Stubble Management
A Guide For Mallee Farmers
This guide has been developed as part of the Improving Soil Health and Reducing Wind Erosion project of the Murray Catchment Management Authority, which has been undertaken by Mallee Sustainable Farming through funding from the Federal Government’s Open Call Bid funds.

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Acknowledgments

Thank you to the following for their involvement in the development of this guide:

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Mallee Sustainable Farming (MSF) Inc. is a farmer driven organisation delivering research and extension services to the < 350mm rainfall Mallee cropping regions of New South Wales, Victoria and South Australia. MSF operates within a region of over four million hectares, extending beyond Balranald in the east to Murray Bridge in the west.

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Introduction

Stubble retention is a key part of sustainable farming systems and can be used by Mallee farmers to improve the profitability and sustainability of their farms.

Reduced erosion and improved soil structure are just a few of the many benefits of stubble retention. Other benefits such as moisture conservation, provision of nutrients, improved biological activity and providing a useful feed source for livestock have also been identified through both research and farmer observations on-farm.

This guide has been designed to assist farmers to accurately assess stubble cover levels over the critical December to June period. It provides information on stubble management practices to ensure adequate levels of stubble are maintained to minimise erosion and harness the many benefits of stubble retention.
Prevention of wind erosion

Wind erosion results in the removal of valuable topsoil that is considered rich in nutrients and organic matter. Lighter textured soils like sands and sandy loams, commonly found in the Mallee, are most susceptible.

Wind erosion commonly occurs under the following conditions:
- soil particles are less than 2mm in diameter (particles sized between 0.05mm to 0.5mm are most susceptible to erosion)
- soil is dry and bare
- wind speed exceeds 20-35km/h

Retaining stubble can provide protection for soils because stubble acts to slow wind speed, both above and within the stubble. A minimum of 50% ground cover is needed to prevent wind erosion, and when there is no crop present stubble is required to provide this ground cover. Standing stubble (anchored by its roots) of at least 10cm in height is twice as effective at reducing wind erosion as loose flat stubble. Figure 1 shows the effect of stubble cover in reducing wind erosion.

Figure 1: Effect of prostrate cover in reducing wind erosion (Leys, Butler and McDonough, 1994).
Stubble contains significant quantities of nutrients, such as nitrogen, phosphorus, sulphur and potassium. As stubble decomposes, nutrients are returned to the soil. Approximately 25 - 35% of the stubble in the paddock at harvest is returned to the soil by the following autumn. Livestock intake is minimal and the predominant reason for breakdown is decomposition after rainfall events.

Burning stubble results in the loss of nutrients that will then not be available for use by future crops. This loss equates to 85% of nitrogen, 74% of sulphur and 15% of other nutrients that were in the stubble prior to burning. An ongoing burning regime can result in a higher depletion of major nutrients (in comparison to stubble retention) and therefore a higher fertiliser cost to farmers in replacing these nutrients. The cost of replacing these nutrients through commonly used fertilisers can be seen in the table below.

<table>
<thead>
<tr>
<th></th>
<th>Nitrogen</th>
<th>Phosphorus</th>
<th>Potassium</th>
<th>Sulphur</th>
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</thead>
<tbody>
<tr>
<td><strong>Stubble nutrient concentration (kg/t)</strong></td>
<td>7</td>
<td>0.9</td>
<td>10</td>
<td>1.2</td>
</tr>
<tr>
<td><strong>Equivalent fertiliser (kg/t)</strong></td>
<td>15 (Urea)</td>
<td>4 (MAP)</td>
<td>20 (Muriate of Potash)</td>
<td>5 (Ammonium Sulphate)</td>
</tr>
<tr>
<td><strong>Equivalent fertiliser value ($/t)</strong></td>
<td>$7.90</td>
<td>$2.70</td>
<td>$13.50</td>
<td>$2.30</td>
</tr>
</tbody>
</table>

Table 1: Nutrients contained in 1 t/ha and the value of these nutrients in terms of fertiliser costs.

Improving soil biology can influence farm profitability in the Mallee by reducing input costs through nutrient efficiencies. Improving the natural level of suppression of cereal root will increase management flexibility through rotation selection; improve product quality (i.e. protein, oil content); and maintain and improve soil quality.

Retaining stubble is important for increasing biological activity as the lightly textured soils of the Mallee are low in biologically available carbon. Well-managed intensive cropping systems that retain stubble have improved nutrient efficiencies, particularly nitrogen. Tillage based Mallee farming systems will often have higher available nitrogen levels at seeding but less will mineralise throughout the year. In no-till stubble retention systems, mineralisation is spread out throughout the season, in response to rainfall, meaning that more nitrogen is available towards the end of the growing season when the crop needs it.

Stubble retention also increases non-symbiotic nitrogen fixing bacteria. These bacteria can fix atmospheric nitrogen without the aid of legume plants and provide an additional source of nitrogen for crops.
Research into long-term stubble retention systems has shown non-symbiotic fixation to contribute up to 20kg of nitrogen per hectare per year – which can be equivalent to 40% of the nitrogen exported from Mallee paddocks.

Under conventional farming systems in the Mallee, losses of up to 50kg/ha of nitrogen have been recorded, in one rainfall event, due to leaching. Deep core sampling to six metres across the Mallee of South Australia, Victoria and New South Wales has shown an average of 600kg of nitrogen per hectare has accumulated below the root zone due to previous leaching events. No-till farming systems with stubble retention will bind nitrogen against leaching and improve the amount of nitrogen carried over from one season to the next.

Long-term stubble retention can also improve water infiltration due to reduced runoff and improved soil health and structure. Stubble retention coupled with reduced tillage enhances soil biology which improves soil structure through the production of organic ‘glues’ and fungal hyphal networks. This not only increases soil aggregation but also improves the stability of the aggregates.

Livestock feed source

Stubble paddocks provide an important feed source for livestock in the summer and autumn months when pasture feed is low. While large volumes of dry cereal stubble material may be present, the dry material has very little nutritional value.

The greatest value feed source in stubble paddocks comes from spilt grain, leaf and green matter (volunteer weeds, self-sown cereals). Livestock will seek out these components as they have a high digestibility, but higher quality feed is required by lambs and pregnant lactating ewes.

Grazing sheep may reduce the need for weed control spraying and herbicide costs, however, sound grazing management is required to maintain ground cover levels. Grazing shortly after harvest at high stocking rates for a short period will allow sheep to extract maximum nutritional benefit without placing too much pressure on soil condition.
For Luke Follett, a farmer from Benanee in New South Wales, stubble retention is important on his farm for reducing soil erosion and maintaining soil moisture.

“I have seen a reduction in soil erosion as a direct result from retaining stubble cover, which is important as my topsoil is only about 150mm deep,” Luke says.

“The stubble also helps to keep moisture in the soil when it rains and improves soil health”.

Luke manages stubble by sowing crops at 300mm spacings and cutting the stubble below this height (below 300 mm). He also uses inter-row sowing using GPS guidance down to 2cm accuracy.

Luke’s seeder has coulters which assists with retained stubble issues – for instance if sheep knock over the stubble.

Sheep also form part of Luke’s farming system. After harvest he grazes sheep for 1-2 months, closely monitoring ground cover levels and rotating paddocks as required.

Luke finds that dust can be a problem when spraying to control weeds, but he has implemented a number of strategies to deal with this.

“I increase the water rate and chemical rate, reduce my speed and try to spray in conditions less conducive to dust,” Luke says.
While stubble retention has many advantages for the profitability of crops, it can also present some challenges in regards to stubble handling, pest control, weed management, disease carryover, and physical and biological factors such as temperature change, nitrogen tie-up and allelopathy. These challenges can be overcome by adopting some of the management practices outlined in the following section.

### Stubble handling

The management of stubble starts at harvest by cutting at the appropriate height and spreading as evenly as possible. The height at which stubble is cut depends on the seeding equipment. Stubble height should be kept below approximately 60-65% of the effective tyne vertical clearance (distance from the ground surface to the first major obstruction on the tyne shank or mounting head).

Stubble height should be no more than 65-70%, preferably less than 50%, of the lowest value of inter-tyne spacing (narrowest clearance between components of any two tynes or between tyne and wheel, in any direction).

Header trails can result in greater stubble handling problems as up to twice the average paddock residue level can be found in the trail and they can remain wetter for longer. Effective chaff and straw spreaders are essential in stubble retention systems.

Other stubble handling tactics that can be used at harvest include straw choppers, harvesting on the diagonal and secondary cutter bars. Rotary headers also smash and break up stubbles more effectively than conventional headers.

### Which machinery is most effective in a stubble retention system?

A major consideration of stubble management systems is the physical management of residues at sowing. One of the first decisions is whether to use a tyned or disc implement.

Tyned seeding machines are often less expensive but handle less stubble. Tyned machines cause more soil disturbance which can reduce the root disease *Rhizoctonia* and improve incorporation of herbicides. Disc machines handle heavier stubble loads and disturb the soil less. Anecdotal evidence suggests that *Rhizoctonia* and herbicide incorporation can be issues for disc seeders in the Mallee. Disc seeders can also suffer from ‘hair pinning’, which occurs when stubble is bent rather than cut and pushed into the sowing groove with the seed.

There are numerous seeding bar setup and operation factors that can influence the stubble handling ability of sowing equipment. These are summarised in Table 2.
Standing stubble can provide coverage for vermin such as mice, which are a particular issue in the Mallee region. Stubble retention systems together with higher cropping frequency may increase the frequency of mouse plagues. The retention of stubble has also increased the prevalence and subsequent damage to crops by Mediterranean snails in some parts of the Mallee.

Burning and cultivating stubble can act to reduce habitat for vermin, however, alternative management options are available. Mice and snails can both be successfully controlled through baiting programs. In addition to baiting, mice numbers can be minimised through good farm hygiene practices that remove sources of food. These can include controlling volunteer weeds along fence lines to stop seed set; heavy grazing of stubble; minimising harvest losses and cleaning up concentrated spills of grain around field bins, augers, silo bags and other grain storage.

An alternative control to burning and baiting snails is ‘bashing’, where a cable is dragged across a paddock on a hot day, knocking the snails off standing stubble onto the ground.
Disease carryover

Stubble can harbour crop diseases and has the potential to transfer disease from one crop to the next. Increases in crown rot, common root rot, eyespot, yellow leaf spot and take-all have been detected in stubble-retained systems. There are a number of management options for farmers to address stubble borne leaf and root disease including:

- crop rotation
- disease resistant varieties
- seed dressings
- foliar fungicides
- time of sowing
- crop nutrition
- inter-row sowing
- stubble manipulation
- weed control in summer and following the season break.

The long-term adoption of stubble retention and conservation farming techniques can actually reduce the incidence of soil borne disease. For example, carbon inputs (stubble, roots) result in changes to the composition and activity of the soil microbial community over time, resulting in greater competition for soil resources leading to increased suppression of many soil borne fungal diseases.

Weed management

Management of weeds is important in stubble retention systems as weeds use valuable water and nutrients. Effective control of summer weeds prevents mechanical issues at seeding time and can reduce the occurrence of *Rhizoctonia*.

An Integrated Weed Management (IWM) approach to weed control is vitally important. Some practices that may be used as part of an IWM program include:

- crop rotations to introduce new herbicide groups
- cutting crop for hay
- brown manuring
- crop topping legumes and pastures
- making use of herbicide resistant crops
- increasing crop competiveness through seeding rates and good nutrition
- delayed sowing and double knocks.

Weeds can also be controlled in stubble systems by capturing weed seeds. Weed seeds in chaff can be collected in chaff carts or concentrated in narrow windrows behind the harvester. Chaff stacks or windrows are then burnt to kill the seeds. Burning chaff stacks and windrows is more effective than burning standing stubble as the burn is hotter and lasts longer. The recently released Harrington Seed Destructor (HSD) smashes the chaff and weed seeds without the need for burning. Chaff carts, windrow burning and the HSD are equally effective. All rely on weed seeds passing through the harvester, however, their effectiveness is reduced when weed seeds shed prior to harvest.
Ian, Daniel and James Linklater have been using a stubble retention system on their Trentham Cliffs farm for over 12 years.

“It’s pretty much all positive with stubble retention,” Ian says.

“The top soil is where we’re investing most of our money, so it’s really too valuable to lose.”

Ian and Daniel manage stubble on their farm by cutting the stubble as short as possible and sowing on 12 inch spacings. They use a knife point seeder, and recently purchased coulters through a Murray Catchment Management Authority incentive to assist with stubble management.

The Linklaters have had problems with water erosion on their farm in the past, and have been impressed with the ability of stubble to absorb water after summer rainfall events.

While weed control can be a challenge when implementing a stubble retention system on-farm, stubble can also assist with weed control according to the Linklaters.

“Not cultivating means the weed seeds are not incorporated into the soil and are retained on the surface where they can be sprayed when they germinate,” Ian says.

“We have also managed to reduce the cost of weed control by applying chemicals with technologies such as WEEDit to reduce the amount of chemical being applied, along with timing the application when weeds are younger and easier and cheaper to kill.”
Stubble retention systems that exclude cultivation rely heavily on herbicides for the control of winter and summer weeds.

Stubble places limitations on herbicide effectiveness because it acts as a physical barrier to the spray target (i.e. weed or soil). Some herbicides that are intercepted by stubble can be washed off by rain and remain effective, whereas others may volatilise while on stubble or bind to it making it ineffective.

Pre-emergent herbicides rely on adequate soil coverage and are generally effective in stubble cover levels up to 50%. When stubble loads exceed 50%, pre-emergent herbicides may not work or reach their full potential.

Some strategies which may increase the effectiveness of herbicide application in stubble retention systems are:

- ensure trash is evenly distributed at harvest to prevent concentrations of trash in header windrows
- leave stubble remaining upright - stubble that is lying flat on the ground reduces the ability of pre-emergent herbicide to reach the soil
- use coarse droplets, high pressure and high water rates (>80L/ha) to penetrate the stubble
- set up the boomspray to achieve double overlap at the height of the stubble
- select appropriate herbicides, as some herbicides bind to stubble while others can wash onto the soil and still be effective
- drive in the direction that the existing stubble was sown and try to use guidance to position the nozzle between stubble rows
- drive at slower speeds to minimise horizontal droplet movement.

It is common for nitrogen to be tied-up (immobilised) during the decomposition of cereal stubbles, reducing its availability to crops. Immobilisation occurs as nitrogen is required by the soil micro-organisms that are decomposing the stubble. The application of additional nitrogen fertiliser is often needed to meet the nitrogen requirements of the growing crop. In seasons with very low rainfall over the non-crop period (50mm compared to an average of 100mm), nitrogen tie-up can be very serious with even added nitrogen becoming unavailable to plants in the short term. This can result in very poor early growth and significant problems with *Rhizoctonia* and yellow leaf spot. Increasing nitrogen fertiliser rates, wider row spacing (more nitrogen per row), deeper placement of nitrogen and minimising the incorporation of stubble residues can help in reducing the occurrence of nitrogen tie-up.

Immobilisation rates have been reported at around 5-13kg per hectare of immobilised nitrogen for every tonne per hectare of decomposed wheat stubble. This nitrogen is not lost permanently as it will remineralise later during crop growth or in subsequent seasons, as stubble decomposes and the microbial requirement for nitrogen declines.
Allelopathy

Allelopathy is the suppression of growth of one plant species by another due to the release of toxic substances. Allelopathic effects are unrelated to nutritional, weed or disease related issues. Allelopathy is worse when stubble is incorporated than when stubble is retained on the surface.

It is only under certain conditions that the negative impacts of allelopathy associated with retained stubble are likely to effect crops. These conditions include: heavy wheat stubble prior to sowing; incorporating stubble when conditions are not favourable for decomposition; long dry summers; late autumn breaks; when weeds are allowed to continually persevere; a predominantly dry growing season with only patchy light rainfall events.

Establishing crops can be affected by retained stubble altering the micro-climate. During the winter months, surface stubble mulch in the order of four tonnes per hectare can reduce the daily temperature range resulting in slower plant growth.

Retained stubble has the potential to delay the emergence of seedlings, slowing leaf growth and increasing disease. Canola seedlings are particularly susceptible to the impact of reduced temperatures and light caused by stubble retention.

Timely sowing and good early nutrition can alleviate some of the effects of the altered micro-climate. Moving stubble away from the emerging seedlings during sowing can also assist. Selecting crops that have long coleoptiles or are cold tolerant (i.e. field peas instead of chickpeas) can also overcome the physical effects of stubble.
James O’Day from Merrinee in Victoria sees the future benefits of stubble management on his farm.

“Stubble retention has helped to limit wind erosion and retain soil moisture on my property, which has been great,” James says.

“The seasons have been quite dry since I began implementing stubble retention on my farm, so I think once the seasons improve I will see even greater benefits.”

James manages stubble on his farm by cutting the stubble as short as possible without affecting the harvesting process. He also uses a disc seeder for good trash flow handling and allows only minimal grazing by livestock.

James says weed control is a particularly important aspect of implementing a stubble retention system. James is implementing rotations that incorporate a range of crops such as oats, field pea and canola to provide greater weed control options. James also controls weeds by creating windrows behind the header to collect weed seeds and burning the rows.

“This is my second year using this management technique and I have seen a significant reduction in brome grass.”

“It is an ongoing process but it’s not hard to do and I made the header chutes myself at minimal cost.”
Stubble is managed over the summer fallow period in a variety of ways. While many farmers elect to leave the stubble standing, others manipulate stubble through cultivation, chaining or rolling. Grazing is also used as a stubble management tool. How stubble is managed over summer will ultimately affect ground cover levels.

To demonstrate the effect of stubble management on ground cover, 10 demonstration sites were established over the 2012/2013 summer fallow period. At each site, standing stubble was compared to cultivation, chaining and rolling. Treatments were applied in January 2013 and ground cover levels were monitored each month until April 2013.

Three sites have been selected to demonstrate the range of final ground cover levels for standing stubble treatment in April (Table 3).

The Euston site had the lowest ground cover in April of 52%. Ground cover in the standing stubble at Lameroo was 66% and at Kyalite 84%.

Rolling or chaining reduced ground cover levels by 5-40% relative to the standing stubble treatment. Incorporating stubble through cultivation dramatically reduced ground cover levels relative to the standing stubble treatment with all cultivated treatments falling below the critical 50% ground cover level in April.

The demonstration sites were established in a very dry summer with only 25-50mm of rain falling across the region from January – April. In wetter summers, greater stubble breakdown can be expected, especially where stubble has been rolled, chained or cultivated and the stubble is in contact with the soil surface.

**Table 3. Impact of stubble treatments on ground cover**

<table>
<thead>
<tr>
<th>Stubble Treatment</th>
<th>Standing</th>
<th>Rolled</th>
<th>Chained</th>
<th>Cultivated</th>
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</thead>
<tbody>
<tr>
<td><strong>Euston</strong></td>
<td>52%</td>
<td>35%</td>
<td>31%</td>
<td>14%</td>
</tr>
<tr>
<td><strong>Lameroo</strong></td>
<td>66%</td>
<td>63%</td>
<td>58%</td>
<td>30%</td>
</tr>
<tr>
<td><strong>Kyalite</strong></td>
<td>84%</td>
<td>76%</td>
<td>72%</td>
<td>46%</td>
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</tbody>
</table>

**Cultivation Treatment**

**Rolling Treatment**

**Chaining Treatment**
### Euston Demonstration Site

<table>
<thead>
<tr>
<th>Standing stubble</th>
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<tbody>
<tr>
<td><img src="image1" alt="Standing stubble" /></td>
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<table>
<thead>
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<table>
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<table>
<thead>
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</tr>
<tr>
<td><img src="image8" alt="Cultivated stubble" /></td>
</tr>
</tbody>
</table>
Kyalite Demonstration Site

Standing stubble

Rolled stubble

Chained stubble

Cultivated stubble
To prevent wind erosion, a minimum of 50% ground cover is needed at all times. When there is no crop or pasture present, such as over summer or when paddocks are fallowed, stubble is the primary source of ground cover in Mallee paddocks.

The ability to visually interpret ground cover levels is important for many farm management decisions including:

- grazing management
- herbicide application
- seeding equipment set up.

This photographic guide is designed to assist farmers and advisors to monitor the ground cover provided by stubble under different stubble management situations. The photographs depict a range of ground cover levels (20% through to 90%) in situations where stubble was left standing, rolled, chained or cultivated.

Each photograph has been taken at eye level. A 50 x 50 cm quadrat has been placed in each photograph to provide a reference point.
20% Ground Cover

- Standing stubble
- Rolled stubble
- Chained stubble
- Cultivated stubble
30% Ground Cover

- Standing stubble
- Rolled stubble
- Chained stubble
- Cultivated stubble
40% Ground Cover

- Standing stubble
- Rolled stubble
- Chained stubble
- Cultivated stubble
60% Ground Cover

- **Standing stubble**
- **Rolled stubble**
- **Chained stubble**
- **Cultivated stubble**
<table>
<thead>
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<th>70% Ground Cover</th>
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<tbody>
<tr>
<td>Standing stubble</td>
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<td><img src="image1" alt="Standing stubble" /></td>
</tr>
<tr>
<td>Chained stubble</td>
</tr>
<tr>
<td><img src="image3" alt="Chained stubble" /></td>
</tr>
</tbody>
</table>
80% Ground Cover

- Standing stubble
- Rolled stubble
- Chained stubble
- Cultivated stubble
There is no photographic example available for cultivated stubble at 90%. 
Glossary

**Allelopathy** - the suppression of growth of one plant species by another due to the release of toxic substances from their residues.

**Direct drilling** - low soil disturbance sowing system where the crop is sown directly into a paddock without prior cultivation.

**Fungal hyphal networks** - long thread like structures of the growth of fungi.

**Hair pinning** - stubble is bent rather than cut and pushed into the sowing groove with the seed. This can reduce soil-seed contact or contaminate the seed row with herbicides impacting on seedling emergence.

**Harrington Seed Destructor** - a machine that destroys weed seeds that pass through the header.

**Micro-climate** - the climate of a small, specific place within an area as contrasted with the climate of the entire area.

**Micro-organism** - any organism, such as a bacterium, protozoan, or virus, of microscopic size.

**Nitrogen tie-up (otherwise known as immobilisation)** - when nitrogen is bound in the soil micro-organisms as they decompose the stubble, making it unavailable for other plants.

**Non-symbiotic nitrogen fixing bacteria** - bacteria in the soil that can fix nitrogen from the air into plant available nitrogen in the soil without the need for a legume host plant.

**Soil aggregation** - the ‘clumping’ of soil particles together by moist clay, organic matter (such as roots), by organic compounds (from bacteria and fungi) and by fungal hyphae.

**Coleoptile** - the pointed protective sheath covering the emerging shoot in monocotyledons such as cereal crops.
References

Pers comm. David Roget.

Further Reading
