STUBBLE MANAGEMENT FACT SHEET

GRDC Grains Research & Development Corporation

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Strategies to manage winter crop stubbles without reaching for the matches

Conservation farming combines minimum or no tillage, full stubble retention and diverse crop rotations. This has resulted in some challenges at seeding and for crop performance, especially when the stubble load is greater than four tonnes per hectare of dry matter. There are a number of techniques, other than burning, which can be employed to deal with heavy stubble loads.

There are many examples of successful full stubble retention systems that achieve excellent crop establishment and weed control. Decisions about stubble management may need to be reviewed annually and in some seasons stubble removal can be a good agronomic option.

KEY POINTS

- There is no single solution to managing heavy stubbles.
- Benefits from retaining stubble can take time to evolve.
- Stubble retention requires a systems approach taking into account seeding technique, herbicide application and crop type.
- Management starts at harvest with even spreading of residue and appropriate cutting height.
- Stubble retention can increase disease, pest and weed pressure and rigorous monitoring is essential.
- Farming system and machinery set-up influence crop establishment in heavy stubbles.
- Sowing inter-row can be the best method to mange stubble at seeding.
- Plan ahead to manage future scenarios where stubble burning could be banned through legislation.

Stubble management to minimise blockages at seeding starts at harvest by matching cutting height to seeder type and row spacing and by spreading as evenly as possible.

PHOTO: EMMA LEONARD

Stubble is defined as the above-ground plant residue left in the field after harvest, including stem, leaf and glume of cereals. In conservation farming systems retained stubble can be mulched, slashed or left standing.

For the majority of growers, stubble burning is not the preferred management tool when dealing with heavy stubble loads but is still often used as a last resort. A 2008 survey of 1172 growers found 47 per cent of southern New South Wales growers and 55 per cent of central Western Australia growers burnt between seven and 10 per cent of stubble, compared to growers in southern Queensland who burnt less than one per cent of stubble area.

In future, legislation could prevent growers from burning stubble, a practice that has been banned in the European Union for over 15 years.

While stubble retention may not always translate to a detectable yield advantage, benefits can come from timeliness of sowing, improved water infiltration and conservation,

enhanced soil fertility, labour and input savings at seeding, and improved air quality through reduction of burning (Table 1). Over time organic matter can accumulate in the surface soil enhancing biological activity and further improving water infiltration.

Stubble treatments and decomposition in the four to six months from harvest to sowing are important influences on the amount and condition of the stubble remaining at sowing. Summer rainfall results in faster stubble decomposition, whereas in drier locations approximately 70 per cent of stubble remains at sowing.

Stubble type is also a major factor in the speed of decomposition. Residue with a lower carbon to nitrogen ratio, for example lupin stubble (C to N 65:1), breaks down faster than cereal residue (200:1) .

PHOTO: EMMA LEONARD

Patchy crop emergence can occur when sowing into heavy stubble but planning ahead and appropriate seeder set-up can minimise this problem.

Four tips when converting to full stubble retention:

1. Start on stubbles with less biomass – canola, pulses or low yielding cereals.
2. Manage the timing of nitrogen application or strategic grazing of winter wheats to reduce the amount of unnecessary biomass.
3. Modify existing equipment.
4. Plan seeding at harvest – match residue management treatment to the capacity of seeding equipment and crop row spacing.

Table 1 Benefit analysis of stubble-related management options with both tyne and disc seeders

Management options	Related benefit	Related limitation
Retain all crop residue with low harvest height versus remove or burn	■ Improved handling with tyne openers ■ Reduced soil erosion ■ Increased water infiltration ■ Organic matter increase and the potential for carbon sequestration ■ Improved soil biology ■ Reduced soil moisture evaporation and improved crop water use efficiency ■ Heat insulation ■ Weed choking mulch effect (allelopathy) ■ Dynamic nutrient release to the crop	■ Increased handling problems at seeding, including hair-pinning, and poor clearance with narrow row spacing limitations ■ Reduced effectiveness of incorporated by sowing (IBS) herbicides ■ Increased crop sensitivity to IBS herbicides, especially when hair-pinning occurs ■ Increased pest and disease risks, depending upon rotations ■ Decreased herbicide efficiency due to spray interception by the stubble, preventing the chemical from reaching weeds
Maximise stubble cutting height and even spread of residue/chaff at harvest	■ Reduced severity of hair-pinning with disc openers ■ Positive trellising effects improving growth and harvestability of crop such as lupins and field peas ■ Increased moisture capture in furrow and reduced moisture evaporation due to wind ■ More even soil moisture conditions and less crop establishment variability ■ More efficient harvest (fuel/ha, work rate, etc) ■ Seedling protection in early growth stages ■ Better IBS herbicide potential in stubble ■ Improved water use efficiency	■ Greater risk of stubble catching and blockage under tyne openers ■ Tall residue can have a negative effect on early cereal and canola growth especially in cold conditions due to reduced solar radiation. ■ Reduced surface residue ground cover increasing inter-row evaporation and runoff especially under wider row spacing ■ Less suitable for grazing stock ■ Decreased herbicide efficiency due to spray interception by the stubble, preventing the chemical from reaching weeds
Inter-row sow	■ Minimises tyne or disc opener, residue interaction ■ Access to a potential package of practical, economic and agronomic benefits ■ Best IBS herbicide potential especially with wider row spacing	■ Requires investment in +/- 2cm RTK precision guidance ■ Implement tracking stability required ■ Unsuitable for row spacing less than 22cm

SOURCE: Ashworth, Desbioles and Tola, 2010.

Solutions

Way back at the beginning – harvest

The management of stubbles starts at harvest by cutting at the appropriate height and spreading as evenly as possible.

When using tyne seeders stubble is easier to manage if cut relatively short at harvest – no greater in height than the distance between rows. Straw lengths of 20cm or less used in combination with modified seeders (see Seeding system set-up) allows tyne machines to operate without major blockages at up to 5t/ha of stubble dry matter.

Cutting low to keep stubble short results in more material passing through the harvester and more material to be spread. Both factors can slow down harvest and increase costs. The more residue for distribution and the wider the harvester comb, the harder it is to achieve even distribution of stubble across the full width of the cut.

Cereal management demonstrations in southern NSW, conducted during 2009-10, as part of the Cereal Stubble Management Project managed by Murrumbidgee Landcare Incorporated, found the amount of trash was 1.5 times greater, on average, in the harvester trail than in the areas one to three metres to one side of the machine, on machines fitted with stubble spinners.

WANTFA research found significant improvement in straw spread with spinners when residue was cut high. This was due to the reduced amount of material to be distributed. This aspect is especially important with large capacity machines with wide fronts which can concentrate residue and chaff by a factor of seven to 11 times.

From this work, it was postulated that when large volumes of stubble are spread, the chaff and straw interacts, increasing the overall bulk of material affected by air-drag. This results in a reduced spread distance. It was found that in both short and tall stubble, harvesters could not spread the full width of the harvester front but when cutting height was maximised straw spreading was more uniform (Figure 1).

Growers have tried a range of practices to help overcome incomplete and uneven stubble spreading and clumping blockages at seeding.

- Harvesting at an angle to the seeding workings gradually staggers the high residue pressure across the cutter bar width to improve overall stubble flow. However, this increases soil compaction, is not appropriate in controlled traffic layouts and can reduce future WUE. Alternatively, harvesting up and back and seeding in the same direction as the harvester improves residue flow.
- Adding a second cutter bar can reduce the chopped straw length before trampling by the wheels. This does not increase the amount of material passing through the machine helping to achieve a more even spread. Second cutter bars have been used with only moderate success because of difficultly in seeing blockage, damage issues

PHOTO: WANTFA

Golden rules for stubble height

Tyne seeders:

- maximum straw length = half the shortest clearance (in any direction horizontally) between seeding tyne assemblies; or 65 per cent of the vertical tyne clearance in the work position, that is from the ground to the lowest shank obstruction under the tool bar; and
- handling of stubble at seeding is improved significantly by inter-row sowing in dry stubble conditions and by lowering speed of travel.

Disc seeders:

- can handle taller standing stubble, with uniformly spread straw and chaff;
- use residue avoidance technique such as inter-sowing into tall standing stubble, with uniformly spread straw and chaff, and consider row cleaners where needed; and
- maximise residue cutting capacity using a sharp disc opener set at optimum depth and operating in dry stubble and firm soil conditions.

and reduced operational speed. Any reduction in operational speed can be a significant problem as most headers require an optimal feed rate for threshing efficiency.

When using disc openers or adopting inter-row sowing techniques stubble height should be maximised.

Canadian trials, in both semi-arid and sub-humid climatic conditions, found stubble height has a significant effect on the microclimate surrounding the seed row. Tall standing stubble can reduce wind speed and solar radiation reaching the surface, which can lead to reduced evaporation. This is, however, not always the case. More soil available water can reduce water stress on the crop during later growth stages.

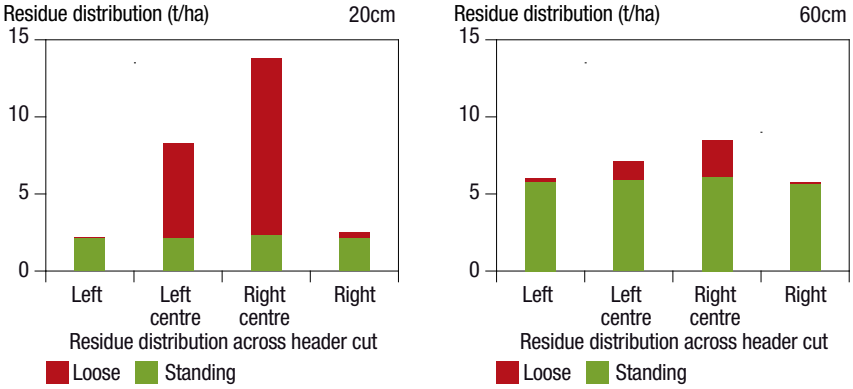
Over a five-year trial, 30 and 15cm cereal stubbles reduced soil moisture evaporation by 27 per cent and 11 per cent respectively compared with a cultivation treatment. Greater kernel number was attributable to taller stubble. This height difference affected yield with the taller stubble generating an increased grain yield of 13.8 per cent and 7.1 per cent for the shorter stubble.

However, there are extra challenges with taller stubbles. High residue can have a negative effect on early cereal and canola growth due to reduced solar radiation, especially when sowing is delayed and soil conditions are colder.

Hair-pinning, rather than clumping, can often occur when using disc openers. When residue is wet and soils are soft, it can result in residue being pushed into the furrow rather than being cut. Hair-pinning inhibits seed/soil contact by promoting residue-seed contact, erratic furrow closure and faster drying of the seed zone. It can also result in herbicide damage as the herbicide on the stubble is incorporated into the seed row.

Standing stubble with uniform chaff spreading is the preferred option when disc seeders are used, so as to minimise the quantity of residue on the soil surface and to reduce hair-pinning risks.

FIGURE 1 Distribution of crop residue when harvesting at 20cm and 60cm residue cutting heights



Note: A cross wind during harvest was the likely source of a higher accumulation right of centre.

SOURCE: WANTFA

TABLE 2 Wheat establishment at Sandilands, South Australia, with in-row and inter-row sowing

Stubble	Sowing row treatment	Plants/m^2	% response to inter-row
Standing	inter-row	176	+27%
	in-row	138	
Slashed	inter-row	192	+17%
	in-row	161	

lsd 5% = 28

SOURCE: Adapted from M McCallum (2004)

TABLE 3 The survival rate (per cent) of weed seeds following a hot burn

Duration (seconds)	Temperature (°C)				
	200	225	250	275	300
10	–	–	–	–	77
20	92	70	55	57	5
40	90	26	15	6	0
60	89	1	0	0	0
80	74	0	0	0	0

SOURCE: D Chitty and M Walsh (2003)

TABLE 4 Nutrients lost from the paddock when a 2t/ha cereal stubble is burnt, baled or otherwise removed at the end of summer

Nitrogen	Phosphorus	Potassium	Sulfur	Trace elements
10kg/ha	1kg/ha	15kg/ha	3kg/ha	Yes

SOURCE: Right Rotations

How much stubble

The amount of stubble can be estimated using this equation:
Amount of stubble (tonnes per hectare) = grain yield (t/ha x (1-HI)/HI.

The harvest index (HI) is the ratio of grain yield to total above-ground biomass and for winter cereals is generally considered to range between 0.2 and 0.5. HI index will be higher in wet seasons with a cool finish.

A field method is to dry and weigh the plant residue found within one square metre (10 measurements from a 10cm by 10cm quadrant). Every 100g/m^2 equals 1t/ha of dry stubble and crop residue.

Wheat stubble volumes can amount to 1.3 to 2.8 times the grain yield and can start to create handling problems from 3 to 4t/ha wheat stubble dry matter.

PHOTO: WANTFA

The best crop emergence is found in rows that are kept stubble free. This can be achieved with inter-row sowing.

Reduce the residue

There are numerous machines designed to help reduce stubble height – some include a shallow incorporation to promote faster decomposition. Examples include: harrows, a prickle chain, Coolamon harrows, disc chains, flail mulchers, the Trash Cutter, off-set discs and The Stubble Cruncher®. Each machine works with varying success depending on the soil type and conditions.

Slashers are most cost effective in hot, dry conditions – a time when the fire risk is also the greatest. If a slasher is used, aim to slash at a height to match the capacity of tyne seeder, using a forward speed of six to eight kilometres per hour. Lower blade settings and slower travel speeds will result in a finer stubble cut.

Summer weed control, while weeds are small, is a must in retained stubble systems. Thick weed trash and vines causes stubble to bunch and block tyne seeders.

Inter-row sowing

When previous crop residue is retained, crop establishment and growth can be affected due to allelopathic effects (allelopathy – see Challenges) and disease carryover. Inter-row sowing can help to reduce the negative effects of stubble retention. Trials in South Australia (Table 2) found a 27 per cent increase in wheat establishment from inter-row compared to in-row sowing in standing stubble. In a one-year trial it was also found inter-row sowing had lower levels of the diseases take-all and crown rot.

The best crop emergence is found in rows that are kept stubble free. Canola can be particularly sensitive to wheat stubble in the seeding row. However, plant residue in the inter-row will help suppress weeds and mulch the soil.

Inter-row sowing lentils and chickpeas into standing cereal stubble provides a trellis effect, increasing crop and podding height as well as harvestability.

Accurate inter-row sowing requires some form of guidance system, at best +/-2cm RTK precision guidance and autosteer on the tractor. Controlled traffic can also assist. Inter-row sowing with tyne seeders has been successfully implemented on row spacings of 22.5cm and wider.

The ability to inter-row sow is also influenced by the stability of the seeder bar when operating. In particular, single disc seeders operating in hard ground can wobble significantly, and automated implement steering can help improve accuracy.

The use of controlled traffic minimises the amount of stubble that is pushed to the ground, which reduces the potential for blockages and is important if the benefits of inter-row sowing are to be maximised.

However, the stability of the seeder in controlled traffic layouts can be affected as moving across to inter-row seeding can result in planting on last year's compacted tramline.

Row spacings

To cope with large stubble loads, an increase in row spacing typically improves sowing operations by allowing greater stubble flow. For this reason 30cm rather than 15 to 20cm row spacing has become popular in conservation farming systems. However, research in WA found yield was reduced by about one per cent for every centimetre widening of row space from a 18cm row spacing. The impact of increasing row spacing was less with lower than average yields.

Wider row spacing reduces power requirement and seeder cost, and can open new options for inter-row weed management. Paired row sowing attachments can also help mitigate any potential yield loss. The optimum row spacing needs to consider all facets of the cropping system and rotation cycle.

Seeding system set-up

Growers cite blockages of sowing implements by stubble as the primary reason for non-adoption of stubble retention, especially in southern and central NSW.

PHOTO: EMMA LEONARD

Tyne design and layout have a major influence on a seeder's ability to perform in heavy stubble loads.

PHOTO: INSTITUTE OF SUSTAINABLE SYSTEMS AND TECHNOLOGIES

Residue managers are designed to remove excess residue ahead of the disc opener to control hair-pinning risks.

Tyne seeders

Modification to the profile and tyne layout can help reduce stubble clumping and blockages. Low cost add-ons such as stubble tubes around the tyne shanks can improve residue flow but bar clearance and tyne layout have greater influence on the machine's ability to cope with heavy stubble loads.

- A straight rather than a curved shank will avoid residue concentrating in a central point.
- Shanks with a rounded cross section have improved residue flow. Narrow edge-on profiles are prone to stubble hair-pinning, in moist conditions, delaying residue flow.
- Vertical or slightly backward leaning shanks promote a more constant off-balancing effect on the residue, reducing build-up unless long weeds such as peach vine or paddy melons are present.
- Any sudden change in shape in shank profile delays residue flow and promotes clumping. Shank mounted brackets encourage residue catching, often promoting blockages. High 'C' shapes, where the upper part of the 'C' is above the stubble flow work well.
- Stream-lined designs with recessed bolt heads for point mounts will also reduce residue catching.

Existing curved shank tynes can be improved by retrofitting stubble tubes to make the face of the shank round and more vertical.

Long knife-point openers can increase the effective vertical clearance of short tynes, but their break-out rating needs to be sufficient to sustain the greater lever arm effect.

The agricultural machinery research team at the University of South Australia suggests modifying and reviewing the layout of the seeding machine according to the stubble load.

Trials showed an inter-tyne spacing of 55 to 60cm was usually adequate in a 3.5 to 4.5t/ha wheat stubble cut at 35 to 40cm. The inter-tyne spacing is the horizontal distance between any two seeding tyne assemblies measured in any direction.

For a 45 to 55cm high stubble, the minimum inter-tyne spacing may need to increase to 65 to 70cm for rolled stubbles and 80cm for standing stubbles. The inter-tyne spacing may have to increase towards the rear of the machine where greater stubble build-up generally occurs.

The following recommendations were developed from researcher and grower experience and highlight the factors to consider when purchasing or retrofitting a tyned seeding bar.

1. Maximise the inter-tyne spacing at all times. This is done via tyne layout pattern, row spacing, rank spacing and rank number. In general, a seeder bar should consist of at least five ranks spaced at least 50cm apart. This allows for space to clear material if it builds up. Often the fifth rank is used to relocate cluttered rows.
2. Match inter-tyne spacing to residue length. Minimum inter-tyne spacing should be approximately twice the residue length. If inter-tyne clearance is small, then residue will need to be cut short.
3. Create a tyne layout that minimises the number of clump interactions with following tynes. In general, the rear of the seeder is more sensitive to blockages than the front ranks, due to residue clumping. Locating press wheels too close to the back rank of tynes can create another pinch point.
4. Position wheels to maximise residue flow. Make sure tynes near the wheels are positioned in front of the wheel, in the working position.
5. When starting stubble retention, start with easier stubble crops such as canola to refine the system before tackling heavy cereal stubbles.
6. Only sow into heavy stubbles after sufficient drying has occurred. Stubble blockages often occur as the dew falls at dusk.
7. Use lower reaching narrow points (such as knife points) and shallower tillage depths to help maximise the vertical clearance.
8. Slow down. Slower operating speeds reduce the risk of residue clumping and blockages.
9. Plant depth can effect trash flow, even small adjustments can decrease this problem.

Disc seeders

Stubble handling with discs can be improved by avoiding residue (inter-row seeding) and maximising cutting efficiency.

Module selection affects residue handling ability. In early tirals, innovations such as the StubbleStar®, showed promising ability to sow into heavy stubbles (12t/ha).

Residue managers, such as row cleaners, can effectively sweep residue from the module's path, decreasing risks. They also create mini windrows away from the seed rows, which minimise the potential negative effect of decomposing stubble (allelopathy – see Poor crop establishment) on the emerging crop. In addition, these windrows can suppress weed germination and act as a compost layer within the inter-row. Southern Farming System (SFS) trials have shown paddocks that have been more intensively grazed or where disc seeders are used will benefit more from these additions.

Residue managers such as coulter discs fitted ahead of paired seeding discs are useful for incorporating herbicides. However, coulter discs can worsen the stubble handling ability of tyne seeders if their use results in hair-pinning rather than cutting.

Residue avoidance can be achieved with inter-row seeding using +/-2cm RTK accuracy guidance and autosteer. This increases the volume of residue handled and improves establishment in the following crop.

PHOTO: PETER NEWMAN

Burning windrows helps remove weed seeds and some pests while retaining standing stubble.

Challenges

Weed management

Conservation farming places greater reliance on herbicides for the control of weeds. However, reducing tillage presents problems with herbicide incorporation, while increased stubble cover can reduce their soil penetration or foliar contact. Each of these factors can reduce the efficacy of specific herbicides.

Consequently, growers need to plan ahead and take an integrated approach to weed control, which includes crop and herbicide rotation.

If a paddock is known to have a weed challenge, management of those weeds in a full stubble retention system can start at harvest. Stubble, chaff and weed seeds can be concentrated in windrows by removing straw spreaders or with stubble chutes. These windrows can then be burnt.

The risk of the windrow burn spreading to the standing stubble can be minimised by aligning windrows parallel to the prevailing winds. The best windrow alignment can be achieved by harvesting and sowing in an up and back pattern, which allows the windrow to be placed between two sowing rows so the standing stubble keeps the windrow in place throughout summer until burning is permitted.

The burning of harvester trails is only effective at reducing weed seeds if temperatures are maintained (Table 3). In order to attain the required temperature, sufficient load and residue concentration is required, plus airflow. It is optimal to burn in a slight breeze to achieve the required temperatures.

Burning can be avoided by using a chaff cart or baler or Harrington Seed Destructor towed directly behind the harvester. However, growers must take into account the loss of nutrients taken with the removal of the straw when planning future fertiliser applications (Table 4).

Stubble as stockfeed

There are mixed points of view on grazing stubbles. Anecdotally, it is suggested there are two choices – nil grazing or heavy grazing and nothing in between. Anchored stubble is easier to sow through than a loose, trampled stubble.

Wheat stubble is a low quality stock feed and once residual seed or leaf biomass is consumed, supplementary feeding may be necessary. In a GRDC-funded *Review of Livestock Impacts on No-till Systems* it was reported that, at moderate stocking rates, sheep will begin to lose weight quickly after four weeks in wheat stubble.

The review found the minimum level of ground cover needed to achieve the goal of moisture retention and avoiding wind and water erosion over summer is about 1t/ha for cereal stubbles, which equates to about 35 per cent stubble cover. Stocking rates should be determined at the start of grazing and monitored over the grazing period.

Poor crop establishment

Research suggests stubble retention can have a negative effect on plant establishment but this varies with crop

type. Stubbles left high also minimise sunlight reaching the soil reducing soil temperature and photosynthesis slowing crop establishment and early crop growth.

These negative effects are unrelated to disease, weed or nutritional problems and are influenced by the allelopathy. Allelochemicals are thought to either leach from stubble or be produced by microorganisms, during the early stages of stubble decomposition. The opportunity for allelopathic chemicals to break down may be minimised by dry summer conditions in southern Australia, and where there is seasonal variability this may increase allelopathic effects on newly sown wheat in stubble-retained systems. There appears to be potential to mitigate allelopathic effects through genetic manipulation of crops and improved crop sequencing.

Growers also need to consider the residual affects of herbicides used in the previous crop.

Inter-row sowing can reduce proximity of residue from the seed row and associated allelopathic effects.

Disease

Stubble retention may significantly increase soil and stubble-borne diseases. Increases in crown rot, common root rot, eyespot, yellow leaf spot and take-all have been detected in stubble-retained systems.

The main strategies to manage disease in these systems are disease resistant varieties; crop rotations; and chemical and biological controls. Growers with successful stubble retention systems stress the importance of forward planning, rotations, disease-resistant varieties, timely sowing and good nutrition to minimise disease risk, followed by monitoring to ensure early disease management.

Decreases in nitrogen availability and immobilisation

During wheat stubble decomposition, immobilisation of nitrogen is common, reducing the immediate availability of nitrogen to emerging crops. Subsequent mineralisation of nitrogen derived from the stubble may augment nitrogen supply later in crop development or in a subsequent crop.

Incorporation of stubble, compared with burning, occasionally increased the nitrogen fertiliser requirement of the following wheat crop in three long-term experiments conducted in Western Australia.

Pests

There is generally an increase in biodiversity due to the habitat created by stubble retention. Slugs, snails, mice and other pests grow in population in some areas where stubble retention is widely practised. Monitoring and management strategies, including baiting, should be enforced.

Patchy stubble burning provides only partial control of snails with up to 50 per cent survival rates recorded. Using stubble treatments such as cabling, rolling and slashing result in up to 90 per cent control and the stubble is retained.

Although there are obstacles to straw residue management, many farmers successfully set up their seeders to achieve excellent seed to soil contact to achieve the target plant establishment counts.

Useful resources:

- **EH Graham Centre Monograph No 1**
  www.csu.edu.au/research/grahamcentre/research/Pub_downloads/Monograph-1-Stubble-Retention-Online-version-12-08-10.pdf
- ***Disc seeding in zero-till farming systems: A review of technology and paddock issues* (2010), Mike Ashworth, Jack Desbiolles and ElKamil Tola, WANTFA**
  Email admin@wantfa.com.au, or sales@boffinsbookshop.com.au
  Ground Cover Direct, freephone 1800 11 00 44, www.grdc.com.au/bookshop
- ***Review of Livestock Impacts on No-Till Systems*** **www.grdc.com.au/director/events/bookshop?category=202**
- **Farming Ahead, Kondinin Group, November 2010 edition** **www.farmingahead.com.au**
- **Southern Farming Systems** **www.sfs.org.au**
- **Dr Jack Desbiolles, agricultural research engineer, Institute for Sustainable Systems and Technologies (ISST), University of South Australia** **Email jack.desbiolles@unisa.edu.au**
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