Managing for stubble retention

Linda Leonard
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Managing for stubble retention

Compiled by
Linda Leonard
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Department of Agriculture, Western Australia

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The Grains Research and Development Corporation is actively involved in the funding of stubble research because grain growers see this as one way of addressing the issue of profitable, sustainable production.

There is no such thing as the ultimate recommendation for stubble handling. Every farm and person has differing resources, attitudes and motivations. This should not prevent anyone from reading and learning from this Bulletin with a view to improving their basic resource - the land.

I would urge growers to assess the contents of this Bulletin and use the information to develop a ‘best practice’ for their individual farms.

Mick McGinniss
Chairman
Western Region
Grains Research and Development Corporation
One of the objectives of sustainable farming systems is to retain as much cover on the soil as possible - this helps to maintain soil structure and protects the soil from erosion.

Improving productivity, maintaining soil structure, and stabilising fragile soils are some of the desired aims of farming. Sound rotations, reduced tillage, effective use of herbicides, maintenance of ground cover and careful management of stock are part of the management process used in achieving these goals.

This Bulletin provides an introduction to stubble retention systems. Its purpose is to create an awareness of the benefits and principles of stubble retention - and describe ways to overcome the problems.

The Bulletin focuses on the desirability of stubble retention in the farming system, while providing a set of guidelines on how to estimate cover and manage stubble so it will fit into a management system. Later publications will involve machinery decision making, machinery conversions, further technological advances and financial aspects of stubble retention systems.

Linda Leonard
Extension Officer
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Also, special thanks to farmers, the Farm Machinery Advisory Committee of Western Australia, advisers, all those who provided comments and feedback, and to Femmeke Roberts for design and graphics.
Stubble handling is part of the total cropping system and needs to be considered in the management process. (Modified from V. Squires and P. Tow, 1991.)
Introduction to stubble retention

Stubble retention is a soil conservation measure that helps to eliminate land degradation. In doing so, it will improve the productivity and sustainability of farming.

Stubble retention can help prevent land degradation in Western Australia’s cropping lands.

The significance of stubble retention

Stubble: • Provides soil with a protective cover that will:
 – reduce the impact of rainfall on the surface and maintain infiltration
 – reduce wind speed at the soil surface
 • Maintains organic matter on the soil
 • Improves soil structure
 • Controls fungal brown spot disease in lupins
 • Reduces atmospheric pollution

Sheets erosion

Wind erosion

Dust clouds

Excessive cultivation
Wind erosion

Wind erosion is mainly a problem on loose, sandy soils. A sign of wind erosion is the windswept appearance of the soil surface and the sand blasting of crops.

Wind erosion is extensive when the land surface is dry and vegetation is sparse. Cropping of the lighter-textured soils of Western Australia has made them even more susceptible to wind erosion. For every 1 mm of soil lost through wind erosion, yield is reduced by 2 per cent.

Sand blasting can reduce cereal yields by as much as 50 per cent and remove emerging lupins crops completely.

Water erosion

Water erosion is mainly a problem in medium and fine-textured soils and is recognised by signs that flowing water has removed or deposited soil.

Soils erode wherever protective plant cover has been removed, leaving bare soil exposed to the force of rain and fast-flowing runoff.

Trials at Chapman Valley have shown suspended soil losses in runoff averaged 1.6 t/ha from traditional tillage, this being up to 10 times more than under a no-tillage sowing.

Soil structure decline

‘Sunday’ soils, so named because they can only be worked for a short time within a narrow range of moisture content, have a weak structure, unstable aggregates and soil particles with weak cohesion. These soils are recognised as being hard-setting when dry, and slippery and boggy when wet.

In clay and clay loams, cultivation brings up massive clods which break down under the impact of rainfall, causing a surface to seal. A hard surface layer prevents infiltration of water and increases runoff and soil loss.

Community awareness

Rivers carrying silt have been reported in Geraldton and Albany, indicating the presence of erosion in the catchments of these streams.

Media reports of erosion and dust clouds blowing over populated areas have made the community more aware of the erosion problems of rural areas. Stubble burning is recognised as a cause of air pollution and has been banned in Germany since 1985 – and more recently, in the United Kingdom.

How to manage for stubble retention

Stubble retention is a management decision to keep some or all crop residues on the soil surface from one season to the next.

Stubble retention is a management tool which needs to be incorporated into your sustainable farm system to overcome the problems of land degradation.
Basic principles

In managing for stubble retention, you should aim to:

- Leave enough stubble to prevent erosion
- Allow seeding machinery access through stubble
- Optimise the maximum potential of the farming system

Benefits

Reduced wind erosion

Stubble protects the soil surface by reducing the surface wind speed and by intercepting sand particles.

Standing stubble is twice as effective as flat stubble in preventing erosion. Loose straw is less effective against soil erosion.

Figure 2 shows that soil loss is reduced with increasing levels of stubble cover. About 50 per cent standing cover by stubble is required for effective erosion control.

![Figure 2. Effect of stubble cover on soil erosion. (P. Findlater, 1989.)](image)

Reduced water erosion

Stubble reduces water erosion by decreasing runoff velocity. The straw forms dams and obstacles for water flowing across the surface of the soil, slowing the flow of water.

Stubble retention reduces the impact of rain drops on the soil surface. The impact of raindrops detaches particles from poorly structured soils and causes surface sealing which increases runoff and soil loss through a decrease in the infiltration rate.

![Water erosion on a paddock unprotected by stubble.](image)
Disease control in lupins

The severity of brown spot in lupins can be reduced with stubble cover. Stubble reduces rain splash of spores from the soil surface onto stems and leaves of young lupin plants.

Figure 3 shows that it is of benefit for growers to have stubble levels of at least 2 t/ha on the surface, in situations of high disease risk.

Stubble also protects lupins from sand blasting, which can kill the seedlings if the hypocotyl is broken. Cotyledons can be damaged by sand blasting, and this can severely retard growth and predispose lupins to infection.

Soil moisture improvement

Stubble can have a small beneficial effect on the moisture content of heavy soils by increasing infiltration rates and by reducing evaporation rates – this can increase grain yield.

The effect of retaining stubble on yield has been examined in trials at Merredin. From 1985 to 1987 there was an average increase in yield from 1081 kg/ha to 1180 kg/ha (see Table 1).

<table>
<thead>
<tr>
<th>Year</th>
<th>Burnt</th>
<th>Normal stubble kg/ha</th>
<th>Added stubble: 2 t/ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>1985</td>
<td>424</td>
<td>560</td>
<td>578</td>
</tr>
<tr>
<td>1986</td>
<td>1944</td>
<td>2048</td>
<td>2101</td>
</tr>
<tr>
<td>1987</td>
<td>876</td>
<td>858</td>
<td>860</td>
</tr>
<tr>
<td>Average</td>
<td>1081</td>
<td>1155</td>
<td>1180</td>
</tr>
</tbody>
</table>

Organic matter and soil structure improvement

Retaining stubble in continuous cropping rotations can maintain or slightly increase soil organic matter.

After eight years of stubble retention on sandplain soils at Merredin and nine years at Wongan Hills, the levels of soil organic matter were tested by measuring the organic carbon percentage.
At Merredin, the soil organic carbon averaged 0.8 per cent and there was no difference between retaining or burning stubble. At Wongan Hills, organic matter on ungrazed plots was 6 per cent higher where all stubble was retained.

Long term trials on heavier soils at Merredin have shown that decreasing the amount of cultivation is more important (for grain yield) than stubble retention. Stubble retention, however, does increase water-stable aggregates on heavy soils. Water-stable aggregates are an indication of soil structural stability (see Table 2).

### Table 2. Water-stable aggregate (WSA%) and organic carbon percentage for stubble and tillage treatments on heavy soils at Merredin. Soil sampled 0-5 cm each September. Data averaged over three years (Jarvis, 1991).

<table>
<thead>
<tr>
<th>Stubble</th>
<th>Tillage</th>
<th>Organic carbon</th>
<th>WSA %</th>
<th>3-year average wheat yield (t/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Burnt</td>
<td>Ploughed</td>
<td>0.81</td>
<td>4.7</td>
<td>1.18</td>
</tr>
<tr>
<td></td>
<td>Direct drilled</td>
<td>0.89</td>
<td>9.7</td>
<td>1.54</td>
</tr>
<tr>
<td>Retained</td>
<td>Ploughed</td>
<td>0.80</td>
<td>8.5</td>
<td>1.12</td>
</tr>
<tr>
<td></td>
<td>Direct drilled</td>
<td>0.89</td>
<td>14.5</td>
<td>1.41</td>
</tr>
</tbody>
</table>

### Returning nutrients to the soil

Nitrogen and sulphur can be lost directly as a result of burning stubble. One tonne of straw contains 7.5 kg of nitrogen. Other elements are lost as ash blows away.
<table>
<thead>
<tr>
<th>Problems</th>
<th>Solutions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Diseases</strong></td>
<td>Use appropriate crop rotations to avoid disease. For example, yellow spot infects wheat and scald only infects barley and barley grass.</td>
</tr>
<tr>
<td>The following diseases are aggravated by stubble retention: yellow spot in wheat, septoria in wheat and oats, net blotch and scald in barley.</td>
<td></td>
</tr>
<tr>
<td><strong>Weed control</strong></td>
<td>Herbicides most likely to be diminished in their effectiveness are trifluralin and simazine. Increasing the rate of chemical by 10 per cent will normally eliminate any problem with the chemical’s efficiency. Use rotary harrows to solve the problem of herbicide incorporation.</td>
</tr>
<tr>
<td>In stubble, weed seeds are not reduced as they would be in a fire. Pre-emergent chemicals can have their efficiency reduced by straw, or by reduced incorporation.</td>
<td></td>
</tr>
<tr>
<td><strong>Phytotoxic effect</strong></td>
<td>Try to keep straw standing or on the soil surface and avoid burying too much straw.</td>
</tr>
<tr>
<td>Germination and growth of the following crop can suffer from toxins released during straw breakdown.</td>
<td></td>
</tr>
<tr>
<td><strong>Nutrient availability</strong></td>
<td>Adding nitrogen fertiliser overcomes a nutrient availability problem. Trials in Western Australia have given variable results with no definite trend toward this extra requirement. Distributing crop residue uniformly can help to maintain a more consistent soil nitrogen level.</td>
</tr>
<tr>
<td>Nutrients are locked up in the soil until the straw decomposes. This is because soil organisms require soil nitrogen to break down the dead material.</td>
<td></td>
</tr>
</tbody>
</table>
Stubble management

The right amount of stubble

To minimise wind and water erosion

Between 30 and 60 per cent ground cover is needed to control erosion: 50 per cent being the safe compromise. Cover needs to be maintained six to eight weeks after emergence. The crop will be sufficiently developed to prevent erosion by then.

• For cereal crops, 1 t/ha stubble corresponds to about 50 per cent of ground cover.
• In lupin crops, 2 t/ha of stubble (50 per cent ground cover).
• In canola, 3 t/ha (50 per cent ground cover).

Anchored stubble is more effective than loose straw at minimising wind erosion. The stubble should contain at least one-third anchored material so that movement of loose straw is restricted within the standing straw.

For disease control in lupins

Ideally there needs to be at least 2 t/ha of cereal stubble (more than 50 per cent cover), to effectively control brown spot in lupins.

Evenly-spread ground cover offers best protection to lupins. Flat stubble is just as effective as standing stubble at preventing raindrop splash. Other methods of disease control are necessary if stubble levels are inadequate. Stubble cover used with a seed dressing will control disease effectively.

How much stubble do you have?

To prevent disease and erosion, you need to check the level of cover and use strategies that will ensure surface cover is maintained.

• Compare field conditions to photographs or pictures of a known percentage cover. These can be used as a guide to estimate ground cover (see photographs on the following page).
• You can measure the amount of cover in a paddock by physically measuring the stubble level. This can be done by using the following methods.

A. Line intersect method

This method consists of:

• Laying a measuring tape diagonally across a number of crop rows. For example, lay out a 100 m tape.
• Count the number of times a piece of residue intersects every metre mark along the tape for the 100 m.
• If stubble intersects at every metre marking, then you have 100 per cent cover.
Assessing ground cover by stubble

This amount of stubble represents a 2 per cent stubble cover (less than 200 kg/ha of stubble).

Field view of 2 per cent stubble cover

This amount of stubble represents a 20 per cent stubble cover (500 kg/ha of stubble).

Field view of 20 per cent stubble cover

This amount of stubble represents a 50 per cent stubble cover (1 t/ha of stubble).

Field view of 50 per cent stubble cover

This amount of stubble represents a 100 per cent stubble cover (> 6 t/ha).

Field view of 100 per cent stubble cover
• Perform this procedure several times in representative parts of the paddock.

• Calculate the average.

B. Pacing the paddock

Pace a paddock and visually count straw at a marked point on the toe of your boots. This will give the same result as the above method.

• Mark a starting point in the paddock with a stake.

• Take 100 steps diagonally across crop rows.

• Stop and turn towards the stake.

• Step back towards the stake noting the stubble at the point marked on your boots.

• If stubble was counted 30 times at the marked points of your boots, then there is 30 per cent cover.

Note: When looking at stubble, do not count tiny bits of straw that are unlikely to provide protection to the soil.

• The amount of stubble you have after harvest can be estimated from grain yield (see Table 3). The grain yield can be used to determine how much surface protection the stubble will provide. Figure 4 shows the relationship between percentage cover and weight of slashed wheat and lupin stubble. Cover will be lower if stubble is standing.

<table>
<thead>
<tr>
<th>Type of crop</th>
<th>Grain yield (t/ha)</th>
<th>Stubble yield (t/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat</td>
<td>4.0 3.6 3.2 2.8 2.4 2.0 1.6 1.2 0.8</td>
<td>7.4 6.7 5.9 5.2 4.4 3.7 2.9 2.2 1.5</td>
</tr>
<tr>
<td>Oats</td>
<td>2.0 1.8 1.6 1.4 1.2 1.0 0.8 0.6 0.4</td>
<td>6.0 5.4 4.8 4.2 3.6 3.0 2.4 1.8 1.2</td>
</tr>
<tr>
<td>Barley</td>
<td>3.8 3.4 3.0 2.6 2.2 1.8 1.4 1.0 0.6</td>
<td>6.8 6.0 5.3 4.6 3.9 3.2 2.4 1.8 1.0</td>
</tr>
<tr>
<td>Lupins</td>
<td>2.0 1.8 1.6 1.4 1.2 1.0 0.8 0.6 0.4</td>
<td>6.0 5.4 4.8 4.2 3.6 3.0 2.4 1.8 1.2</td>
</tr>
</tbody>
</table>

Figure 4. Relationship between surface cover and stubble weight for slashed wheat and lupin stubble. (Adapted from Leys and Heinjus, Department of Agriculture, South Australia, 1991.)
Why you need to know stubble levels

Tillage operations reduce the level of surface cover. The amount of stubble buried depends on the number of tillage passes and the type of implement used. Table 4 shows the amount of cover reduced by particular implements.

From these measurements and measurements taken at harvest, it is now possible for you to manage the quantity of stubble you have from harvest through the summer and autumn, leaving enough cover to prevent erosion and disease in crops.

Calculate as follows:

Step 1. How much stubble you have after harvest (from page 9)
[minus]

Step 2. How much is buried by seeding equipment (Table 4)
[minus]

Step 3. How much you need (page 7) = How much stubble you can break down or remove safely.

This is demonstrated in Table 5.

<table>
<thead>
<tr>
<th>Implement</th>
<th>Reduction of cover per working (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plough</td>
<td>65 - 85</td>
</tr>
<tr>
<td>Combine, wide row, narrow points</td>
<td>30 - 50</td>
</tr>
<tr>
<td>Combine, normal spacing, full cultivation</td>
<td>50 - 60</td>
</tr>
<tr>
<td>Culti trash</td>
<td>75 - 80</td>
</tr>
<tr>
<td>No-till discs</td>
<td>5 - 20</td>
</tr>
</tbody>
</table>

Table 4. The estimated reduction in stubble cover after a particular tillage operation

<table>
<thead>
<tr>
<th>How much stubble after harvest (Table 3) minus</th>
<th>How much is buried after seeding (Table 4) minus</th>
<th>How much you need (for erosion or disease control) =</th>
<th>How much stubble you can remove safely</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.9 t/ha stubble (1 t/ha wheat yield) minus</td>
<td>1 t/ha (using a tined implement which buries 50% see Table 4) minus</td>
<td>1 t/ha for wind erosion control =</td>
<td>Do not remove, lightly graze only</td>
</tr>
<tr>
<td>1.9 t/ha stubble (1 t/ha wheat yield) minus</td>
<td>400 kg/ha (using a no-till disc implement which buries 20% see Table 4) minus</td>
<td>1 t/ha for wind erosion control =</td>
<td>500 kg/ha can be stacked safely – leaving enough cover to prevent erosion</td>
</tr>
<tr>
<td>5.9 t/ha stubble (3.2 t/ha wheat yield) minus</td>
<td>1.2 t/ha (using a no-till disc implement as above) minus</td>
<td>1 t/ha for wind erosion control =</td>
<td>3.7 t/ha can be broken down or removed</td>
</tr>
<tr>
<td>3 t/ha stubble (1 t/ha lupin yield) minus</td>
<td>1.5 t/ha (tined implements bury 50%) minus</td>
<td>2 t/ha needed for wind erosion =</td>
<td>Do not remove, lightly graze only</td>
</tr>
<tr>
<td>3 t/ha stubble (1 t/ha lupin yield) minus</td>
<td>600 kg/ha (no-till disc implement buries 20%) minus</td>
<td>2 t/ha needed for wind erosion =</td>
<td>Do not remove, lightly graze only</td>
</tr>
<tr>
<td>6 t/ha stubble (2 t/ha lupin yield) minus</td>
<td>3 t/ha (50% buried with tined implement) minus</td>
<td>2 t/ha for wind erosion =</td>
<td>1 t/ha can be broken down or removed</td>
</tr>
</tbody>
</table>

Table 5. A simplified stubble management ready reckoner
Managing for stubble retention

Reasons for managing stubble levels

High stubble levels (greater than 7t/ha) can have a harmful effect on the cropping environment. Such levels can:

- Alter the germination of weeds; make brome grass less dormant and increase the seed dormancy of wild radish.
- Provide ideal habitats for insects and pests; snail and mite populations may increase.
- Increase the level of toxicity to the plant. If stubble is incorporated and soil becomes waterlogged, toxins are leached from decomposing residue.
- Cause hair-pinning of stubble, which reduces seed/soil contact.
- Reduce the effectiveness of chemicals for weed control. This may reduce the range of chemical groups that can be used.
- Increase the incidence of cereal diseases from the carryover of too much stubble.
- Decrease soil temperatures resulting in poor early growth.

It may be necessary to remove stubble to control these problems. These problems become more prevalent in areas of higher rainfall that have higher stubble levels. However, rainfall does enable the stubble to break down faster.
If you decide to retain your stubble, be practical about it. Stubble retention is a management practice which is an integral part of a cropping system.

Just as you make the decision to grow a crop, leave a paddock to pasture, or decide on what herbicides to use, you should look at the benefits of stubble retention in your cropping program.

Stubble retention demands a degree of technical and management skill that, when handled correctly, is easy to apply.

The decision to retain your stubble will depend on:

• the risk of erosion on your property
• the rotations practised for that year
• the ability of your machinery to handle stubble
• your desire to improve the soil

**The risk of erosion**

Western Australian soils need most protection in the autumn-winter.

The potential erosion hazard of a paddock is determined by:

• Exposure of the site: Wind erosion can occur with wind speeds as low as 18 km/h depending on the soil surface condition. Sandy soils are more prone to erosion than clay-based soils. Hill tops are more prone than valleys.

• Dryness of the site: Dry soil blows more easily.

• Looseness of the soil: Overgrazing and fast cultivation can increase the risk of erosion, even on heavy soils. Both can break up the soil surface, leaving the soil loose and powdery.

• Adequacy of ground cover: Sheep will remove vegetation and ground cover. Ground cover prevents wind reaching the soil surface and reduces the chances of particle movement.

**Crop rotations**

Current farming rotations practised in the Western Australian wheatbelt mainly involve the growing of cereals, lupins, canola, peas and pastures.

In a stubble retention system you need to consider:

• The economic impact on your cropping income – with and without stubble retention.
• Whether the next crop would be one that is susceptible to disease that attacks the leaf, stem, crown, or roots.
• Consider the value of your pasture. Balance erosion versus pasture production. In cereal/pasture rotations, stubble may decrease pasture emergence. (See Figure 5.) Note that pasture emergence is not greatly affected at stubble levels required to control wind erosion.

• Look at stocking rates and keep a close eye on pasture levels. Sheep prefer eating burr rather than stubble. Pasture levels may drop because of over-grazing rather than stubble density. Sheep condition will normally deteriorate before stubble levels fall below those levels required to control wind erosion.

In cereal/lupin rotations it is best to keep as much stubble as is practicable. The susceptibility of lupin seedlings to sand blasting and disease is an example of the economic benefit of stubble retention.

In continuous cereal rotations there may be times when you need to burn your stubble because of the incidence of cereal diseases. The extent of disease carryover in stubble depends on your locality, cereal rotation and density of stubble.

Machinery availability

No one knows the capability of your seeding machinery better than you.

To retain stubble, your machinery must be able to handle it. Test the stubble handling capability of your machinery on paddocks or areas within a paddock.

If your machinery cannot handle the level of stubble, manipulate the stubble to suit your seeding equipment. Cutting stubble short and spreading it evenly will improve stubble handling with all machinery.
You may need to modify existing machinery or buy machinery capable of handling more stubble. Single disc and double disc machinery are capable of handling high levels of stubble without treatment. Sowing with tines into stubble requires more planning. Coulters, disc/tine combinations and wide row spacing are choices available for better stubble handling.

When buying machinery, your choice should be determined by soil type, rotations practised, crop yields (that is, stubble levels), finances and preference. The machinery selected should not only be able to handle stubble but be compatible with non-stubble retention systems as well.

**What stubble retention involves**

Good stubble management involves planning before harvest.

Stubble retention involves knowing about the choices available to manage stubbles.

The best way to reduce stubble levels is to manage them at harvest. Good stubble management at harvest reduces problems at seeding.

**Management choices after harvest**

The aim of post-harvest stubble management is to confidently enter the 'seeding program' knowing that:

- there will be no machine blockages caused by excessive stubble length or stubble volume;
- stubble levels are acceptable for erosion and disease control requirements, given the preferred management techniques; and
- weeds are adequately controlled over the summer period.

If stubble is short and well spread after a normal summer, few problems are anticipated with tillage or seeding operations. If no weed control problems are expected, little more needs to be done.

However, if this is not the case then a stubble management plan will be needed.

Stubble can be either:

- broken down
- removed
- incorporated

**Grazing management**

Sheep can pulverise dry soil and loosen its surface, increasing the risk of erosion. Special care is needed when sandy soils and grain legumes are grazed.
## Management choices at harvest

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Features</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cut low</td>
<td>Harvest low with an open front header.</td>
<td>More straw will be flowing through the header than normal, reducing harvesting work rate up to 33 per cent.</td>
</tr>
<tr>
<td>Straw chopper and chaff spreader</td>
<td>Chops, splits and spreads straw and chaff over the width of the header.</td>
<td>Avoids concentration of straw and chaff in the header trail. Requires up to 30 hp to operate.</td>
</tr>
<tr>
<td>Second cutter bar</td>
<td>Cuts straw to required height without excess straw going through header.</td>
<td>Does not reduce header efficiency. Ideal for headers that do not have the capacity to cut low. Prone to damage if paddock is not free from obstacles. Requires 3-5 hp.</td>
</tr>
<tr>
<td>Swathing</td>
<td>The straw is cut low and crop is protected from staining and head loss in cereals or pod shattering in lupins.</td>
<td>More important in high rainfall areas where harvest time is limited.</td>
</tr>
<tr>
<td>Catcher bin</td>
<td>It catches seeds and chaff off the sieves. It can be dumped and burnt or used as a feed supplement.</td>
<td>Operation is done at harvest and is being evaluated for weed seed bank control.</td>
</tr>
<tr>
<td>Harvest at more than 5° angle</td>
<td>Harvest at an angle of greater than a 5° angle to normal seeder working.</td>
<td>This will ensure stubble knocked to the ground is not lying across normal seeder working and is more likely to pass through the seeder without problems.</td>
</tr>
</tbody>
</table>
The grazing potential of stubble is estimated by:

(i) Stocking rate (DSE/ha) is:

The amount of stubble you need to reduce (from Table 5)

\[
\text{Removal rate (2 kg/hd/day) \times number of days}
\]

For example: You need to manage 1 t/ha stubble

\[
\begin{align*}
\text{DSE/ha} &= \frac{1000 \text{ kg/ha}}{2 \times 120 \text{ days}} \\
&= 4.2 \text{ DSE/ha}
\end{align*}
\]

(ii) No. of grazing days is:

The amount you need to reduce

Removal rate (2 kg/hd/day) \times \text{stocking rate (DSE/ha)}

For example:

\[
\begin{align*}
\text{No. of grazing days} &= \frac{1000 \text{ kg/ha}}{2 \times 5} \\
&= 100 \text{ grazing days}
\end{align*}
\]

Stock will not graze a paddock evenly. Grazing patterns of livestock lead to bare areas, while other areas remain well covered. Consider moving watering points around the paddock so grazing is not concentrated in one area. Use electric fencing for better management.

**Dealing with alternative crop stubbles**

The grazing value of alternative crops is in the grain. Therefore, there will be less value in grazing paddocks if you can increase your harvesting efficiency. This is achieved by using modified header fronts that reduce harvest losses. Chopping and spreading the residue after harvest leaves sufficient ground cover to control erosion, especially in field peas where the residue rolls up easily and can be blown away by the wind, offering little protection to the soil. If the stubble needs to be grazed it should be managed in the following manner.

**Pea stubble**

- In heavy to medium soil types, graze after harvest for a short time (six to eight weeks).
- If summer rain occurs, a slow, shallow working with narrow points or shallow discing will help to anchor residue.
- For sandy surfaces, do not graze. At best, defer grazing until just before sowing — and only to clear up seeds.

**Canola stubble**

The most effective ways to reduce canola residue:

- For medium to heavy soils, graze the stubble after harvest only to obtain the benefit of pod and leaf material.
- If stubble levels are heavy, rake and burn the windrow or cold-burn the stubble before the break of season.
## Breaking down stubble

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Features</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rolling</td>
<td>Rollers or prickle chains flatten stubble to hasten its breakdown.</td>
<td>Header trails must be well spread for this method to work.</td>
</tr>
<tr>
<td>Slashing/mowing</td>
<td>Where stubble has been left long, slashing will reduce its length. Performed under hot dry conditions for maximum benefits.</td>
<td>Will not cut stubble lying on the ground. High fire risk in stony country. Very time consuming operation.</td>
</tr>
<tr>
<td>Cross harrow</td>
<td>Dump or leaf harrows help spread header trails.</td>
<td>Care must be taken not to loosen too much stubble or it will blow away.</td>
</tr>
<tr>
<td>Chaining</td>
<td>Dragging chains or cables at high speed can break stubble down. Two passes in opposite directions gives best results.</td>
<td>Creates dust. If stubble is not brittle it will be left in long lengths lying on the ground.</td>
</tr>
</tbody>
</table>

- In light soils, run a chain or prickle chain over the stubble in mid summer, when canola stubble is brittle.

### Lupin stubble

There is little value in grazing lupin stubble where there is less than 50 to 150 kg/ha of grain on the ground.

### Sowing into stubble

To obtain the maximum benefit of retained stubble, all crops should be direct-drilled through and under the stubble, not into it.

With all direct-drilled crops, grassweed control in the year before cropping is essential.
## Removal of stubble

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Features</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grazing</td>
<td>Effective at reducing stubble levels in paddock.</td>
<td>Over-grazing can leave soil bare and prone to erosion. Sheep tend to flatten long stubble. Move watering points so grazing is not limited to one area. Especially important when grazing lupins.</td>
</tr>
<tr>
<td>Burning the header trails</td>
<td>If chaff and straw were not spread at harvest and stubble is short, burning the header trail will decrease straw levels.</td>
<td>There is a risk of burning the whole paddock where the density of lying stubble is too high. Best to burn when conditions are cold or moist, with no wind.</td>
</tr>
<tr>
<td>Raking and burning the windrows</td>
<td>Raking and burning the windrow removes standing and lying stubble by putting it into rows.</td>
<td>Risk of burning the whole paddock where the density of stubble is high. Best to burn when conditions are cold or moist, with no wind.</td>
</tr>
<tr>
<td>Raking and baling</td>
<td>Baling straw will reduce the bulk of straw.</td>
<td>Bales have been used to make paper, used as fuel, or as feed. Transport costs and marketing may be a problem.</td>
</tr>
<tr>
<td>Cold burn</td>
<td>Using fire harrows to carry out a cold burn decreases the density of straw.</td>
<td>May burn the whole paddock if conditions are not perfect for a cold burn. Burn just before seeding. Do not burn on sandy soils, especially if they have been grazed in summer.</td>
</tr>
<tr>
<td>Hot burn</td>
<td>Method of reducing weed seed levels, if weeds are becoming resistant to herbicides.</td>
<td>May burn tree lines and bush. Burn as close to seeding as possible. Do not burn on sandy soils, especially if they have been grazed over summer.</td>
</tr>
</tbody>
</table>
Incorporation of stubble

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Features</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cultivating/discing</td>
<td>With summer rain, cultivating or turning the stubble into the soil will speed up its breakdown.</td>
<td>Breakdown will not occur if soil is dry. Long pieces of straw embedded in the soil can cause blockages at seeding. Cultivation damages the structure of heavy soils. Incorporation before seeding may reduce emergence.</td>
</tr>
</tbody>
</table>

Tables 6 and 7 give a rough estimate of the ability of machinery to handle stubble in treated and untreated stubble. Machinery will handle more stubble if it is cut short. Stubble flow through machines is also dependent on the moisture content of stubble and whether or not stubble is lying flat or standing.

**Tine implements**

The key to a successful stubble retention farming system using tined implements is to prepare the stubble at harvest by cutting the straw into short lengths.

**Important stubble handling factors in seeding machine design**

- Tine and point shape (rounded edges and no sharp bends are best)
- Tine ‘nominal’ underframe clearance, that is, the clearance of the lowest major obstruction on the tine (the larger this clearance the better)
- Tine pattern and spacing
- Tine break-out force (higher gives better digging ability but trash flow may be better with lower tine tension, for example, vibra shank tines)
- Tine clearance around wheels (avoid tines close to the rear and side of the tyre)
- Coulters may improve stubble flow (better on firm soils with relatively dry stubble)
- Rotary harrows are needed to level the seedbed and spread the stubble evenly

**Tine spacing**

Rules of thumb:
- For stubble levels of 3 to 5 t/ha (1.5 to 2.5 t/ha grain yield), the maximum length of all stubble must be less than 1/3 the distance between tines on any bar of the seeder.
- For stubble levels up to 3 t/ha (1.5 t/ha grain yield), the maximum length of all stubble must be less than 1/2 the distance between tines on any bar of the seeder.

Six-bar combine seeders and modern five-bar air seeder bars have been designed to handle higher levels of stubble. The tines are placed further apart to allow the stubble to flow between them but even these seeders will not operate if the stubble is poorly managed.

Wide row spacing of wheat reduces yields by only a small amount. Wheat grain yield is reduced by 4 per cent as row spacing is increased from 180 mm to 360 mm.
Table 6. The ability of seeding machinery to handle stubble cut to 200 mm height and spread evenly

<table>
<thead>
<tr>
<th>Crop yield</th>
<th>1 t/ha</th>
<th>2 t/ha</th>
<th>3 t/ha</th>
<th>4 t/ha</th>
<th>5 t/ha</th>
<th>6 t/ha</th>
<th>7 t/ha</th>
<th>9 t/ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level of stubble at seeding</td>
<td>less than 1 t/ha</td>
<td>2 t/ha</td>
<td>2.5 t/ha</td>
<td>3 t/ha</td>
<td>3.5 t/ha</td>
<td>4 t/ha</td>
<td>5 t/ha</td>
<td>6 t/ha</td>
</tr>
</tbody>
</table>

**Equipment**

<table>
<thead>
<tr>
<th>Equipment</th>
<th>4 bar combine (180 mm, 7&quot;)</th>
<th>6 bar combine (190 mm, 7.5&quot;)</th>
<th>6 bar combine (380 mm, 15&quot;)*</th>
<th>4 bar air seeder</th>
<th>5 bar air seeder</th>
<th>Culti trash</th>
<th>Tandem offset disc air seeder</th>
<th>Single disc opener</th>
<th>Double disc opener</th>
<th>Triple disc opener</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 bar combine (180 mm, 7&quot;)</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
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<td>✔</td>
</tr>
<tr>
<td>6 bar combine (190 mm, 7.5&quot;)</td>
<td>✔</td>
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<tr>
<td>4 bar air seeder</td>
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<tr>
<td>5 bar air seeder</td>
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<tr>
<td>Tandem offset disc air seeder</td>
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<tr>
<td>Single disc opener</td>
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<tr>
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</tr>
</tbody>
</table>

* Cultivating tines removed

Table 7. The ability of seeding machinery to handle untreated stubble

<table>
<thead>
<tr>
<th>Crop yield</th>
<th>1 t/ha</th>
<th>2 t/ha</th>
<th>3 t/ha</th>
<th>4 t/ha</th>
<th>5 t/ha</th>
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</tbody>
</table>

**Equipment**

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<th>Equipment</th>
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<tr>
<td>4 bar air seeder</td>
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<tr>
<td>5 bar air seeder</td>
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<td>✔</td>
</tr>
<tr>
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<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
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</tr>
<tr>
<td>Tandem offset disc air seeder</td>
<td>✔</td>
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<tr>
<td>Single disc opener</td>
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</tr>
</tbody>
</table>

* Cultivating tines removed
Fertiliser toxicity is affected by:

- soil type (texture and phosphorus absorption capacity)
- soil moisture
- concentration of fertiliser (band width)
- seed/fertiliser contact

Why seed placement is important:

- Deep seed placement delays emergence; it is equivalent to a later sowing date.
- Seedlings emerging from a greater depth are weaker and tiller poorly compared with seeds sown shallower.
- Seeds sown too shallow will be more prone to droughting.

Research has shown that there is no reduction in lupin yield by going to wider row spacing, so the stubble handling ability of any tined machine can be dramatically improved by going to a wider row spacing. The average yield from 10 experiments comparing row spacings was 1.28 t/ha for normal 19 cm row spacing and 1.33 t/ha for double-width row spacing.

**Fertiliser toxicity**

With wide row spacing, the same seed and fertiliser rates are used per hectare so there is a doubling of seed and fertiliser rates in each row. This can result in fertiliser toxicity when the fertiliser is drilled with the seed – which reduces establishment and seedling vigour.

Deep banding is one way to avoid the problem of fertiliser toxicity when using wide row spacing. Top dressing is a less effective way of applying fertiliser but can be used in high rainfall areas.

**Disc implements**

The key to a successful stubble retention farming system using disc implements is to spread the straw and chaff evenly at harvest.

Single disc and double disc zero-till designs appear to have good seed placement while leaving most of the stubble on the surface – provided they can penetrate the soil. Current research and farmer experiences are being used to further evaluate and develop crop establishment systems with these machines.

These machines are heavily reliant on herbicides for weed control and their effects on soil diseases are unclear.

Problems of disc penetration with the culti-trash type of disc machine include penetration, incorporation of disease spores, drying of the soil surface, and variable seed placement.

Spreading the stubble at harvest will leave an even seed bed, free from lumps of straw.

Seed placement can be improved by modifying the tube placement on culti-trash disc seeders. The seed tube can be placed behind the bearing on the back discs.
### Attachments for finishing and levelling the seedbed

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Features</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Heavy rotary harrows</strong></td>
<td>Levels ridges and clumps of stubble. Can retrieve buried stubble. Good chemical incorporation.</td>
<td>A heavy weight to pull, especially if added to lightweight seeders.</td>
</tr>
<tr>
<td><strong>Light rotary harrows</strong></td>
<td>Versatile and relatively cheap. Smooths ridges and spreads stubble.</td>
<td>Not as heavy as some rotary harrows but not as aggressive either.</td>
</tr>
<tr>
<td><strong>Finger harrows</strong></td>
<td>Can smooth out soils free of stubble. Rakes stubble.</td>
<td>By adjusting the fingers, the harrow can handle higher levels of stubble but it is not very effective.</td>
</tr>
<tr>
<td><strong>Press wheels</strong></td>
<td>Improves contact of seed with soil and may improve depth control of seeding.</td>
<td>Does not provide weed kill action or chemical incorporation.</td>
</tr>
</tbody>
</table>

After sowing

Buried stubble can reduce seed/soil contact. It may be advantageous to bring stubble to the surface. Equipment may also be used to bury the seed and level the seedbed.
# Summary of machinery to manage stubble

<table>
<thead>
<tr>
<th>Operation</th>
<th>Stubble density</th>
<th>less than 2.5 t/ha</th>
<th>2.5 – 5 t/ha</th>
<th>greater than 5 t/ha</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Harvesting machinery</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spreader</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chopper</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Second cutter bar</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Open front header</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Swath</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Harvest treatment</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cut 30 cm</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cut stubble into</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt; 20 cm lengths</td>
<td></td>
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<td></td>
</tr>
<tr>
<td><strong>Post harvest</strong></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Break down the stubble*</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Remove*</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Incorporate*</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Seeding machinery</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No-till disc</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Culti-trash**</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6 bar tined combine**</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Airseeder**</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>6 bar combine (wide rows)**</td>
<td></td>
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</tr>
</tbody>
</table>

* See choices for retaining stubble, page 12.
** With rotary harrows
Summary

- Stubble retention is a part of the cropping system that needs careful management.
- Stubble retention contributes to the sustainability of farming, that is, it prevents erosion and improves soil structure and water infiltration.

- Stubble management begins at harvest.

- To increase choices for seeding, cut the stubble short at or after harvest, and spread evenly, preferably at harvest.

- Bare soil increases the risk of erosion; beware of over-grazing and leave enough stubble on the surface to have 50 per cent ground cover.

- Burning should be your last resort. If you need to burn, do so as close to seeding as possible.
Further reading


**Videos**

Productions of the Department of Agriculture, Western Australia:

- Stubble: The burning question
- Stubble handling begins at harvest

Kondinin Group productions

- The last straw