnt from experience that you just need to stop and change it, because the wrong depth can matter."

While they tried a new system to change the depth, John found it was not easier or as durable so they reverted back to the old system. In the future, John is looking at putting a ProTrakker system on his bar so seed can be placed in last year's row if that is where the moisture is.

"We have been talking about ProTrakkers to increase the level of accuracy for seeding tynes – it's the same chasing moisture situation, where the moisture is sometimes in a row, so you want to hit that row," John says.

CONTROLLED TRAFFIC FARMING THE GOAL

The Chapmans are looking at moving to a 12m controlled traffic farming system and as part of that John is looking to upgrade his 15m DBS to an 18m model. John believes there is enough data available now that proves the benefits of adopting the system. He also believes that for deep ripping to be worthwhile, people must be operating on a controlled traffic farming system.

"You recompact the soil 80 per cent in the first pass, so there's not much point in doing that sort of work if you're not going to have some sort of controlled traffic system in place," John says.

DEEP RIPPING

The Chapmans first trialled deep ripping in 2018 and John is really happy with the result.

"We only did a paddock as a trial and it costs us $125 per hectare, and I think I'll get that money back pretty easy, because that paddock is a sand over gravel," John says.

"The jury's still out a little bit and I don't think you want to be first in anything, you want to be second, but I think ripping the right soil types for the right reasons will become more and more popular."

> "Everything in farming takes five years – what we're planting today, harvesting at the end of the year has taken us five years to grow it."
>
> – JOHN CHAPMAN, BRUCE ROCK

The Chapmans grow Scepter(Φ), Ninja(Φ) and Zen(Φ), primarily because they yield well. In addition, they also grow barley as an alternative to a long-season wheat.

PHOTO: CUSSONSMEDIA

THREE WHEAT VARIETIES PLUS BARLEY

While coleoptile length is a factor, the Chapmans grow Scepter(Φ), Ninja(Φ) and Zen(Φ), primarily because they yield well and the different length of season acts as a frost mitigation tool. They are comfortable planting Ninja(Φ) and Zen(Φ) at 50 to 60mm deep, particularly in warm soils.

"This year we planted two noodle wheats, a long one (Zen(Φ)) and a short one (Ninja(Φ)) because we had some moisture at depth and a lot of the time we're planting early and don't know if it's going to rain anyway, so we will split varieties for frost risk management," John says.

In addition, John says they also grow barley as their alternative to a long season wheat. As they have a significant canola and barley program to get through before they start wheat, they do not need more varieties to cover their risk.

TARGETED NUTRITION

John sums up their approach to fertiliser as, "put on the amount of fertiliser that the plant needs, and no more". The Chapmans' Multistream bin runs two granular fertilisers, Agstar and MOP as well as Flexi-N, so they are able to tailor phosphorus, potassium and nitrogen rates accordingly. They do not run variable rate technology, as John does not believe it is worth adding the complication. They also do not tend to adjust their starter fertiliser depending on seasonal conditions, but are instead more likely to adjust nitrogen later in the season.

"I think the last five years, our P rates have dropped a fair bit because we have got some pretty good phosphate banks but other things have gone up, so we're cutting out P for K," John says.

"It's just good to have separate N, P and K, so you can adjust them in each paddock so it's not one rate across the farm.

"We run 0 to 100kg/ha Agstar and then we also run a box with MOP in it, which would turn on and off depending on K rates, which range from 10 to 40kg/ha.

LIMING

The Chapmans have also invested significantly in applying lime across their farms over the past 10 years. John believes it is important to focus on one of their biggest constraints before launching into deep ripping.

"WA uses half the amount of lime it's supposed to and I probably use double because it's pretty clear that has been one of our biggest constraints," says John.

"Your return on investment for lime was, I think, three to five years to get your money back, and you're ahead forever.

"Everything in farming takes five years – what we're planting today, harvesting at the end of the year has taken us five years to grow it."

IN SUMMARY

- DBS chases moisture
- Barley is the equivalent of a long-season wheat
- Only deep rip if other constraints have been addressed

MORE INFORMATION

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Pulling canola out rather than sowing it half-wet half-dry at Mount Walker

SNAPSHOT

GROWERS: Robert and Maxine, Mitchell and Adam Miolini

LOCATION: Mount Walker

CROPPING AREA: 3600ha

ENTERPRISES: Cropping and sheep

ANNUAL RAINFALL: 300mm

SOIL TYPES: Mostly good loams with some heavy loams and lighter soils

2018 CROP PROGRAM: 1700ha barley, 1530ha wheat and 370ha lupins

Robert, Adam and Mitch Miolini will choose not to sow canola rather than sowing it in half-wet, half-dry conditions. PHOTO: CUSSONSMEDIA

Experience has taught the Miolini family that it is just not worth sowing canola in half-wet half-dry conditions. It needs to be either dry or wet, rather than a mix of both.

"When it came to sowing canola in 2018, it was still at that patchy half-wet half-dry stage, and we'd been burnt in 2017 with poor crop establishment, so we decided to leave canola out of our program this year," Robert Miolini says.

As the rest of the program progresses, Robert makes case-by-case decisions on whether to seed in half-wet half-dry conditions.

"I guess it's on the day when you're looking at an individual paddock whether you think, 'okay, this one might work,' so you have a go at it – there's not really much else you can do," Robert says.

"If you've got to stop and wait for it completely to dry out and then start again, that could take too long, and then you get a 2mm rainfall event in between that makes it worse than what it was if you had gone earlier."

Irrespective of the conditions, the Miolinis use their DBS to dig to approximately 100mm so they will have at least 50mm of loose soil beneath the seed to maximise root growth.

DEEP DRAINS

Salinity rather than soil acidity is the major soil constraint on the Miolini home farm. When they bought the property 10 years ago, they deep ripped and dug some deep drains on affected country to reduce salt levels. They were growing some pretty good crops on that country when they had a flood in 2016, which seemed to undo all of their good work.

"When the flood came, water laid in those salty areas for a couple of months and set it all again, so we've opened it all up again, and had the drains cleaned, so hopefully we can get a bit of that back to what it was like before," Robert says.

"We have been advised to apply 4t/ha of lime and 1t/ha of gypsum on those saline areas so we'll probably try some of that and see if it gets it back quicker, now that it's all been opened up."

BARLEY IN SALTIER SOILS

Barley has become an important part of the Miolini family's grain enterprise as in addition to performing well in their better country, it also performs on their saltier soils. They begin dry sowing with Scope$^{\phi}$ and then shift to Spartacus CL$^{\phi}$, which they find is better suited to shorter seasons.

"In 2017, Spartacus CL$^{\phi}$ went 3.2t/ha and that was put in three or four weeks after the Scope$^{\phi}$ and the best Scope$^{\phi}$ went was 3t/ha," Robert says.

In terms of which performs better in the saltier country, Robert believes the Spartacus CL$^{\phi}$ has probably produced the best results.

"We thought in 2017 that Spartacus CL$^{\phi}$ had grown quite well on some of our salty country compared to Scope$^{\phi}$, as the Scope$^{\phi}$ tends to go really yellow and Spartacus CL$^{\phi}$ didn't seem to do that," Robert says.

"I don't know whether it was because it was so wet that it was keeping the salt level down so the Spartacus CL$^{\phi}$ could grow through it – it is hard to know because we haven't had the Scope$^{\phi}$ on that country before when it was so wet."

CONSERVING MOISTURE

After experiencing a delay in the boom spray resuming spraying after automatically shutting off at the end of runs, the importance of summer spraying to conserve moisture was confirmed for the Miolinis.

On their home farm saline soils are the Miolinis' main soil constraint and they have had good results with deep drains. PHOTO: CUSSONSMEDIA

"When we turned around the boom didn't come back on for about 70m and we didn't go back and spray that out, so the wheat crop in that was absolutely shocking compared to where it had been sprayed – it's just so important to conserve moisture by eliminating weeds," Robert says.

"Some of the best trials you can ever do are mistakes that you can see and learn from."

CANOLA ESTABLISHMENT

Like lupins, canola is a handy weed management tool for the Miolinis, but it does not deliver the same nutritional benefits and establishment can be tricky. Generally, the Miolinis have been sowing canola into their pasture paddocks, as they yield better than if the canola is planted onto cereal stubbles.

"If we get the opportunity we tend to try and offset disc those paddocks to a depth of probably two inches just to give a better seed bed for the canola, rather than try to chop into a pasture paddock and the soil ending up too lumpy around the seed," Robert says.

"Some of the best trials you can ever do are mistakes that you can see and learn from." – ROBERT MIOLINI, MOUNT WALKER

FUTURE PLANS

On their original farm the Miolinis are going to trial a deep ripper and a Plozza Plough with and without lime on a paddock of yellow sandplain. While not sure quite what the results will be, they have been persuaded to trial the amelioration tool after growers at Muntagin had success with it.

Robert says their sheep flock has provided another valuable source of income, which was particularly important in the tough years of the early 2000s. However, as one son, Adam, believes sheep fit their system, while the other son, Mitchell, does not, time will tell if sheep remain part of their enterprise mix.

IN SUMMARY

- Do not sow canola if there are half-dry, half-wet conditions
- Deep drains and deep ripping reduces saline conditions
- Offset disc pasture paddocks prior to sowing with canola

MORE INFORMATION

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Setting paddocks up is the key at Mt Walker South

SNAPSHOT

GROWERS: Austin, Darien and Steven Pascoe

LOCATION: Mt Walker South

CROPPING AREA: 3450ha

ENTERPRISES: Cropping and livestock

ANNUAL RAINFALL: 300mm

SOIL TYPES: Mainly sand over gravel and some yellow sandplain

2018 CROP PROGRAM: 1941ha wheat, 440ha lupins, 177ha export hay, 177ha oats and 718ha canola

When oaten hay was a bigger part of Austin and Steven Pascoe's cropping program, they would sow oats onto their lupin stubbles. Now, after returning to growing canola, the Pascoes sow canola onto their lupin stubbles to maximise the potential of their most profitable crop. PHOTO: CUSSONSMEDIA

While many would sow wheat on lupin stubbles, for Austin Pascoe it makes much more sense to sow canola on lupin stubbles to maximise the potential of their most profitable crop. Originally when oaten hay was a bigger part of their program, before their return to canola, Austin used the same approach and grew oaten hay following lupins.

"In 2017, we had one canola paddock that was on oat stubble and one on lupin stubble, and it was 0.6t/ha better on the lupin stubble, which blew us away," Austin says.

"They were seeded basically the same day, had all the same fertiliser, same chemicals, but the lupin stubble was just so much better.

"The hay used to go onto lupin stubble because that was our best return, it's the best set up paddock, so you pick your best return crops to go on your best paddocks.

"It certainly proved it in 2017 because we thought lupins weren't giving us the benefit that they used to years ago and it certainly proved me wrong that yes, we were still getting a very good benefit from that free nitrogen."

CANOLA FOLLOWS LUPINS

After having the benefit of soil nitrogen on canola confirmed in 2017, the Pascoes sow all of their ATR Bonito(Φ) canola at about 2kg/ha into lupin stubbles. Austin believes by taking advantage of the soil nitrogen they are maximising establishment by not relying on artificial nitrogen, which can cause toxicity issues, particularly in marginal conditions.

"Establishment is way better than if you use bought nitrogen, just the strike rate is so much better – sometimes you think, 'what's happened to the seeding rate?' but the seeding rate's been the same, it's just been the strike rate," Austin says.

While all their canola is generally sown dry, Austin is confident that with his older DBS the crop will germinate on 5mm. However, he would prefer to have more reliable weather forecasts to know more rain is coming.

"I would like a better forecast so you know you can go seven days out from a rain event and you will get that rain event because you don't want to sow all these hectares of canola and then find you get a 2mm rain event, because that causes problems," Austin says.

DEEP RIPPING

Twenty-five years ago, Austin started deep ripping after using a rod to gauge how compacted his soils were. He found their yellow sandplain soils were the most compacted, which subsequently resulted in their best response.

"We actually did tissue tests the first year after we started playing around with deep ripping, and the trace elements and phosphorus levels were off the scale compared to the soil right next door that hadn't been deep ripped," Austin says.

"So, it really did open up a fertiliser bank that was hidden underneath that hardpan."

While they had good results on their sandplain soils, it did not work in the gravel or conglomerate soils and as all of their paddocks are made up of different soil types, they started to question their deep-ripping plans.

"That's where it opened a can of worms because all the paddocks had different soil types in them, so we couldn't just go across the whole paddock, and then during seeding the following year, it was just too difficult, so we decided to buy a DBS," Austin says.

DBS

The Pascoes primarily bought the DBS on 25cm spacings for improved seed placement and establishment, including being able to partially rip the soil with the points. In addition, they found it helped to reduce wind erosion, a common problem.

"Originally, we went out to 9-inch points, but then we went back to 8-inch because we just found the pressures that we had to run for the 9-inch points were too harsh on the machine," Austin says.

In 2018, the Pascoes used 6-inch points because there was no moisture at depth, so they saw little point in ripping further beneath the seed.

"I don't believe you have to place seed deeper to get the moisture because with the press wheel, the capillary action will bring the moisture to the seed," Austin says.

Therefore, the Pascoes do not sow deeper to chase moisture at depth, sowing their Ninja(D), Mace(D) and Scepter(D) at about 16mm.

SUMMER SPRAYING

Experience has taught the Pascoes that summer spraying is critical, particularly on their dry starts.

"I've seen in the past where I ran out of chemical and there's a little triangle piece in the middle of a paddock and I'd say, 'It doesn't matter, we won't go back and do that,' well, come cropping time, that bit where the summer weeds got away, the germination was half," Austin says.

"Another tool we'd like to have is a WeedSeeker® or a WEEDit, which I think every farmer will have eventually, because saving money on chemicals during summer spraying means the equipment will pay for itself down the track."

KEEPING WEED NUMBERS LOW

Austin Pascoe knows with his DBS he is reliant on chemicals for weed control and so is focused on keeping weed numbers low to maximise the crop's potential. They are prepared to spray out weed escapees, desiccate, crop-top and use hay as a tool to manage grasses.

"With a DBS bar, it's a numbers game with chemicals and you rely more on your chemicals if you're not using knockdowns or you get these late starts or dry starts, if you've kept your numbers low you're halfway there already," Austin says.

"In the past we've had a wet year and didn't spray all the grass out in the lupins, and we paid a penalty for about five or six years after that particular lupin crop, trying to control the grasses that we let get away.

"In the future, if that happened again, we'd just go out and desiccate or crop-top where those weeds were."

FUTURE PLANS

Austin believes soil health has a big influence on yields and is looking to trial applying microbes through the boom spray, having coated seeds with microbes previously.

"I do believe microbes play a big part in yields, and soil health is everything really – that's what we've been chasing here from way back when we first started deep ripping," Austin says.

"We are always looking, always learning because every year's different and nothing is ever set in concrete."

In 2018, the Pascoes used six-inch points rather than their traditional eight-inch points on their DBS bar as they saw no point digging deeper when there was no moisture at depth. PHOTO: CUSSONSMEDIA

> **"Another tool we'd like to have is a WeedSeeker® or a WEEDit, which I think every farmer will have eventually because saving money on chemicals during summer spraying means the equipment will pay for itself down the track."**
>
> **– AUSTIN PASCOE, MOUNT WALKER SOUTH**

IN SUMMARY

- Canola on lupin stubble for best profitability
- Deep ripping is difficult in paddocks with inconsistent soil types
- Summer spraying and keeping weed numbers low is critical

MORE INFORMATION

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Farm-size on-row off-row experiment at Wickepin shows the benefits of on-row sowing

SNAPSHOT

GROWERS: Gary and Sue Lang

LOCATION: Wickepin

FARM SIZE: 4630ha

ENTERPRISES: Cropping and sheep

ANNUAL RAINFALL: 400mm

SOIL TYPES: Predominantly duplex with some heavy clays

2018 CROP PROGRAM: 1100ha barley, 1400ha wheat, 900ha canola, 340ha lupins, and 180ha oats

Gary Lang replaced his Conserva Pak with a DBS in 2018 and the slight difference in tyne spacing (DBS 300mm and Conserva Pak 304mm) resulted in a large demonstration of on-row and off-row sowing. PHOTO: CUSSONSMEDIA

A recent change in seeding equipment has resulted in a whole-of-farm demonstration of the benefits of on-row versus off-row sowing for Gary Lang and he is rpleased with what he has seen.

The Langs have run a 12m controlled traffic farming system for 10 years, and up until 2018 had a John Deere Conserva Pak on 30cm spacings and a Simplicity Cart out the back. They pulled that rig with a four-wheel drive tractor, then a front-wheel assist tractor, and most recently a track CAT Challenger tractor. The current DBS seeding bar was purchased for the 2018 season.

"We upgraded because we were finding we had to do a lot of maintenance on the Conserva Pak, plus we also had problems actually pulling it in straight lines, it tended to crab-walk a bit, but really maintenance was the biggest issue," Gary says.

"We chose a DBS because, rather than go to Dowerin and look at new shiny things, we spent a day driving within 100km of home, probably did 400km for the day, looking at five different brands from three to 10 years old.

"The DBS was in far better nick than all the rest, plus we also had a friend buy a block next door, and he was getting good establishment with the DBS, so we thought it was worth trying."

ON-ROW SOWING

2018 produced some interesting experiences with the DBS for the Langs in terms of establishment. They continued using ProTrakker with their new DBS, but there was a difference in spacings between the Conserva Pak (304mm) spacings and the DBS (300mm). Gary describes the result as being like a 'really interesting, very large experiment'.

"There's 4mm difference, so every pass of the seeder has all the different row placements you would like, so we went from on-row to off-row across the whole 12m every pass on the farm," Gary says.

"I said all summer the one thing we don't want is a dry seeding because we've seen it in the past, and we've been targeting sowing on the row or close to the row for some time, because we've seen that work before.

"However, we got what we didn't want in terms of the seeding start this year and we got 3920ha of on and off-row experiment, which doesn't matter when it's wet or when it's clay, but when it's sandy we got some pretty interesting results."

The biggest impact of the seeding tyne moving on and off-row was seen in the Langs' sandy soils and the sand over clays.

"It's really easy to see because last year's rows are still sitting there as stubble," Gary says.

"We got a fantastic germination where we could get the seed in the previous year's row, and the difference in crop where it germinated on 25 May rain verses not, is just amazing.

"The rows were very straight in 2018, so we'll be fine next year, but in 2017 they did move a little bit more than I would like – so wherever we were on-row, we had fantastic germinations and wherever we were off-row, very patchy germinations."

The improved germination on-row was consistent across all crop types, Gary reports, saying in fact that some of the canola seeded in early April germinated on-row straight away, which resulted in a wide range of crop growth stages. However, management of staggered germination is not something that worries Gary, other than missing out on some ryegrass control through canopy closure.

"It means we just have to spray when we're not going to affect too many early buds – to some extent the Select® went on when it normally would go on, even though in places there wasn't a lot of canola there," Gary says.

The benefits of on-row sowing were most obvious on the Langs' sandier soils. PHOTO: GARY LANG

> "We got a fantastic germination where we could get the seed in the previous year's row, and the difference in crop where it germinated on 25 May rain verses not is just amazing."
> – GARY LANG, WICKEPIN

Rather than be concerned by the variation in seed placement in 2018, Gary says the process has actually made him excited for the next season, because the success of the in-row seed germination validates what they have been trying to do.

"In 2019 it will be really easy to get in the row because the bar wants to pull into the row anyway, that's the path with the least resistance, that's really easy," Gary says.

"In the crops where you can go in the row it's fine, so all the lupin stubbles, all the canola stubbles and where we burn cereals to plant canola you'll go in the row, and all the rest will be within five centimetres, 95 per cent of the time I would think."

Gary is uncertain why there was a better germination in the row than off the row because conditions were dry at the time of seeding and the opening rains came after the crop was planted.

"Despite the fact that it was sown before the rain, the new moisture was all still going into the old canola rows, not the new cereal rows," Gary says.

"It's a question that we can't quite work out – whether there's non-wetting soil around the new rows, which pushes it out, it's a really interesting thing."

BURNING FOR FROST

The Langs burn cereal stubbles to lower their frost risk, meaning trash flow is not an issue and they can seed easily into last year's row. However, they do not burn stubbles on all areas of the farm, such as sandhills, and in these areas they seed into the cereal stubble on the outside of the row.

Gary says they burn stubbles for frost only, saying that if frost was not a problem, they probably would not burn any country. When they do burn stubbles, their approach is to blanket burn as close to seeding as possible, believing there is enough trial data to indicate a half to one-degree difference.

"We were losing barley as fast as we were losing wheat at one stage, because we were doing the full conserving stubble approach, but now our results have improved," Gary says.

With variation in terms of crop growth stages lowering frost risk, Gary is not as concerned about late sowing as others and says he never has been.

The inter-row germination was poorer than where the crop was sown into the previous year's row. PHOTO: GARY LANG

"However, I do hang my hat a little on 2016. We actually made a small profit and that was the worst frost you would have ever seen. Frost is our number one problem.

"What changed our frost risk in 2016 is because I'd been able to sign oat contracts at $300/t for our worst frost area of 600ha.

"Also, because we had an early start, you can grow a lot of oats.

"We've got some oats in for the 2018 season, but the start didn't give me the confidence to plant a lot of oats. However, when it comes to mitigating the risk of frost, we use all the strategies including crop selection, delayed sowing, burning and livestock."

SHOULD CANOLA FOLLOW PASTURE?

The other area the Langs are investigating is an observation of 300kg/ha of extra canola yield after pasture than cereals, with the debate being whether it is due to nitrogen or frost.

"I've had these debates with a couple of agronomists, and at the end of the day I'll let them work it out – as a farmer, I'll take the 300kg/ha, $180/ha and not be particularly worried what's causing it," Gary says.

"As a farmer, you don't really need to know, but it is interesting – it's happened for two years in a row, and the crops look like it'll happen again in 2018."

IN SUMMARY

- Benefits of on-row sowing were very obvious on sandier soils
- Burning cereal stubbles for frost management facilitates on-row sowing
- Frost is the biggest management issue

MORE INFORMATION

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Seeding in the row works on non-wetting soils at Pingrup

SNAPSHOT

GROWERS: Paul and Siobhan Hicks

LOCATION: Pingrup

CROPPING AREA: 4500ha

ENTERPRISES: 100 per cent cropping

ANNUAL RAINFALL: 320mm

SOIL TYPES: Sand over clay through to lake bank heavy country with some gravelly soils

2018 CROP PROGRAM: 650ha wheat, 1500ha barley, 800ha export hay and 400ha lupins

After initially trialling soil wetters to improve crop establishment, Paul Hicks has discovered seeding in the row has a much greater influence on germination than applying wetters. PHOTO: CUSSONSMEDIA

The two biggest issues Paul Hicks faces in his farming operation are frost and non-wetting soils. Paul has reduced his frost risk by mapping EM38 gamma radiometrics across his farm and using a digital elevation model to determine his most at-risk paddocks, which are now sown to export hay.

The path to better managing his non-wetting soils, however, is a long one. In 2008, they began trialling different soil wetters and had pretty good results in the first year.

"However, when we applied it in the second year the results weren't as conclusive and we weren't sure why it didn't perform, so it was a bit disappointing," Paul says.

ON-ROW SOWING

In 2009, the Hicks changed their bar from a 13.7-metre Flexi-Coil on 23cm spacing to a 18.3m John Deere Air Hoe Drill on 25cm spacing and set up the wetter behind the press wheel gang. However, they were disappointed with the result as the germination was inconsistent.

"The second year of owning the 60-foot bar, we didn't have our auto steer settings quite right and so the runs one way were in the furrow, the runs the other way were between the furrows," Paul says.

"We came back about four weeks after seeding and only every second lap had come up and we thought that the seed actually hadn't been planted one way.

"We dug around and sure enough the seed was there, but we discovered where we'd seeded in the same row as the previous year, it all came up and where we'd seeded in the inter-rows, it was very patchy.

"We found if you dig across your non-wetting soils after a rain, beneath the stubbles there is a band of moisture about 50mm wide and 100mm deep. It showed us very clearly that we need to seed in the row, so then we set about developing a system."

DEVELOPING THE SYSTEM

Paul began to develop a side banding sowing boot that offsets seed placement by 25mm, so the knifepoint runs along the left edge of the furrow, without bulldozing the stubble in the row, and the wing places the seed under last year's stubble. The Hicks found that while the tractor may be driving in a perfectly straight line, the bar can drift sufficiently that the seed is no longer placed in the old furrow. As a result, Paul worked with Nick Ross from Precision Agronomics to develop a control module to allow the bar to steer independently from the tractor so the tynes would track in close to the previous year's furrow to better access soil moisture. This is now known as iTILL®, which was released in 2013 and while 10cm GPS tractor guidance is sufficient to operate the system, Paul says that RTK is better.

ITILL®

"The tractor guidance is doing its thing, but the seeder bar has a sensor that feels where the previous year's crop rows were, so it actually has its own fine tuning if you like, and so it can fine tune where the seed placement has got to be," Paul says.

Paul describes the iTILL® as looking a bit like an articulated joint on a tractor drawbar with one ram either side with brackets that mount onto the drawbar. It also has a sensor so it knows where centre is.

SETUP ADVICE

Paul advises those setting up an iTILL® that, while helpful, it is not essential to be on RTK. However it must be on 10cm steering so the drawbar can swing enough and the tynes need to be evenly spaced across the bar. In addition, he says it is essential to seed in the same direction each year, so does not advise skipping rows.

"If they're 10-inch row spaces, and sometimes there are wheels in the way that you can't move, but the idea is when you seed the second year, each tyne needs to be following where the same

> **"We find that probably 70 to 80 per cent of the improved germination is actually from seeding in the row, however if you want the icing on the cake, you use the wetter but it comes at a cost."** – PAUL HICKS, PINGRUP

tyne went the year before and if you can do that, you'll get really good results," Paul says.

"In practice, it is virtually impossible to get identical row spacings right across the bar, so for this reason we always start a paddock in the same place and drive in the same run direction every year.

"The first year you use it, you're trying to get your rows straight and you need to sow them identically the same each year, so we don't skip rows, which can mean travel direction gets out of sync.

"We give the boys a map which shows where we start in the paddock and so, we seed up and back up and move along."

While Paul says growers will see the benefit of the system in year one, he believes it is year two when the benefits are really obvious.

"In year two we unfold the bar, the boys drive forward about 100m with the machine in the ground, get everything straight, hop out, go and see that the outside tyne is actually on the outside row of the previous year, on the correct side of it, and then you fine-tune your auto-steer, nudge it and away you go," Paul says.

SENSOR

Paul says the iTILL® system has a timer delay, about 15 seconds for a tow between and 10 seconds for a tow behind, which gives time for the bar when it comes out of a corner to straighten up and then engage.

"The system is designed so that it's not zigzagging all the time – it's actually trying to make the row straight, but it only moves when it needs to and it is quite accurate so we are within 5 to 10mm, 90 per cent of the time," Paul says.

"When you get to the end of the run, you lift the machine out of the ground, the system knows when the bar is lifted up, and then it will recentre the drawbar ready for the next run to start.

"The algorithm is written in such a way that if it's in a canola stubble and the sensor is getting whacked around 10 times a second, it does a lot of averaging before it tries to steer, but if you're in a paddock where you've had sheep in there and there's not a lot of stubble left, and it gets hit once every two seconds, it will actually respond really quickly."

CAMERA

Paul says that the iTill® kit comes with a camera aimed at an individual row, usually in the centre of the machine so the driver can monitor row placement. In addition, it is also a handy tool to monitor soil throw to ensure the furrow is not being filled with soil from the inter-row.

ITILL® PRO

Paul has recently released iTILL® Pro for 2018. He says that one of the key improvements is the incorporation of wifi, which allows the system to connect to any mobile device platform.

"Because it is wireless, it allows you to hop out of the tractor cab with your phone, walk around the iTiLL® Pro hitch, check all your sensors are right and if you're driving in a ute, you can actually join the network while the tractor is working and see what it's doing, which works really well," Paul says.

NEED FOR WETTER?

After initially placing the wetter behind the press wheel gang, the Hicks have found it is much better to place the wetter with the seed. However, despite originally doing a lot of work with soil wetters, they have actually cut back on their use now.

"We find that probably 70 to 80 per cent of the improved germination is actually from seeding in the row, however if you really want the icing on the cake, you use the wetter but it comes at a cost," Paul says.

CSIRO's Phil Ward and recently retired Dr Margaret Roper have managed a trial at the Hicks' property investigating seeding in the row, between the row, with and without soil wetter, which is referred to in the 'Mitigation' section of this booklet. Paul believes the evidence is quite conclusive that there is no disadvantage in seeding in the row and quite often there is quite a benefit from doing so.

IN SUMMARY

- iTiLL® Pro significantly improves seed germination in marginal conditions by sowing in the row
- Make sure tyne spacings are even before using iTILL®
- Always start a paddock in the same place and drive in the same run direction every year

MORE INFORMATION

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Key case study findings

Maximising Potential

As all growers featured in this booklet sow at least some, if not a fair proportion, of their program dry every year, growers often do not know at the time of seeding whether it is going to be a 'good' break or not. Therefore, growers are focusing on setting the paddocks up by addressing constraints so that the crop's potential can be maximised. These constraints include non-wetting soils, soil compaction, salinity and soil acidity.

CHASING MOISTURE

Most growers had tried sowing deeper to chase moisture at depth with varying results. With many wind events in 2018, furrow fill was common among growers and so if they had chased moisture and sown deeper and then experienced furrow fill, crops were trying to emerge from significantly deeper than originally planned. As a result, many have resolved not to sow deeper, with the belief that if the seed is on the surface, it will eventually get enough moisture to germinate. In particular, canola is sown shallow as growers either experienced germination problems or believed it was too risky.

For those growers prepared to chase moisture, it was with wheat. Some growers are using Magenta(1) because of its longer coleoptile, while others just used what was in their silo, often Scepter(1), which is not known for having a long coleoptile. Many growers are keen to see the development of long coleoptile wheats, particularly for seeding into marginal moisture or when there is moisture at depth.

ON-ROW SOWING

Many growers believed on-row sowing was the way to go, particularly in dry conditions, but sowing into cereal stubbles in particular can be challenging.

WET–DRY SOILS

In wet–dry soils, all growers agreed it was difficult to ensure good crop establishment and most made the decision on whether to sow or not in those conditions on a case-by-case basis.

CONSERVING MOISTURE

Many growers commented they were seeing a reduction in growing season rainfall, with more rain falling in the summer months. All acknowledged the importance of conserving this moisture and were prepared to spray as required, which could mean three or four applications.

AMELIORATION TECHNIQUES

The best amelioration technique for the situation was still being determined, with many growers trying different techniques such as wetters, mouldboard ploughing, deep ripping and Plozza ploughing. Some had more confidence determining the right technique for the right constraint, more particularly in the Geraldton port zone.

References

Amjad, M, and Anderson, W (2006) 'Managing yield reductions from wide row spacing in wheat', Australian Journal of Experimental Agriculture, 46, 1313-1321.

Anderson, G, Erickson, T, Davies, S, and McDonald, G (2018) 'Seeds coated with wetters improved cereal germination on water repellent soils', GRDC Crop Update Papers, www.giwa.org.au/2018researchupdates (GRDC Project code: DAW00244 DPIRD Code: FFPJ04).

Bakker, D, Bowden, B, Poulish, G, Hulse, K, Davies, S, and Scanlan, C (2014) 'Managing non-wetting and crop nutrition of forest gravels', GRDC Crop Update Papers, www.giwa.org.au/2014crop-updates (GRDC Project Code: DAW00204).

Blackwell, P, Hagan, J, Davies, S, Bakker, D, Hall, D, Roper, M, Ward, P, and Matthews, A (2014) 'Smart no-till furrow sowing to optimise whole-farm profit on non-wetting soil', GRDC Crop Update Papers, www.giwa.org.au/2014-crop-updates (GRDC Project Code: DAW00204).

Bell, R, Hall, D, and Sochacki, S (2017) 'Crop nutrition and the response to claying sands,' Crop Update Papers Not Presented, www.giwa.org.au/2017researchupdates (GRDC Project Code: UMU00041).

Betti, G, Davies, S, and Reynolds C (2018) 'How can we ameliorate water repellent soils cost effectively? Indications from three trials in WA', Crop Update Papers, www.giwa.org.au/2018researchupdates (GRDC Project Code: DAW00244).

Brill, R, McMullen, G, and Gardner, M (2012) 'The effect of sowing depth on the establishment of several commercial wheat varieties', Capturing Opportunities and Overcoming Obstacles in Australian Agronomy. Proceedings of the 16th Australian Agronomy Conference, 14-18 October 2012, Armidale, NSW (GRDC Project Code: DAN00129).

Brill, R, Gardner, M, and Jenkins, L (2014) 'Canola establishment – does size matter?' GRDC Grains Research Update for Advisors (Ballarat, Victoria) 2014, GRDC.

Brill, R and Orchard, B (2013) 'Improving barley yield in western New South Wales', Proceedings of the 16th Australian Barley Technical Symposium, Melbourne.

Busi, R, Gaines, T, Walsh, M, and Powles, S (2012) 'Understanding the potential for resistance evolution to the new herbicide pyroxasulfone; field selection at high doses versus recurrent selection at low doses', Weed Research, 52, 489-499.

Davies, S (2018) 'Soil water repellence – overview', www.agric.wa.gov.au/water-repellence/soil-water-repellence-overview (GRDC Project Code: DAW00244).

Davies, S, Blackwell, P, Bakker, D, Scanlan, S, Roper, M, and Ward, P (2012) 'Developing and assessing agronomic strategies for water repellent soils', GRDC Crop Update Papers, www.giwa.org.au/2012-crop-updates (GRDC Project Code: DAW00204 and CSP139).

Davies, S, Hagan, J, Reynolds, C, Smee, V, Lefroy, W, Andrew, J, and Newman, P (2015) 'Long-term responses to soil amelioration – benefits will last more than 10 years!', GRDC Crop Update Papers, www.giwa.org.au/2015-crop-updates (GRDC Project Code: DAW00204).

Davies, S, Lemon, J, and Hall, D (2017) 'Claying to ameliorate soils water repellence', www.agric.wa.gov.au/water-repellence/claying-ameliorate-soil-water-repellence (GRDC Project Code: DAW00204).

Davies, S, McDonald, G, Anderson, G, Harte, L, Poulish, G, Devlin, R, and Jenkinson, R (2016) 'New opportunities for soil wetting agents on repellent soils', GRDC Crop Update Papers, www.giwa.org.au/2016researchupdates (GRDC Project Code: DAW00244).

Davies, S, McDonald, G, Betti, G, Anderson, G, Harte, L, Poulish, G, Bakker, D, Devlin, R, and Jenkinson, R (2016) 'Assessing options for managing water repellent gravels, GRDC Crop Update Papers, www.giwa.org.au/2016researchupdates (GRDC Project Code: DAW00244).

Davies, S, Zaicou-Kunesch, C, Kupsch, M, and Devlin, R (2015) 'Assessing agronomic options for managing wheat on water repellent soils', GRDC Crop Update Papers, www.giwa.org.au/2015-crop-updates (GRDC Project Code: DAW00204 and DAW00218).

Desbiolles, J, Davoren, B, and Roget, D (2004) 'Separate seed and fertiliser to lift yields', Farming Ahead Magazine, www.clw.csiro.au/publications/farming_ahead/2004/26-27%20FA%20JUNE_149%202004.pdf.

Edwards, T, Betti, G, Hall, D, Davies, S, and Sinnot, A (2018) 'Ripping and clay delving on shallow clay duplex soil: First Year results from a site at Grass Patch WA', Crop Update Papers, www.giwa.org.au/2018researchupdates (GRDC Project Code: DAW00244).

Edwards, T, Davies, S, McDonald, G, Hall, D, and Moore, J (2018) 'Understanding interactions between pre-emergent herbicides and inversion tillage', Crop Update Papers, www.giwa.org.au/2018researchupdates (GRDC Project Code: DAW00244).

Fettell, N (2009) 'Barley varieties and management – Central West', GRDC Update Paper, September 2009, https://grdc.com.au/resources-and-publications/grdc-update-papers/tab-content/grdc-update-papers/2009/09/barley-varieties-and-management-central-nsw.

Fettell, N, Bowden, P, McNee, T, and Border, N (2010) 'Procrop Barley Growth and Development', NSW Department of Industry and Investment.

Fletcher, A, Weeks, C, and Lawes, R (2016) 'Why are farmers early/dry sowing?', GRDC Crop Update Papers, www.giwa.wa.org.au/2016researchupdates (GRDC Project Code: WAN00021).

French, B (2015) 'The importance of wheat cultivar and seed size for deep sowing', GRDC Crop Update Papers, www.giwa.org.au/2015-crop-updates (GRDC Project Code: DAN0104).

French, B (2015) 'The importance of wheat cultivar and seed size for deep sowing' GRDC Crop Update Papers, www.giwa.org.au/2015-crop-updates (GRDC Project Code: DAW218).

French, B (2014) 'Wheat variety response to dry sowing and seeding depth', GRDC Crop Update Papers, www.giwa.org.au/2014-crop-updates (GRDC Project code: DAW218).

French, B (2014), 'Deep seeding wheat to chase moisture 2014 trial report', DPIRD, www.agric.wa.gov.au/grains-research-development/deep-seeding-wheat-chase-moisture-2014-trial-report (GRDC Project code: DAW218).

French, R, and Harries, M (2006) 'A role for wide rows in lupin cultivation in Western Australia', Agronomy Australia Proceedings 2006, www.agronomyaustraliaproceedings.org/images/sampledata/2006/concurrent/systems/4557_frenchrj.pdf.

GRDC (2011) 'Fertiliser toxicity Fact Sheet', GRDC, https://grdc.com.au/__data/assets/pdf_file/0019/203635/fertiliser-toxicity.pdf.

GRDC (2014) Combatting non-wetting soils – A tour of on farm research in Western Australia.

GRDC (2018) 'New generation soil wetters perform in forest gravels', GRDC GroundCover 136, September-October 2018 – West, 41, http://groundcover.realviewdigital.com/?xml=GCW&iid=161092 - folio=40 (GRDC Project Code: DAW00244).

Hall, D, Jones, H, Crabtree, W, and Daniels, T (2010) 'Claying and deep ripping can increase crop yields and profits on water repellent sands with marginal fertility in southern Western Australia', Australian Journal of Soil Research, 48, 178-187 (GRDC Project Code: DAW0093 and WAN3).

Harries, M, and Seymour, M (2017) 'Canola establishment: seed depth, seed size and hybrid vs OP', GRDC Crop Update papers www.giwa.org.au/2017researchupdates (GRDC Project Code: DAW0227).

Harries, M, and Seymour, M (2016) 'Canola variety by time of sowing in the Northern Region', GRDC Crop Update Papers, www.giwa.org.au/2016researchupdates (GRDC Project Code: 88801194).

Harries, M, Seymour, M, Pinkney, C, Suckling, K, Cripps, B, and Ford, R (2015) 'Wide row canola why bother; a summary of a series of small plot and farmer trials and farmer experiences', GRDC Crop Update Papers, www.giwa.org.au/2015-crop-updates (GRDC Project Code: DAW 00277).

Harries, M, French, B, Sprigg, S, and Bucat, J (2018) 'Sow shallow with big seed for best canola establishment'. Canola agronomy research in Western Australia Bulletin 4986, DPIRD, CSIRO and GRDC, DAW00227, www.agric.wa.gov.au/canola/canola-agronomy-research-western-australia-bulletin. (GRDC Project Code: DAW00227).

Herbert, A (2009) 'Opportunity costs of land degradation hazards in the South-West Agricultural Region: Calculating the costs of production losses due to land degradation'. Department of Agriculture and Food, Western Australia, Perth. Report 349.

Isbister, B, Parker, W, Riethmuller, G, and Davies, S (2018) 'Seeding into deep ripped or renovated soils', DPIRD, www.agric.wa.gov.au/soil-compaction/seeding-deep-ripped-or-renovated-soils (GRDC Project Code: DAW00243 and DAW244).

Kerr, R, Ward, P, Roper, M, Micin, S, and Davies, S (2017) 'Managing water repellency with minimal soil disturbance', GRDC Crop Update Papers, www.giwa.org.au/2017researchupdates (GRDC Project Code: DAW00244).

Kleeman, S, Gurjeet, G, and Coventry, D (2004) 'Effects of N-fertiliser rate and placement on wheat (Triticum aestivum)', 4th International Crop Science Congress, www.cropscience.org.au/icsc2004/poster/2/5/1/1254_kleemanns.htm.

Malik, R, and Curry, J (2018) 'Is April the best sowing opp for wheat', GRDC Crop Update Papers, www.giwa.org.au/2018researchupdates (GRDC Project Code: DAW00227, DAW00249 and DAW00224).

Minkey, D, McNee, M, Celenza, L, Fletcher, A, Abretch, D, Sharma, D, and Weeks, C (2017) WANTFA, CSIRO, DPIRD, Planfarm, GRDC Dry Seeding Report (GRDC Project Code: WAN00021).

Newman, P (2014) 'Aim for the narrowest possible row spacing', GRDC Crop Update Papers, www.giwa.org.au/2014-crop-updates (GRDC Project Code: UCS00017 and PLN00008).

Noak, S, Mayfiled, A, and Hooper, P (2016) 'Hart long-term seeding systems trial', www.hartfieldsite.org.au/media/Seeding_systems_a_long_term_trial_at_Hart_2016_web.pdf.

Pelzter, S (2018) 'Factors affecting grain crop field establishment', DPIRD, www.agric.wa.gov.au/barley/factors-affecting-grain-crop-field-establishment.

Peltzer, S (2015) 'Diagnosing groups D & J Herbicide Damage in Cereals', www.agric.wa.gov.au/mycrop/diagnosing-groups-d-j-herbicide-damage-cereals.

Porker, K, and Wheeler, R (2013) 'Barley time of sowing and depth', Hart Trial Results 2013, www.hartfieldsite.org.au/media/2013%20TRIAL%20RESULTS/06_Barley_time_of_sowing__depth_2013HartTrialResultsBook.pdf.

Pritchard, I (2018) 'Lupin essentials – growing a successful lupin crop', DPIRD, www.agric.wa.gov.au/lupins/lupin-essentials---growing-successful-lupin-crop

Roper, M (2015) 'Novel solutions for managing non-wetting soils', GRDC Final Report, https://grdc.com.au/research/reports/report?id=6233 (GRDC Project Code: CSP00139).

Roper, M, Ward, P, and Davies, S (2015) 'Maintain water channels' GroundCover Supplement, 118, Soil Constraints, September-October 2015, https://grdc.com.au/resources-and-publications/groundcover/ground-cover-supplements/ground-cover-issue-118-soil-constraints/maintain-water-channels (GRDC Project Code: CSP00139).

References *(cont)*

Roper, M, Davies, S, Blackwell, P, Hall, D, Bakker, D, Jongepier R, and Ward, P (2015) 'Management options for water repellent soils in Australian dryland agriculture', Soil Research, 53, 786-806.

Scanlan, C, Davies, S, and Best, B (2013) 'Managing nutrition on soils that have been treated for water repellence', GRDC Crop Update Papers, www.giwa.org.au/2013-crop-updates (GRDC Project Code: DAW00204).

Scott, B, Martin, P, and Reithmuller, G (2013) 'Row spacing of winter crops in broad scale agriculture in Southern Australia', Graham Centre Monograph No 3 https://cdn.csu.edu.au/__data/assets/pdf_file/0010/922465/2013-Row-spacing-of-winter-crops-in-broad-acre-agriculture-in-southern-Australia.pdf.

Shackley, B, Zaicou-Kunesch, C, and Curry, J (2017) 'Early sown wheat – opportunities and risks', GRDC Crop Update Papers, www.giwa.org.au/2017researchupdates (GRDC Project Code: DAW00249).

Shackley, B, Zaicou-Kunesch, C, Curry, J, and Nicol, D (2018) 'Capturing early sowing opportunities for wheat in WA', GRDC Crop Update Papers, www.giwa.org.au/2018researchpapers (GRDC Project Code: DAW00249).

Van Gool, D, Vernon, L, and Runge, W (2008) Land Resources in the South-West Agricultural Region. A shire-based summary of land degradation and land capability. Resource management technical report 330. Department of Primary Industries and Regional Development, Perth, WA.

Zaicou-Kunesch, C, Shackley, B, French, B, Nicol, D, Trainor, G, and Curry, J (2018) 'Wheat yield losses from delayed sowing or emergence', DPIRD, www.agric.wa.gov.au/grains-research-development/wheat-yield-losses-delayed-sowing-or-emergence (GRDC Project Code: DAW00218, DAW00147).

Notes

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