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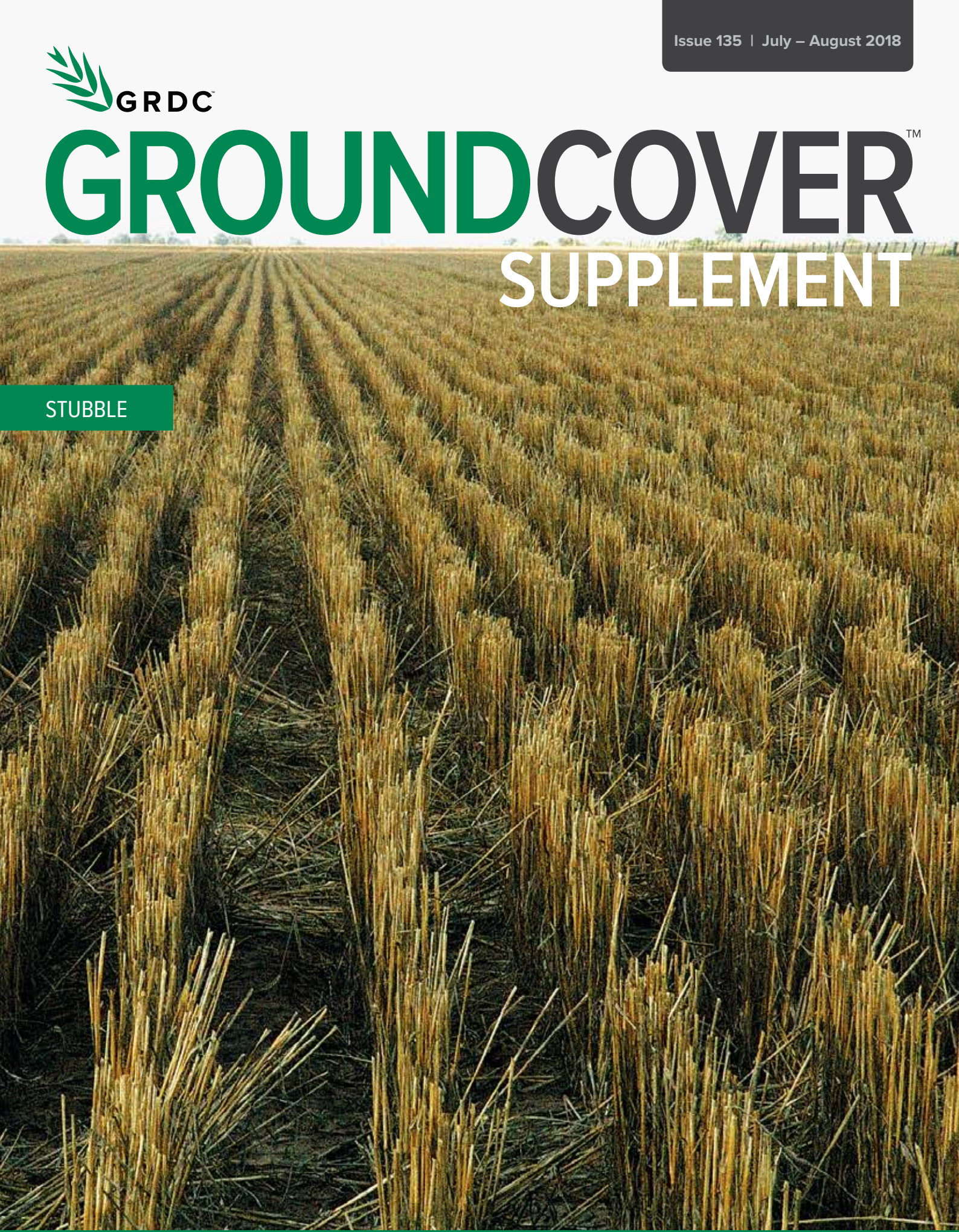
GRDC

GROUNDCOVER™ SUPPLEMENT

STUBBLE



A PROFITABLE STUBBLE SYSTEM

By Andrew Etherton

GRDC manager agronomy, soils and farming systems

Across Australia, stubble is retained on approximately 60 per cent of cropped land, with about three-quarters of this retained as standing stubble. The days of multiple workings of paddocks and summer dust storms that carried away precious topsoils are now fortunately a rare occurrence. Instead many growers have adopted stubble-retention practices because they know that despite the challenges faced, the benefits of improved soil water infiltration and storage, along with reduced soil erosion, are valuable to assist with managing seasonal variability in rainfall.

The adoption of stubble retention has required significant changes in other farming practices. Yet growers have embraced stubble retention and adapted both their equipment and their farming practices. There will always be challenges to overcome in fine-tuning systems that incorporate stubble retention regardless of whether they are in the low, medium or high-rainfall areas. Concerns identified include confirming the amount of stubble needed to prevent erosion and evaluating the modifications that enable machinery to handle heavy stubble loads.

To address these and other questions, the GRDC initiative 'Maintaining Profitable Farming Systems with Retained Stubble', also known as the Stubble Initiative, was developed to support grain growers across New South Wales, South Australia, Victoria and Tasmania through the development of regional guidelines to help growers retain stubbles profitably.

Farm systems groups worked with growers on locally relevant issues, while contributing to coordinated R&D on pests, weeds, disease and nutrition in stubble-retention systems across southern Australia. The R&D was coordinated and supported by CSIRO, with communications and extension coordinated by SARDI.

The Stubble Initiative, which concluded in June 2018, has enabled partners to address locally relevant issues with coordinated support for R&D and extension over five years. The goal was to provide growers from south-eastern Australia with practical information and knowledge to guide their cropping programs and crop-management decisions with the retention of stubbles while overcoming the associated challenges. Each group has developed (and has made available) regionally specific guidelines for stubble retention.

These guidelines cover the five phases for stubble management:

- harvest;
- post-harvest;
- preparation for seeding;
- seeding; and
- in-crop agronomy.

This *GroundCover™ Supplement* provides a snapshot of key recommendations for each phase, along with the outcomes of other research in stubble-retained systems.

For growers it all begins with harvest, where decisions made about cutting height and trash management will affect operations throughout the coming season (pages 3 and 4). In post-harvest, summer/fallow management and grazing affect soil properties for following crops (pages 5 and 6). In preparation for seeding, growers select crop sequences that will influence nutrition requirements and decisions about reduction or removal of stubbles before sowing (pages 7 to 9). Sowing decisions depend on machinery, row spacings and placement (pages 10 to 12). Finally, retained-stubble systems affect in-crop agronomic management, such as weeds and diseases (pages 13 to 15).

The farming systems groups participating in the Stubble Initiative were the Eyre Peninsula Agricultural Research Foundation, Central West Farming Systems, Mallee Sustainable Farming, Riverine Plains, MacKillop Farm Management Group, Birchip Cropping Group, Southern Farming Systems, Irrigated Cropping Council, Victorian No-Till Farmers Association, Mid North High Rainfall Zone Group, Yorke Peninsula Alkaline Soils Group, Upper North Farming Systems, Lower Eyre Agricultural Development Association and FarmLink Research. □

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Cover: Stubble in precision agriculture system. Photo: Rebecca Thyer

STUBBLE MANAGEMENT BEGINS AT HARVEST

Take a flexible approach to managing stubble to ensure you do not compromise on the big things: weeds, diseases, pests and timeliness

By Tony Swan, Dr John Kirkegaard, Dr Cassandra Schefe, Phil Bowden, Claire Browne, Felicity Turner and Trent Potter

■ There is no perfect stubble-management strategy for every paddock. Crop rotations, weeds, disease, pests, stubble load, harvest and sowing machinery and the desired level of cover will largely dictate how stubble should be managed.

Planning and management start before harvest and continue through the fallow to sowing. To assist growers with developing a plan for each paddock, the GRDC's Stubble Initiative has developed a series of questions for growers to consider (see far right).

Harvest height (50cm on left, 15cm on right) is a key consideration in stubble retention.

PHOTO: SOUTHERN FARMING SYSTEMS

FAST FACT

Growers need to consider their stubble-management options on a paddock-by-paddock basis.

KEY STUBBLE MANAGEMENT QUESTIONS

- What is my seeding system – disc or tyne – row spacing and accuracy of sowing?
- What crop am I harvesting, potential grain yield and estimated crop residue level?
- What is the preferred harvest height, level of spread and preferred harvest speed?
- Is the crop standing or lodged?
- Do I have a weed problem that requires harvest weed-seed control?
- Will I need any post-harvest stubble management (grazing, baling, mulching, incorporating and adding nutrients, burning)?
- What crop will be sown into the paddock next year?
- What is the risk of pests and disease in the following crop?
- What herbicide options am I considering for all crop types and stubble loads?
- What is the erosion risk based on soil type and topography?

STUBBLE LOAD

Estimate the stubble load in each paddock before harvest to select the best management practices. Wheat stubble loads are usually 1.5 to two times the grain yield, while canola is about three times the grain yield. Stubble loads greater than four tonnes per hectare need careful planning and management from harvest onwards.

Crops can be successfully established in stubble loads of up to 6t/ha with tyne seeders with good planning (smash and spread straw, sow at 15 degrees to previous year's crop or use coulters). Sowing into stubble loads greater than 8t/ha will need careful post-harvest management for success with tyne seeders, or, alternatively, sown with a disc seeder.

HARVEST HEIGHT

Stubble height and spread pattern across the swath are the first considerations for harvest. Ideal cutting height will vary according to crop type and yield, next season's crop and capability of seeding equipment. Other considerations are risk of weather damage at harvest (speed of operations) and impact on fallow spraying. Harvesting high or with a stripper front is the quickest and most efficient method of producing the least residue, which may need to be threshed, chopped or spread (see page 4).

SEEDING SYSTEMS

Tall standing stubble is better suited to disc-seeding operations, or where post-harvest operations such as grazing, mulching, incorporation, baling or burning are planned. For tyne seeding systems, harvesting low and ensuring straw length is reduced by smashing and spreading evenly across the swath width is important to avoid large mounds, potential blockages at sowing, poor crop emergence and nitrogen tie-up.

WEEDS

If harvest weed-seed control is necessary, harvesting low is essential to maximise seed capture. Seed capture is not effective if weed seeds mature and scatter before the crop matures. Narrow windrow burning for canola stubble or lower-yielding cereal stubbles is effective provided there is a minimum of 20t/ha of dry matter in the row. Chaff decks, which drop chaff and weed seeds on tramlines while spreading smashed straw over the entire swath, chaff carts or the Integrated Harrington Seed Destructor may be better suited to higher cereal stubble loads.

CROP SEQUENCES

Crop sequence is very important, especially in high stubble loads. Canola can struggle to establish in heavy cereal stubble, whereas faba beans and other grain legumes are better able to emerge through heavy stubbles and will assist in stubble decomposition. Where sclerotonia risk is low, a double break, such as sowing canola into a less antagonistic legume stubble, is profitable and provides effective weed management. □

GRDC Research Codes BWD00024, CSP00186, CWF00018, EPF00001, CSP00174, MFM00006, RPI00009, YCR00003

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PROFITABLE HEADER SET-UP

KEY POINTS

- A lower stubble height can benefit subsequent crops by allowing better weed control with herbicides and faster crop establishment
- Harvesting low can cost more: each 10cm reduction in harvest height results in an average 10 per cent reduction in speed

By Tony Swan, Dr John Kirkegaard, Dr Cassandra Schefe, Phil Bowden, Claire Brown, Jon Midwood, Felicity Turner and Trent Potter

A flexible approach to managing stubble means that crops can be harvested high or low, depending on the season, stubble load and weed management, and that various strategies can be implemented post-harvest if required, depending on seeder type, the following crop and the farming system. Large stubble loads can potentially create challenges for all sowing systems and influence the ability of seedlings to emerge, the type and effectiveness of herbicides that can be applied, the ability of the crop protection chemicals to reach the intended target (soil, weed, pest or crop), and the effect that thick stubble load can have on emerging seedlings.

HARVEST HEIGHT

Harvesting high or using a stripper front are the quickest and most efficient methods and produce the least amount of residue, which needs to be threshed, chopped and spread as evenly as possible. As part of the GRDC's Stubble Initiative several farming systems groups and CSIRO compared harvest efficiency and costs at different harvest heights (Table 1). As a general rule, there is a 10 per cent reduction in harvest speed for every 10-centimetre reduction in harvest height, meaning it can cost significantly more to harvest low.

Tall standing stubble is more suited to disc-seeding operations, or where post-harvest operations, such as grazing, mulching, incorporation (with or without added nutrients), baling or burning are planned. However, there can be some negatives to retaining tall stubble. Several groups found that wheat sown into taller wheat stubble (45cm compared with 15cm) received less solar radiation and may be exposed to cooler temperatures, which can reduce early growth and tiller numbers.

WEED MANAGEMENT

Herbicide-resistant weeds have also become a problem in the modern stubble-retained farming system and harvest height is an important factor in the successful implementation of non-chemical harvest weed-seed control techniques, such as chaff carts, chaff decks, narrow windrow burning and, more recently, use of the Integrated Harrington Seed Destructor (iHSD).

The prototype iHSD was tested at Furner, South Australia; Inverleigh, Victoria; and Temora, NSW (by MacKillop Farm Management Group, Southern Farming Systems and FarmLink Research) in 2015-2016, at a constant speed of four kilometres per hour, to compare efficiency and cost. At Furner, reducing the harvest height from 30cm to 15cm increased the engine load by 10 per cent and fuel use by 15 per cent (Table 2). Activating the prototype iHSD further increased engine load and fuel use.

While the iHSD works well, the major issue is getting the weed seeds into the harvester front. Harvest height is critical. Research by Dr John Broster, from Charles Sturt University, shows that about 88 per cent of annual ryegrass was captured when harvesting at 10cm compared with 48 per cent at 40cm, depending on the season, ryegrass maturity at harvest and orientation. □

Contributors to this research were: Birchip Cropping Group, CSIRO, Central West Farming Systems, FarmLink Research, MacKillop Farm Management Group, Riverine Plains, Southern Farming Systems and Yeruga Crop Research.

GRDC Research Codes BWD00024, CSP00186, CWF00018, CSP00174, MFM00006, RPI00009, SFS00032, YCR00003

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TABLE 1 Harvesting wheat in 2014 at Streatham, Victoria, at three harvest heights (engine load = 90%) using a Case IH 9120 header and cost analysis determined at contract rates of $400 per hour.

Stubble height	Average speed (km/h)	Percentage difference in km/h	Time to harvest 100ha (hours)	Harvest costs ($/100ha)	Fuel cost ($/100ha)	Cost ($/ha)
50cm	7.05	15cm vs 50cm = 38.3%	8.3	3305	789	$41
30cm	5.45	30cm vs 50cm = 22.7%	10.7	4264	1040	$53
15cm	4.35	15cm vs 30cm = 20.2%	13.3	5332	1272	$66

SOURCE: SOUTHERN FARMING SYSTEMS

TABLE 2 A Case IH 9120 harvesting wheat conventionally at 30cm, 15cm for baling or narrow windrow burning, or at 15cm with prototype iHSD in Furner, SA, in 2016.

Harvest height	Grain yield (t/ha)	Speed (km/h)	Engine load (%)	Fuel use (L/ha)
30cm	4.7	3.8	59.8	14.3
15cm	4.6	4.0	65.5	16.4
% change from 30cm to 15cm	ns	ns	+10%	+15%
15cm + iHSD	4.6	4.0	88.7	22.7
% change from 15cm to 15cm + iHSD	ns	ns	+35%	+38%

SOURCE: MACKILLOP FARM MANAGEMENT GROUP

MANAGING STUBBLE IN SUMMER PROTECTS SOILS AND PROFITS

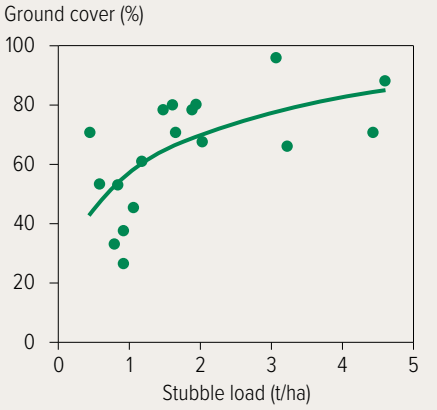
PHOTO: JOHN KIRKEGAARD, CSIRO

Maintaining at least 70 per cent cover is essential to avoid soil loss due to erosion caused by wind or summer storms.

FAST FACT

About two to three tonnes per hectare of cereal residue achieves the 70 per cent cover required to minimise soil erosion and maximise water capture in the majority of seasons.

FIGURE 1 Aim for a cereal stubble load of 2 to 3t/ha to achieve 70 per cent ground cover.



SOURCE: MICHAEL MOODIE, MALLEE SUSTAINABLE FARMING

Weeds, stubble and livestock are the most important factors in protecting soil: aim for a weed-free fallow with at least two tonnes of stubble per hectare retained on the soil surface

By Dr John Kirkegaard

■ Australian growers are the world's leading adopters of no-till, stubble-retained farming systems because protecting the soil and capturing water make sense in dryland farming. But just how valuable is stubble cover, and how can we maximise these benefits while minimising the problems posed by heavy stubbles?

WEED CONTROL

Diligent weed control during the summer fallow is the key to maximising the benefits from stubble-retained systems. Summer weeds, even at low density or when grazed, can use precious soil water that may otherwise be stored for subsequent crops. Weeds also take up mineral nitrogen, which is then tied up in the weed residue.

In a series of 26 recent experiments across southern Australia, as part of the GRDC Water Use Efficiency Initiative (2008–13), strict summer weed control increased the amount of stored water by 40 millimetres at sowing, mineral nitrogen by 40 kilograms per hectare, and wheat yield by 0.8 tonnes per hectare, with a return on investment of $5.60 for every dollar spent.

Delayed or missed sprays could halve the return on investment by reducing water and nitrogen available to crops, but were always preferable to not spraying at all. Without this weed control the benefits of the retained stubble to water conservation are largely lost.

HOW MUCH STUBBLE?

Maintaining stubble cover to protect soil structure and increase infiltration and water storage over summer is accepted practice. The big decision for growers is whether to manage, reduce or remove stubble prior to sowing to ensure effective and timely seeding, and this depends on the seeding equipment, weed management strategy and the type of crop to be sown.

Fortunately, the first few tonnes of stubble do most of the work in terms of soil protection and improved water infiltration. About 2 to 3t/ha of cereal residue achieves the 70 per cent cover required to minimise soil erosion and maximise water capture in the majority of seasons (Figure 1).

This amount of stubble presents few problems for most seeding systems or for weed management, and should be considered a target threshold to maintain where possible.

Heavier stubble loads can increase the duration of soil water storage near the soil surface by slowing evaporation in autumn and late summer, and this benefit can often be seen in windrows of heavy stubble, or when fires or stock remove areas of stubble.

The benefits of retaining surface water in heavier stubbles for early sowing depend on the timing and amount of rainfall prior to sowing and may not occur on all soils or in all seasons. A good policy is to retain stubble whenever possible, but manage it to ensure a timely seeding operation and good weed control.

GRAZING

Several recent studies as part of the GRDC's Stubble Initiative have shown that light grazing of stubble in summer has little impact on water storage or the yield of subsequent crops, provided sufficient cover (70 per cent) is retained on the soil surface. Increased soil mineral nitrogen after grazing heavy stubbles in some seasons can actually increase the yield of some crops.

Consequently, whole-farm income is generally unaffected or improved by careful stubble grazing. The real problem is overgrazing – sheep do damage with their mouths, not their hooves. □

GRDC Research Codes CSP00186, CSP00174, MSF00003

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GRAZING BENEFITS STUBBLE-RETENTION CROPPING SYSTEMS AS WELL AS LIVESTOCK

While grazing is just one of the many post-harvest strategies for stubble management, it can ultimately increase the profitability of the whole system for mixed farms

KEY POINTS

- To protect soil from erosion retain at least 70 per cent ground cover (about 2 to 3t/ha of cereal stubble)
- Grazing can benefit stubble-retention systems by reducing stubble load and improving nitrogen cycling, while any compaction caused by livestock is shallow and removed by the sowing process

FarmLink staff Kellie Jones and Colin Fritsch measure the steady-state rate of water infiltration in a cereal stubble at Temora in March 2017.

PHOTO: FARMLINK RESEARCH

By Tony Swan, Dr John Kirkegaard, Phil Bowden, Amanda Cook, Kellie Jones and Helen McMillian

Stubble provides a valuable feed resource that allows pasture paddocks to be spelled during summer, while grazing helps the cropping program by reducing the amount of stubble in preparation for sowing and increasing nutrient availability to crops by speeding up the breakdown process and reducing nitrogen tie-up.

Grazing of stubble should be carefully managed so that sufficient stubble quantities are maintained to protect the soil surface from wind and water erosion, and maximise water infiltration and water storage. It is widely accepted that a minimum of 70 per cent ground cover is required to minimise erosion and maximise water infiltration and stored soil water. Retain at least two to three tonnes per hectare of stubble to maximise the yield of the following crop (see page 5).

However, what about the effect of livestock on soil compaction and the cropping system's nutrient balance? These were investigated as part of a long-term CSIRO and FarmLink Research study at Temora, New South Wales, from 2009 to 2017, supported through the GRDC's Water Use Efficiency and Stubble initiatives.

COMPACTION CONCERNS

Overgrazing can reduce the amount of water that can infiltrate the soil surface, but this is due to removal of plant cover, not compaction. In the ungrazed treatments at Temora with no grazing or wheel traffic for nine years, the steady-state infiltration rate of water in March 2017 was 28 millimetres per hour, compared with an infiltration rate of 23mm/hour where canola or wheat stubble was grazed post-harvest every year.

Although the water infiltration rate was slightly lower in the grazed treatment, there are few rainfall events with an intensity greater than 23mm per hour over the summer fallow. This explains why careful grazing had little impact on stored soil water and subsequent yield.

Interestingly, when comparing the effect of establishing a crop with either a disc or tyne seeder, there was no difference in the steady-state infiltration rate across all treatments, whether stubble was grazed or not. In a no-till, controlled-traffic system the full crop potential can be reached when carefully grazing crop stubbles sown with either a disc or tyne seeder.

NUTRIENT BENEFITS

The nutritional value of stubble to livestock has been much studied, but what about the benefit to the cropping system's nutrition? Livestock will redistribute nutrients across the paddock through urine and manure, and increase stubble breakdown by trampling residues, improving contact between the straw and soil.

In addition, by removing some of the carbon-rich stubble, they also reduce the potential nitrogen tie-up that can reduce nitrogen availability to the young crop. Together these processes can improve the availability of nutrients to crops grown in grazed stubble.

This was demonstrated by the long-term study at Temora, where grazing stubbles in a canola/wheat/wheat sequence improved the yield of crops through improved nitrogen availability. For instance, grazing canola stubble increased soil mineral nitrogen for the first wheat crop by 13 kilograms nitrogen/ha, while grazing the stubble of the first wheat crop increased mineral nitrogen for the second wheat crop by 33kg N/ha. When stubble is broken down in a grazing animal's gut there is no tie-up of nitrogen as there would be if stubble were left on the soil surface to break down (see pages 8 and 9). □

GRDC Research Codes CSP00174, EPF00001, CWF00018

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REDUCE RISK WITH A TWO-YEAR BREAK FROM CEREALS

KEY POINTS

- Continuous wheat is a high-risk option for growers in the low to medium-rainfall zones
- A two-year break that included a well-adapted grain legume reduced risk while a two-year pasture break was the lowest-risk option

By Katherine Hollaway, Amanda Cook, Ed Hunt, Nigel Wilhelm and Michael Moodie

■ Economic analysis has shown that continuous wheat rotations may be a more profitable option with good seasonal conditions but is a riskier option in poor seasons (Figure 1). In low to medium-rainfall farming systems, where cereals tend to dominate, weeds, disease and/or nitrogen can limit cereal yields.

Taking a two-year break from cereals reduces risk by providing an opportunity to control grass weeds and cereal diseases, improving the overall profitability of the system. GRDC research through the Crop Sequencing Initiative (2010–15) demonstrated that a two-year break from cereals improved subsequent wheat yields, particularly when good control of grass weeds was achieved.

ECONOMIC ANALYSIS

As part of the GRDC's Stubble Initiative, the Eyre Peninsula Agricultural Research Foundation (EPARF) compared the economic benefits and risk of different crop sequences in low-rainfall farming systems on the Eyre Peninsula over five seasons using average prices. This analysis, by Ed Hunt, shows that including livestock in the farming system can greatly increase farm resilience in below-average seasons.

A two-year pasture break with sheep in a wheat sequence (pasture/pasture/wheat/wheat/wheat) significantly reduced losses in below-average seasons (decile 1 and 3), when compared with continuous-cropping sequences. Continuous wheat had the greatest losses. In a decile 1 year the PPWWW sequence returned $85 per hectare more than the continuous wheat option, which over a 2000ha program equates to $170,000. While this option was the lowest risk, it did not capture all the economic benefit in above-average seasons (Figure 1).

A two-year break with a well-adapted grain legume (field pea/canola/wheat/wheat/wheat) was the reduced-risk option that was also able to capture the upside in above-average seasons. This option reduced losses in below-average seasons compared with continuous wheat and remains the preferred option while legume grain prices are buoyant.

In above-average seasons continuous wheat generated good profits as long as appropriate nitrogen inputs were applied to maximise yield (70 kilograms per hectare in the decile 5 and 7 years, and 90kg/ha in the decile 9 year). But this option had the greatest potential losses in below-average years, making it a risky option.

A low-input option to reduce costs, capping nitrogen input at 50kg/ha, was also trialled. This option failed to reduce risk in below-average seasons and also failed to capitalise on above-average seasons, making it the highest-risk option.

OPTIONS

Break crops provide growers with alternative options for weed control, reduced cereal root disease levels (if grass weeds are controlled), increased soil nitrogen (if a legume option is used) and the potential to conserve soil moisture for the next cereal crop. Managing the factor most limiting to yield is critical to success and growers need to consider break-crop options on a paddock-by-paddock basis for this reason. Choices will depend on the agronomic constraint limiting production (weeds, nitrogen or disease) and other factors such as crop suitability (Table 1). □

GRDC Research Codes EPF00001, MSF00003, DAS00119

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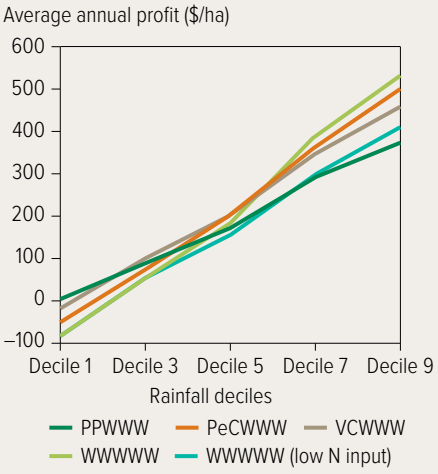
FIGURE 1 Continuous wheat may be more profitable when seasonal conditions are good (decile 7 and 9 rainfall) but is a high risk with low returns in poor seasons (decile 1 and 3). In below-average seasons a pasture/wheat sequence (PPWWW) was a more resilient option.



W = wheat P = pasture Pe = field pea
C = canola V = vetch

SOURCE: EPARF

TABLE 1 Select break crops based on specific paddock constraints.

Situation	Canola	Oats	Lentils	Field peas	Chickpeas	Legume-dominant pasture
I want to control grassy weeds	✓	O	X	O	O	O
I want to increase nitrogen	X	X	✓	✓	✓	✓✓
I want to reduce disease inoculum levels	✓	O	✓	✓	✓	O
I have sandy soils	O	O	O	X	O	O
My terrain is rocky	O	O	X	X	O	O
Hay is not suitable for me	O	X	O	X	O	✓

✓ = ideal for this situation, O = can be suitable, X = not likely to be the best option

SOURCE: MALLEE SUSTAINABLE FARMING

Why do stubble-retained systems need more nitrogen?

More than 70 per cent of the nitrogen contained in stubble is lost through burning, yet stubble-retained systems need more nitrogen than stubble-burnt systems to optimise yield

KEY POINTS

- Stubble can immobilise nitrogen and reduce yields by 0.3 to 0.5t/ha in modern systems, with cereal-on-cereal most at risk
- Reduce heavy stubble loads (bale, graze, late-burn)
- Add more nitrogen (up to 5kg nitrogen per t/ha of cereal residue) and apply it early, deep banding if feasible

By Dr John Kirkegaard, Dr Vadakattu Gupta, Dr Therese McBeath, Dr Alan Richardson, Tony Swan and Dr James Hunt

PHOTO: CSIRO AND GRASSROOTS AGRONOMY

Stubble-retained systems require extra applied nitrogen to overcome tie-up that can reduce yield by 0.3 to 0.5 t/ha.

Stubble's ability to protect the soil surface and increase the capture and storage of rainfall is why Australian growers are the highest adopters of stubble-retained systems worldwide. The benefits of stubble for soil and water conservation are clear, but the impact on nitrogen cycling is less well understood, especially in modern, no-till systems where the stubble remains on the soil surface.

Stubble-retained systems need more nitrogen than traditional burnt stubbles, partly due to tie-up of nitrogen by stubble, but also because the nitrogen contained in stubble is not a good source of nitrogen for crops.

FARMING MICROBES

There are two crops growing in every paddock: the above-ground crop (wheat or canola, for instance) and the below-ground crop – microbes. Two-thirds of microbes live in the top 10 centimetres of soil and they can double in weight each growing season using carbon from crop residues and root exudates for energy.

Cereal stubbles provide plenty of carbon, with a carbon-to-nitrogen ratio of about 90:1. But microbes have a 7:1 ratio, meaning they compete with the crop for nitrogen and temporarily 'tie-up' or immobilise the nitrogen in their bodies. As they die, they slowly release the nitrogen back into the soil.

A worst-case scenario for nitrogen tie-up is when large amounts of cereal residue are incorporated into the soil close to the time of sowing, as the competition between microbes and the crop for nitrogen is intense, and early nitrogen deficiency can limit crop yield potential in some circumstances.

But does nitrogen tie-up occur in modern farming systems where stubbles are left on the surface or standing? Recent CSIRO research within the GRDC Stubble Initiative has found that it does.

In two long-term field experiments CSIRO investigated where the nitrogen in retained stubble ends up, and how to avoid yield penalties from nitrogen tie-up.

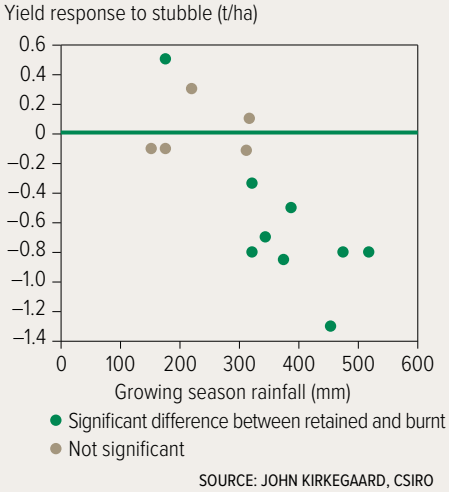
SECOND WHEAT

At Temora, New South Wales, CSIRO compared nitrogen and crop growth in a nine-year, no-till, controlled-traffic, inter-row sowing trial with a canola/wheat/wheat sequence where weeds were strictly controlled.

Stubble was fully retained or reduced by either early crash grazing for seven to 10 days after harvest or late stubble burning about a month before sowing.

Stubble retention had little impact on crop yield, except in the second wheat crop, where yields were consistently reduced by an average of half a tonne per hectare when stubble was retained (Table 1). When stubble was reduced there was a significant increase in pre-sowing soil mineral nitrogen: 13 kilograms per hectare more in the burnt treatment and 33kg/ha more in the grazed.

FIGURE 1 Retained stubble was more likely to reduce yield, when compared with burnt stubble, in wetter seasons at Harden, NSW (shown by the points below the line), suggesting that nitrogen tie-up may be involved.



SOURCE: JOHN KIRKEGAARD, CSIRO

NITROGEN TIE-UP

In another long-term study at Harden, NSW (over 28 years), the average wheat yield in stubble-retained systems was 0.3 tonnes per hectare less than stubble burnt systems. These lower yields were mostly observed in wetter seasons (Figure 1).

In 2017, to see whether reduced yield was due to nitrogen tie-up at the site, CSIRO measured the impact of doubling the nitrogen rate (from 50 to 100kg N/ha) on both burnt and stubble-retained plots. Nitrogen was applied by early broadcasting at sowing or by deep-banding to reduce the potential for microbes (found mainly in the soil surface) to immobilise the nitrogen.

The additional nitrogen improved crop growth, yield and protein in the stubble-retained treatments more than the burnt treatments, indicating that nitrogen was limiting via tie-up in the stubble. Deep banding also improved yield in both stubble-retained and burnt treatments but had more impact on the stubble-retained treatment (see top right for a link to the full GRDC Update paper).

CSIRO also tracked the fate of the nitrogen in retained wheat stubble using stubble grown and labelled with a stable radioisotope of nitrogen (N15). The wheat stubble was set up at three experimental sites at Karoonda, South Australia (Mallee sand), Horsham, Victoria (Wimmera vertosol), and Temora (acidic loam) in the summer fallow of 2014, and two successive wheat crops were grown in 2015 and 2016. The amount of nitrogen originally added in the stubble could be traced in the crops, the soil or remaining in undecomposed stubble over two seasons (Table 2).

For the two wheat crops grown in 2015 and 2016, only one to six per cent of their nitrogen requirement was provided by the nitrogen from the stubble, while more than 50 per cent of the original nitrogen remained locked-up in the stubble or the microbial pool. While stubble is a great source of carbon for microbes, it provides almost no nitrogen for crops.

Cereal stubble can tie-up nitrogen, with yield penalties of 0.3 to 0.5t/ha, mainly in successive cereal crops. Overcome yield penalties either by reducing the stubble load, or by applying more nitrogen (approximately 5kg nitrogen per t/ha of cereal residue) and applying it earlier to the following crop. Deep placement of nitrogen improves nitrogen capture by crops irrespective of stubble management but is more effective in stubble-retained situations. □

GRDC Research Codes CSP00186, CSP00174, MSF00003, BWD00024

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GRDC Update paper 'The effects of stubble on nitrogen tie-up and supply': https://grdc.com.au/resources-and-publications/grdc-update-papers/tab-content/grdc-update-papers/2018/02/the-effects-of-stubble-on-nitrogen-tie-up-and-supply

More than 50 per cent of nitrogen from previous crop stubble remains locked in the stubble or the microbial pool after two years of cropping.

PHOTO: CSIRO

TABLE 1 Effect of stubble burning or grazing on wheat (W) and canola (C) grain yields (t/ha) at Temora, NSW.

	2009 W	2010 C	2011 W	2012 W	2013 C	2014 W	2015 W	2016 C	2017 W
Retain	1.7	4.2	4.6	4.4	0.7	3.8	4.1	3.2	3.7
Burn	1.7	4.0	4.6	5.0*	1.0	3.8	4.6*	3.2	3.2
Graze	1.7	4.3	4.5	4.8*	0.9	3.7	5.3*	3.3	3.3

* Yield was significantly different to stubble retained (P<0.05).

TABLE 2 The fate of nitrogen contained in retained wheat residue after two years of cropping at three sites in southern Australia.

	Temora	Horsham	Karoonda
Stubble load in 2014 (t/ha)	7.5	4.0	2.5
N in stubble in 2014 (kg/ha)	55	32	12
After two wheat crops (2015-16):			
% still in stubble	10	20	20
% in soil organic matter	35	40	45
% removed in crop	22	14	8.5
% unaccounted (lost)	33	26	26.5

SOURCE: CSIRO

STUBBLE RETENTION ON KANGAROO ISLAND

By Jenny Stanton, Keith Bolto and Felicity Turner

■ Stubble retention has improved soil health and made it possible to successfully grow crops in an increasingly challenging environment, but come sowing time you are more likely to hear cursing than praise, particularly in high-rainfall environments such as Kangaroo Island, South Australia. Blockages of seeding equipment are the most common challenge, but reduced efficacy of pre-emergent herbicides and poor seed-to-soil contact and emergence can also be problems.

Agriculture Kangaroo Island (AgKI), in collaboration with the MacKillop Farm Management Group (MFMG), worked with growers on Kangaroo Island to see how they were addressing the challenges of stubble-retention in this high-rainfall environment (550 millimetres) with a challenging range of soil types.

As part of the GRDC Stubble Initiative, the learnings were shared through a seeding machinery field day and case studies on growers such as Travis Bell and Ben Pontifex.

TYNES

Based at Kingscote, Travis Bell uses a DBS tyned seeder with a long knife point and a closer connected to the press wheel via a linkage, enabling both small and large seed to be accurately placed at a consistent depth. The machine can sow all crops ranging from kikuyu grass and canola to broad beans, and performs even in sand and heavy clays. Crops are cut at 250mm high to eliminate long sections of stubble.

The DBS can handle heavy stubble loads going through a five-tonne per hectare wheat crop with no problems even under damp conditions. A GPS guidance system allows the Bells to sow inter-row most of the time to improve stubble flow through the machine, but they use sensors on the seeding bar for this to work perfectly.

The tyned machine provides good seed-to-soil contact and also allows the effective use of pre-emergent chemicals that require incorporation. A key challenge for Mr Bell was getting the speed of sowing right: at higher speeds there is too much soil throw resulting in inaccurate seeding depth and herbicide damage, particularly on sandier soils.

LARGE DISCS

Ben Pontifex, who farms a range of different soil types on Kangaroo Island, uses a Tobin Bullet single disc machine with a much larger disc than usual and seeding boots that he has modified to handle large broad bean seeds. The larger discs allow placement of bean seed to 75mm deep but can also accurately place small seeds.

Hairpinning – a common problem with disc seeders where the disc pushes long pieces of stubble into the ground reducing seed-to-soil contact – is more of an issue when sowing small seed such as canola because there is less pressure from the disc at shallow depth to cut through stubble on the ground. While Mr Pontifex has been able to overcome this issue by burning stubble or aerially broadcasting canola, he has now set up his rotations so that canola is sown into bean stubble where hairpinning is much less of an issue.

Most single disc seeders do not usually provide sufficient soil throw for pre-emergent herbicides that require incorporation. However, Mr Pontifex has found that the larger discs and fast travel speeds (up to 16 kilometres per hour) provide relatively large amounts of soil throw, enabling effective control.

The seeder performs well in all soil types, with the exception of sticky, wet clay, so the sowing of this small area of clay is delayed under these conditions. For Mr Pontifex the main challenge is the weight of the machine, which increases the likelihood of it getting bogged; however, he says this is a necessary evil as the weight is essential for good disc penetration to allow deep seeding and stubble cutting. □

FAST FACT

The best machine for your situation is not a simple decision, even if budget is no limitation, and modifications will probably be required.

GRDC Research Code MFM00006

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Ben Pontifex finds the larger disc size works well for sowing in heavy stubbles.

PHOTO: SARAH PONTIFEX

WHAT'S ALL THE ROW ABOUT ROW SPACINGS?

Growers considering changes to row spacing and row placement need to weigh up all the benefits and risks to limit the impact on crop yields and the weed population

By Genevieve Clarke and Claire Browne

■ It is well known that the key benefits of stubble retention are increased infiltration and storage of soil moisture and reduced soil erosion. Unfortunately, with heavy stubble loads these benefits can come at the cost of blockages of seeding equipment and poor seed-to-soil contact, leading many growers to experiment with wider row spacings and inter-row sowing to overcome these challenges.

Through the GRDC's Stubble Initiative farming systems groups across the southern and northern regions, including Birchip Cropping Group (BCG), have worked with grain growers to help them navigate the implications of changes to sowing placement.

ROW SPACING

The ideal row spacing for stubble-retained systems will vary depending on the farming system. Wider rows make it easier to use inter-row sowing and avoid blockages, but the rainfall zone and yield potential are particularly important.

Widening of row spacings above the traditional seven inches (17.5 centimetres) will generally result in a yield penalty in cereal crops (about 0.5 t/ha in the low to medium-rainfall zones). However, growers have experimented with the use of wider rows in stubble-retained systems to improve the ease of stubble management at sowing.

Yet the need to increase the ability of crops to compete with weeds has encouraged growers in lower-rainfall environments to reconsider narrower row spacings. BCG research in 2015, through the GRDC's 'Overdependence on Agrochemicals' project in the Southern Mallee, found faster weed establishment and higher weed populations in Mace$^{\phi}$ wheat sown on wider row spacings. In the trial there were 35 weeds per square metre at the 22.5cm row spacing, compared with 44 weeds/m^2 at the 30.5cm spacing and 48 weeds/m^2 at the 38cm row spacing.

TABLE 1 Impact of seed placement with respect to previous stubble rows on barley at Bute, SA, 2017.

Treatment	Offset	Plants/m^2	Tillers/m^2	Yield (t/ha)
On row	0cm	105 a	270 b	2.33
Alongside row	5cm	95 a	315 a	2.43
1/3 inter-row	8cm	91 a	268 b	2.50
1/2 inter-row	12cm	88 a	285 ab	2.54
LSD		20	34	NS

Numbers followed by the same letters are not significantly different. SOURCE: YERUGA CROP RESEARCH

PHOTO: BCG

Mark Kentish checks emergence of inter-row-sown wheat at Piangil, Victoria, in 2017.

FAST FACT

Wider row spacings make it easier to sow into retained stubble systems but can come at the cost of reduced yield and higher weed populations.

INTER-ROW SOWING

With the technological advances in GPS accuracy many growers have effectively implemented inter-row sowing. The potential to improve stubble flow and reduce seeder blockages are driving this adoption, increasing the ease of stubble management in a retained-stubble system. In heavy stubble loads a wider row spacing (30cm and higher) makes inter-row sowing easier to implement.

As part of the GRDC's Stubble Initiative, Yeruga Crop Research compared the impact of different seed placement with respect to previous crop stubble rows on barley production at Bute, South Australia, in 2017. There was little difference in yield and plant establishment from inter-row sowing, although tiller numbers appeared to increase when sown offset alongside the row (Table 1).

Although the yield did not significantly increase, other benefits may include improved sowing efficiency and stubble flow and reduced seeder blockages. Soil-borne disease levels of take-all, crown rot, common root rot and root lesion nematodes have also been shown to be consistently lower in the inter-row when compared with on-row.

Inter-row sowing is not suitable for all situations. In non-wetting sands, on or near-row sowing provides better access to soil moisture.

Growers considering their options for row spacing and inter-row sowing should consult Stubble Initiative guidelines. See 'More information' below. □

GRDC Research Codes BWD00024, YCR00003, CWF00020, UNF00002, EPF00001

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The Stubble Project Victoria and Tasmania, https://thestubbleproject.wordpress.com

EMERGENCE A TESTING TIME FOR HRZ CANOLA

PHOTO: TRENT POTTER

Cereal stubble can lead to poor emergence and growth of canola.

When growing canola in a stubble-retained system in the HRZ, separating seed from stubble, achieving good soil-to-seed contact and managing pests are key to success

KEY POINTS

- Avoid sowing canola in direct contact with heavy stubble residues. Instead use inter-row sowing or remove excess stubble
- Vigilant monitoring of pests, especially at the establishment stage, is required as stubble provides the perfect environment for insects, snails, slugs and mice

By Jon Midwood and Trent Potter

Canola provides a highly profitable and important weed and disease break for growers in the high-rainfall zone (HRZ). Yet the vulnerable canola seedlings struggle to establish in heavy cereal stubbles, proving a real challenge for growers hoping to reap the benefits of retained-stubble systems. Faced with heavy cereal stubbles growers often turn to burning to remove both stubble and pests, but would prefer to avoid this practice if they could find another way to improve canola emergence. As part of the GRDC's Stubble Initiative, Southern Farming Systems, the Mid North High Rainfall Zone Group and the Yorke Peninsula Alkaline Soils Group have been looking at options with growers.

POOR COMPETITOR

Always a poor competitor at the establishment stage, canola was thought to suffer from allelochemicals released by cereal stubble or from nitrogen tie-up, but studies by CSIRO have dismissed these theories. In fact, it is simply the herculean struggle of a tiny seedling growing up through the stubble, with the exposed growing point very easily damaged at the cotyledon stage. As the hypocotyl has to grow further than in bare soil the plant's energy reserves are exhausted and the elongated hypocotyl seedling is more vulnerable to soil-borne diseases. Canola establishes better when the seed is kept separate from retained stubble and good seed-to-soil contact is achieved.

Inter-row sowing is one of the most successful ways of separating seed from stubble and increasing seed-to-soil contact, but requires wider row spacing and erect stubble with minimal inter-row residue. Unlike cereals, canola plants compensate well for wider row spacing, maintaining both yield and competitiveness against weeds. Minimising seeder blockages and hairpinning at sowing is important and can be improved by increasing the row spacing. Some growers are fitting row cleaning attachments to seeders to sweep aside the loose stubble in the inter-row area.

Another option is to grow highly vigorous pulse crops, such as faba beans or lupins, following cereals that promote stubble breakdown to reduce stubble loads before planting canola, with the added bonus of increasing the supply of nitrogen for the canola crop.

MONITOR PESTS

Snails, slugs, insect pests and mice are also serious threats to canola establishment, with stubble providing the perfect habitat for them to survive and thrive. Stubble cover and the sporadic nature of pest infestations also make it difficult for researchers to effectively monitor pests and develop strategies. Most growers rely on baiting, insecticide seed treatments or other 'insurance' applications to keep on top of pests.

Achieving good establishment of canola requires attention to detail including the selection of high-quality hybrid seed, or grading retained seed (greater than 2mm in size) to select the larger fraction. In heavy cereal stubble loads (more than six tonnes per hectare) removing all or part of the stubble as late as possible will provide most of the benefits of stubble retention and eliminate many of the problems.

Strategic stubble burning prior to sowing may also assist with snail and slug control and can reduce blackleg risk by removing previous canola stubble from the inter-row. Other options available for successful canola establishment in heavy stubbles include baling, heavy grazing or other stubble removal activities. □

GRDC Research Codes BWD00024, YCR00003

More information: Jon Midwood, Southern Farming Systems, 0400 666 434, jmidwood@sfs.org.au; Trent Potter, Yeruga Crop Research, 0427 608 306, trent@yeruga.com.au; The Stubble Project, http://bit.ly/2svTbui

TABLE 1 Overcoming the challenges of establishing canola in retained cereal stubble in the high-rainfall zone.

Problem	Cause	Potential remedy
Seeder blockages	High stubble residue	Inter-row sowing, even trash spread, wide rows
Poor soil-seed contact	Hairpinning straw and trash in soil	Inter-row sowing, erect stubble, rotations, burning
Seedling damage	Insects, slugs and snails eat seedlings	Burning, rolling, seed dressings, baiting, insecticides
Lower early vigour	Contact with stubble reduces vigour	Inter-row sowing, erect stubble, hybrid or >2mm retained seed
	Shading in early growth stages	Short stubble, wider row spaces, hybrid or >2mm retained seed
	Nitrogen tie-up	Apply nitrogen before or at sowing, early post-emergent application

SOURCE: SOUTHERN FARMING SYSTEMS

HITTING THE TARGET WITH PRE-EMERGENT HERBICIDES

How you manage stubble at harvest affects the efficacy of pre-emergent herbicides applied next season

By Amanda Cook, Nigel Wilhelm, Trent Potter, Jacob Giles and Katherine Hollaway

FAST FACT

The taller the standing stubble, the more difficult it is for spray to penetrate to the soil surface. Slowing the speed of the spray rig and increasing the water rate will improve spray penetration.

■ Stubble can prevent pre-emergent herbicides from reaching the soil surface, leading to uneven coverage and reduced herbicide efficacy. While this varies depending on the herbicide, its solubility and soil moisture, stubble generally starts to be a problem when stubble loads exceed 45 to 50 per cent of ground cover, which is between 1.7 and 2.5 tonnes per hectare of cereal stubble.

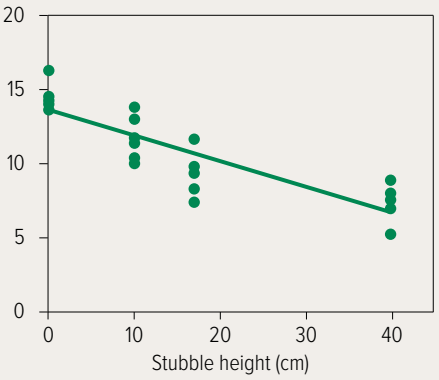
The impact of stubble on the efficacy of pre-emergent herbicides was investigated by several farming systems groups as part of the GRDC's Stubble Initiative. Each group has developed local guidelines to help growers use pre-emergent herbicides effectively in stubble-retained systems.

Stubble management begins at harvest. Stubble not left standing will break down more rapidly if spread evenly, rather than left in the header row, and when choppers are used at harvest to mulch and pulverise stubble into smaller pieces.

It is more effective to spray standing stubble but the Lower Eyre Agricultural Development Association (LEADA), working with the South Australian Research and Development Institute (SARDI), has found that getting the herbicide down into the stubble can be challenging. As part of the GRDC's Stubble Initiative they demonstrated that spray coverage of soil decreases with increasing stubble height (Figure 1). Setting the spray boom height so that the double overlap occurs at the height of the stubble rather than the ground enables a more even application and maximises efficacy; however, this can also increase the potential for spray drift.

Higher water rates allow greater penetration of the stubble and better weed control (Table 1). Research during the initiative has confirmed water rates greater than 70 to 80 litres per hectare in medium stubble loads and 80 to 100L/ha in high stubble loads are necessary for adequate herbicide application. A wind blowing across the stubble rows enables more herbicide to hit the soil or target weeds.

FIGURE 1 Herbicide soil coverage is reduced as cereal stubble height increases.



Note: Spray applied at Ungarra, SA, in 2017 at a Delta T of 3.4 and 15km/h winds. Water rate was 70L/ha with a coarse droplet and addition of Li-700® to maintain optimum droplet size. Application speed 15km/h.

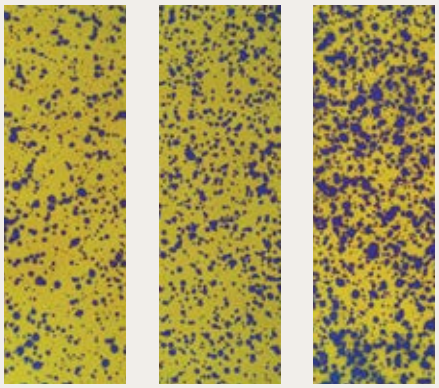
SOURCE: LEADA

Speeds slower than 16 kilometres per hour allow more spray to reach the soil, improving herbicide efficacy. FarmLink Research has shown that only 10 per cent of herbicide reached the soil when spraying at 30km/h and less than 20 per cent at 20km/h. Where possible, spray in the direction of the stubble rows to maximise the herbicide that reaches the target or soil.

Match nozzle spacing to row spacing (when using guidance) so that nozzles can be positioned between stubble rows to minimise stubble interception. Ideally, go no wider than 25-centimetre nozzle spacing to minimise misses. Nozzles that produce a larger droplet size have a better chance of penetrating stubble. Air-induction nozzles can increase droplet size at lower rates, but the trade-off is that droplets are more likely to be retained on stubble.

When burning stubbles, ash will bind to herbicides reducing efficacy. Aim for a hotter burn weeks ahead of sowing to reduce the amount of ash retained in the paddock. □

FIGURE 2 Spray cards set up by LEADA in 2016 show the increasing spray coverage achieved in stubble with increasing water rate: (from left) 60L/ha (11 per cent coverage), 100L/ha (16.5 per cent coverage) and 140L/ha (26.5 per cent coverage).



SOURCE: BLAKE GONTAR, SARDI

GRDC Research Codes BWD00024, CSP00174, CWF00018, EPF00001, LEA00002, MFM00006, MSF00003, UNF00002, YCR00003

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TABLE 1 Pre-emergent herbicides provided more effective control of ryegrass when higher water rates were used at Ungarra, South Australia, in 2015.

Water rate (L/ha)	Ryegrass (plants/m²)	Reduction of ryegrass plants compared with control (%)
50	21 a	52
100	12 b	73
150	11 b	75

Numbers followed by the same letters are not significantly different.

SOURCE: LEADA

BROME RIM PUTS WEED STRATEGIES TO THE PROFITABILITY TEST

Highly herbicide-resistant ryegrass has received much of the integrated weed management attention, but for many growers brome management is just as demanding, especially in the sandy, low-rainfall regions where it grows strongest

By Dr Marta Monjardino and Dr Rick Llewellyn

GRDC research confirms brome grass is one of the most costly weeds in Australia and is the number one grass weed enemy in many regions. Reasons include:

- a lack of reliable pre-emergent herbicide control options in cereals;
- the evolution of later-germinating populations in no-till systems;
- the ability of brome grass to grow well on sandy soils where crop competition can often be poor;
- limited selective herbicide options in cereals; and
- increasing resistance risk.

In addition, harvest weed-seed practices, which can be highly effective with ryegrass, typically have much less impact on brome due to its early seed shedding.

While growers and advisers have explored strategies for managing herbicide-resistant ryegrass using the University of Western Australia's (UWA) RIM (Ryegrass Integrated Management), there was no equivalent for brome grass. To address this gap CSIRO has developed Brome RIM, through the GRDC Stubble Initiative and in collaboration with UWA, the University of Adelaide and grower groups such as Mallee Sustainable Farming.

TESTING OPTIONS

Brome RIM allows growers and advisers to quickly set up crop/pasture and management sequences and test a full range of crop and brome management options for impact on crop yields, weed populations and profitability for up to 10 years. The tool has already been used in many workshops and trials with growers keen to test the cost-effectiveness of practices such as crop sequence changes, narrow windrow burning, reduced reliance on Group B herbicides and greater crop competition for seed-set suppression.

CSIRO used a Brome RIM scenario to analyse the long-term value of a practice change that increases crop competition. Options to improve crop competition on sandy soils include using soil wetting agents on non-wetting soils, on-row seeding options, new seeding systems or more competitive varieties. Here researchers consider the value of a seed-placement innovation such as near-row sowing that could increase establishment of cereals on non-wetting sandy soils to the equivalent of increasing wheat seeding rates from 60 kilograms per hectare to 90kg/ha but without additional seed cost.

Over a 10-year wheat/barley/wheat/lupin crop sequence the scenario assumed only one brome plant per square metre set seed in the previous year. Sowing was at a standard seeding rate in a no-till system, one week after the break in cereals and dry in lupins. Cereal herbicides were glyphosate knockdown (double-knock in the first wheat) and pre-emergent trifluralin (trifluralin + metribuzin in barley). Lupin herbicides were pre-emergent simazine, post-emergent clethodim and crop-topping.

The high cereal crop competition scenario resulted in an overall average net benefit (gross margin) of $23/ha/year (12 per cent) and was able to maintain low weed numbers (Figure 1). Without high crop competition it is likely that there would need to be some reliance on Group B/Clearfield® options in cereal crops to maintain weed populations.

For growers weighing up brome management options, Brome RIM can help identify break-even investment rates and other potential benefits such as increased flexibility to reduce Group B herbicide use. Brome RIM and other RIM versions are available for free download from the Australian Herbicide Resistance Initiative website (https://ahri.uwa.edu.au). □

GRDC Research Codes CSP00186, MSF00003

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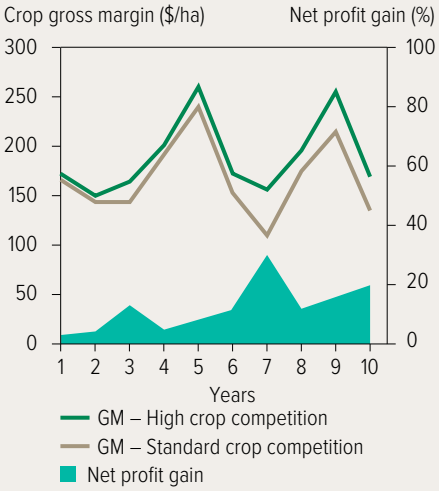
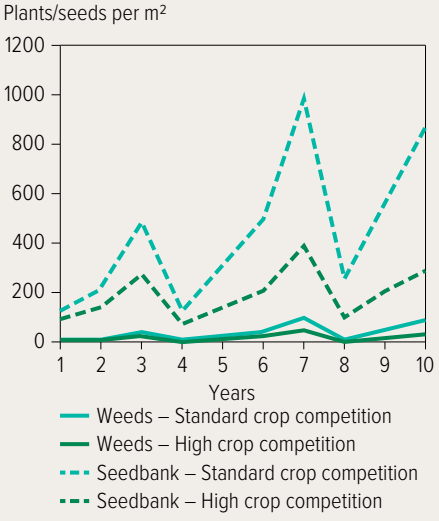
FAST FACT

Brome RIM allows growers and advisers to compare the benefits of different management practices on profitability and brome grass weed populations.

FIGURE 1 The Brome RIM model showed that higher crop competition improved the annual crop gross margin and net profit gain (top) by reducing the weed populations (bottom) over a 10-year wheat/barley/wheat/lupin crop sequence.



SOURCE: CSIRO



SOURCE: CSIRO

SOUTH AUSTRALIAN GROWERS REAP THE BENEFITS OF HWSC

In stubble-retained farming systems harvest weed-seed control provides one of the most effective methods of reducing the grass weed seedbank, but making sure the weed seeds are captured by the header is essential

KEY POINTS

- Harvest weed-seed capture success relies on maximising the number of weed seeds that enter the header
- Taking the time to fine-tune these techniques to your situation is worth the effort

By Trent Potter

■ Getting the grain harvested quickly is often a high priority for growers looking to reduce the risk of weather damage, but in retained-stubble systems harvest is also an important time to set up stubble for sowing the next crop. While this can mean a slower harvest, it can save time pre-seeding and, more importantly, may provide the best opportunity to manage grass weeds using harvest weed-seed control (HWSC).

Tools such as chaff carts, the Integrated Harrington Seed Destructor (iHSD), narrow windrow burning, chaff lining and chaff decks substantially reduce the weed seedbank. For instance, Australian Herbicide Resistance Initiative (AHRI) research has shown that the iHSD can destroy 96 per cent of ryegrass seeds, 99 per cent of wild oats seeds and 98 per cent of brome grass seeds entering the harvester.

CHALLENGE

The real challenge for growers is making sure that weed seeds enter the harvester in the first place. This involves harvesting low to maximise seed capture, but also making sure weed seed does not fall out of the seed head before the crop matures. In 2013, Dr John Broster, from Charles Sturt University, found that 88 per cent of annual ryegrass was captured when harvesting at 10 centimetres compared with 48 per cent at 40cm.

A two-week delay in harvesting wheat after crop maturity has been shown by AHRI to reduce head retention of ryegrass to about 75 per cent, wild oats to about 50 per cent and brome grass to about 70 per cent. Windrowing can help retain weed seed, with 95 per cent of ryegrass retained three weeks after windrowing barley, compared with 62 per cent in standing plants.

As part of the GRDC's Stubble Initiative, Yeruga Crop Research worked with the Mid North High Rainfall Zone Group and the Yorke Peninsula Alkaline Soils Group to see how local growers were using HWSC to reduce the impact of grass weeds in stubble-retained systems.

LOCAL GROWERS

Dan Wilson has used a chaff cart for six years when harvesting barley at his family farm at Whitwarta, SA, and windrows about seven to 10 days before harvest to reduce weed-seed shedding. To avoid the risk of burning the chaff dumps, Mr Wilson bales them to feedlot his cattle, with the additional carrying capacity more than making up for the cost of the chaff cart and baling.

Mr Wilson places his chaff dumps at each end of the paddock to simplify baling. Weeds are no problem in the dumps because moisture rots and destroys the seeds remaining in the chaff on the ground.

Andy Barr, who farms near Pinery, SA, had been burning narrow windrows to reduce the weed seedbank for more than 10 years, but found it was often difficult to get a burn hot enough to kill the weed seeds but not take out the whole paddock. Determined to improve his success rate he recorded the temperature, humidity, windspeed and the Delta T for each windrow burn in 2012 and found the best indicator of success was Delta T.

"A Delta T, that combination of temperature and humidity we read from our little handheld weather station, of between 5 and 8 worked best for us. If the Delta T was below 4 then two out of three burns were too cold and if the Delta T was above 10 then all the jobs were too vigorous," he says. □

GRDC Research Code YCR00003

More information: Trent Potter, Yeruga Crop Research, 0427 608 306, trent@yeruga.com.au

Andy Barr uses harvest weed-seed control techniques such as narrow windrow burning and chaff carts.

PHOTO: MIKE ROBERTS

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- **Compare** results from multiple trials to identify trends

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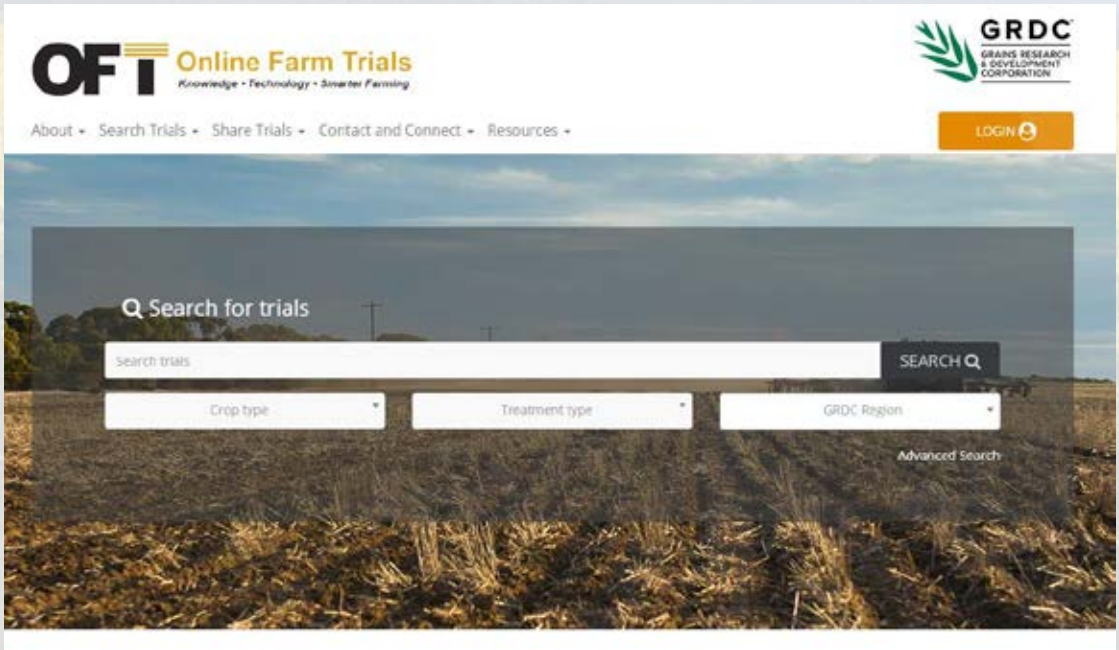

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