EH GRAHAM CENTRE
for Agricultural Innovation

Stubble Management – an integrated approach

Take home messages

- Stubble management requires an integrated management approach, combining several strategies.
- Estimating stubble loads before harvest will help identify the best management practices to use during and post harvest, and pre sowing.
- If stubble cannot be retained due to heavy disease or weed burdens, adopt best management practices to achieve an effective burn to minimise the environmental impact.

The benefits of stubble retention are well known, but wet seasons have seen a shift in farmer attitudes towards stubble management. Managing high stubble loads requires careful planning to ensure effective sowing during the following season.

Stubble retention protects soil from erosion, aids soil moisture storage, through better infiltration and reduced surface run-off and lower evaporation rates. The ground cover offered by stubble may also help maintain soil structure by increasing soil microbial activity.

Despite the benefits, large stubble loads can present challenges, blocking machinery at sowing. Careful planning and selecting the right machinery can solve these issues, but burning is also an option.

The advantages and disadvantages of stubble retention can be split into long-term and short-term effects and are summarised in Table 1.

Stubble loads

Stubble management starts at harvest. The relationship between grain yield and estimates of stubble after harvest is shown in Figure 1.

Harvest Index (HI) can be used to estimate stubble loads from estimated grain yield. HI is the ratio of grain yield to total above ground biomass. For wheat the HI generally ranges from 0.3-0.5 (see Table 2). There can be large variations in HI depending on factors such as seasonal conditions, crop variety, soil type/fertility, fertiliser and lime use, disease levels and weed competition.

Research conducted by the Agricultural Machinery Research and Design Centre at the University of South Australia, showed wheat stubble levels amount to 1.3-2.8 times the grain yield, and start to create handling problems from stubble levels of 3-4 t/ha. Typically a 4 t/ha wheat crop at Wagga (Table 2) has a stubble load of 2.1 times the grain yield (i.e. 8.4 t/ha).

A method to estimate ground cover is to stand in a representative area of the paddock with feet 500 mm apart. Imagine a square quadrat (500 mm x 500 mm) in front of your feet, look down and estimate the percentage of area covered by plant material. Do this 10 times across the paddock and average the results. See Figure 2.

Stubble management options

At harvest

The main management decisions at harvest are the header cutting height and the spread pattern of the stubble. If using tramlines and inter-row sowing standing stubble will make sowing easier.

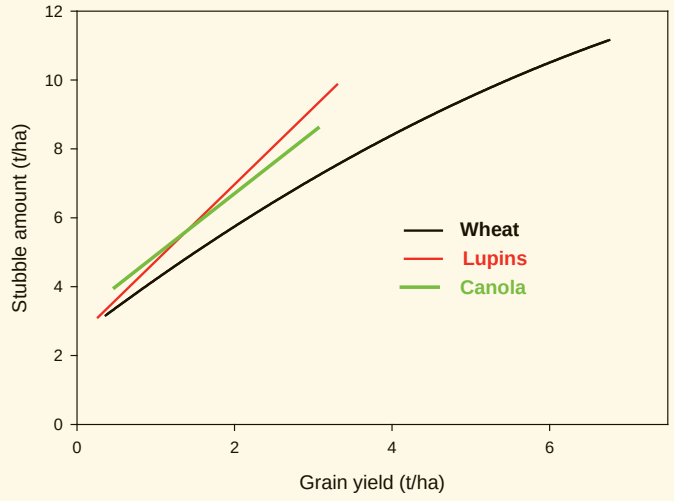


Figure 1. Estimate of stubble from grain yield at Wagga Wagga, NSW. *Source: D Heenan et al (2004) and M Conyers (pers comm).*

Table 1. Potential advantages and disadvantages of stubble retention

Short-term advantages

1. Reduced wind and water erosion

- To determine the value of ground cover for wind erosion control, assess the percentage of covered ground viewed directly from above. Critical ground cover – 30% in standing stubble (30-60 cm high) and 50-60% for prostrate stubble.
- Stubble cover reduced the erosive effects of water by reducing the impact of raindrops on the soil surface and decreasing run off and its velocity. Research at Wagga Wagga, NSW shows stubble retention during autumn compared with stubble burning resulted in reduced run-off from direct drilled wheat (15 compared with 25 mm/yr) and decreased soil loss (0.5 compared with 1.4 t/ha/yr) as measured over 40 months on a site of 8% slope.

2. Moisture conservation

- Retained stubble improves water infiltration.
- Stubble increases soil moisture retention, particularly in the soil surface pre-sowing and during early crop development.

3. Avoidance of the smoke hazard from burning

Short-term disadvantages

1. Interference with machinery

- Older sowing equipment is often limited in its capacity to sow through thick stubble. Tined machines can experience blockages at relatively low levels (2.2 t/ha) particularly if the stubble is wet. Many farmers modify conventional machinery to sow into heavy stubble, avoiding the cost of buying specialised machinery.
- Disc seeders are less likely to block in stubble, while more recent innovations such as the Stubble Star and Happy Seeder can sow into heavy stubbles (loads greater than 9 t/ha).

2. Disease and pest carryover in stubble retention versus burning

- Stubble retention can significantly increase disease levels including crown rot, common root rot, yellow spot, eyespot and take-all.
- It is important to accurately identify disease and implement strategies to minimise risk. Consider these steps:
  - Implement sound crop rotations and select disease resistant varieties;
  - Use seed and fertiliser treatments to provide prolonged disease protection;
  - Ensure adequate nutrition to promote early seedling vigour;
  - Use foliar fungicide spray applications when disease is confirmed and economic thresholds for crop losses are attained;
  - Burning can reduce stubble cover that will potentially harbour vermin. Stubble harbours mice, potentially resulting in damage to young crop seedlings. In the alkaline soils of South Australia it also results in increased crop damage by Mediterranean snails.

3. Weed control is crucial

- Follow these strategies:
  - Know the weed spectrum in paddocks and use an integrated approach for effective and timely monitoring and weed control.
  - Control emerging summer weeds.
  - Match herbicides to stubble conditions and follow herbicide application recommendations and rates.
  - Recognise that pre-emergent herbicides, particularly those requiring incorporation, have limitations in stubble management systems.

4. Immobilisation of nitrogen by retained stubble

- When wheat stubble is decomposing, immobilisation of nitrogen is common, reducing the immediate availability of nitrogen to crops.

5. Allelopathic effects of retained stubble

- Stubble can have negative effects on newly sown crops. These effects are unrelated to disease, weed or nutritional problems and are called allelopathic effects. Allelopathy is the inhibition (or benefit) of growth in a plant species by chemicals produced by another species. Allelochemicals can leach from the stubble or be produced by the micro-organisms present in the early stages of stubble decomposition.

6. Physical effects of retained stubble

- Stubble mulch can alter the microclimate for newly sown crops, reducing the daily range of temperatures under the stubble layer. However, temperatures above the mulch can increase. Stubble mulch also blocks light and can cause etiolated plants.

Long- term advantages

1. Improved conditions for plant growth

- Retaining stubble may contribute to the accumulation of soil organic carbon or sequestering carbon that would potentially be lost through burning or removing stubble.

2. Increased earthworm numbers

Long-term disadvantages

1. Development of herbicide resistance in weeds

- The increased reliance on herbicides with retained stubble systems to achieve effective weed control may result in the development of herbicide resistance.

2. Stratification of the soil profile

- Stubble retention can result in increased soil acidification at the 0-10 cm depth. Soil pH_{Ca} was 0.20 units lower with retained compared with burnt stubble in a long-term crop rotation trial at Wagga Wagga, NSW, in a lupin/wheat rotation using direct drilling.
- Research shows direct drilled and no-tilled systems accumulated some immobile nutrients in the soil surface.

Source: EH Graham Centre Monograph 1: Stubble retention in Southern Australia (2010).

If inter-row sowing is not used, the cutting height is determined by the sowing machinery used, the amount of residue the machinery can handle and the available options for stubble management before sowing.

Table 2. Indicative grain and stubble yields

	Wheat	*Canola*	*Lupins*
Grain yield (t/ha)	4.0	2.0	2.0
Stubble yield (t/ha)	8.4	6.7	7.0

Source: MK Conyers (pers comm).

After harvest

The amount of stubble left on the paddock, stubble characteristics post-harvest and the amount of stubble sowing machinery can handle, all determine how to manage stubble after harvest. There are a number of options available to manage stubble including grazing with livestock, slashing, mulching or harrowing and strategic burning.

Stubble can provide a useful feed source for livestock. It is important to monitor stocking rates to ensure paddocks are not overgrazed, exposing them to erosion.

Prickle chains are used behind sowing equipment to assist seed covering and levelling of the soil surface.

At sowing

The major challenge of stubble retention is the physical management of crop residues.

Tined implements are often less expensive than discs and may also reduce the risk of rhizoctonia bare patch due to increased soil disturbance, but they handle less stubble. While disc machinery handles heavier stubble loads and disturbs the soil less, they can result in 'hair pinning' (that is, stubble is bent rather than cut and pushed into the sowing groove with the seed), which reduces seed/soil contact. Other equipment combinations including press wheels, coulter discs, trailing harrows, rotary harrows or finger tyne harrows also help to manage stubble at sowing.

Inter-row sowing allows crops to be sown into standing stubble and relatively high stubble loads without needing to chop, spread or burn stubble. Figure 3 shows various stubble management options.

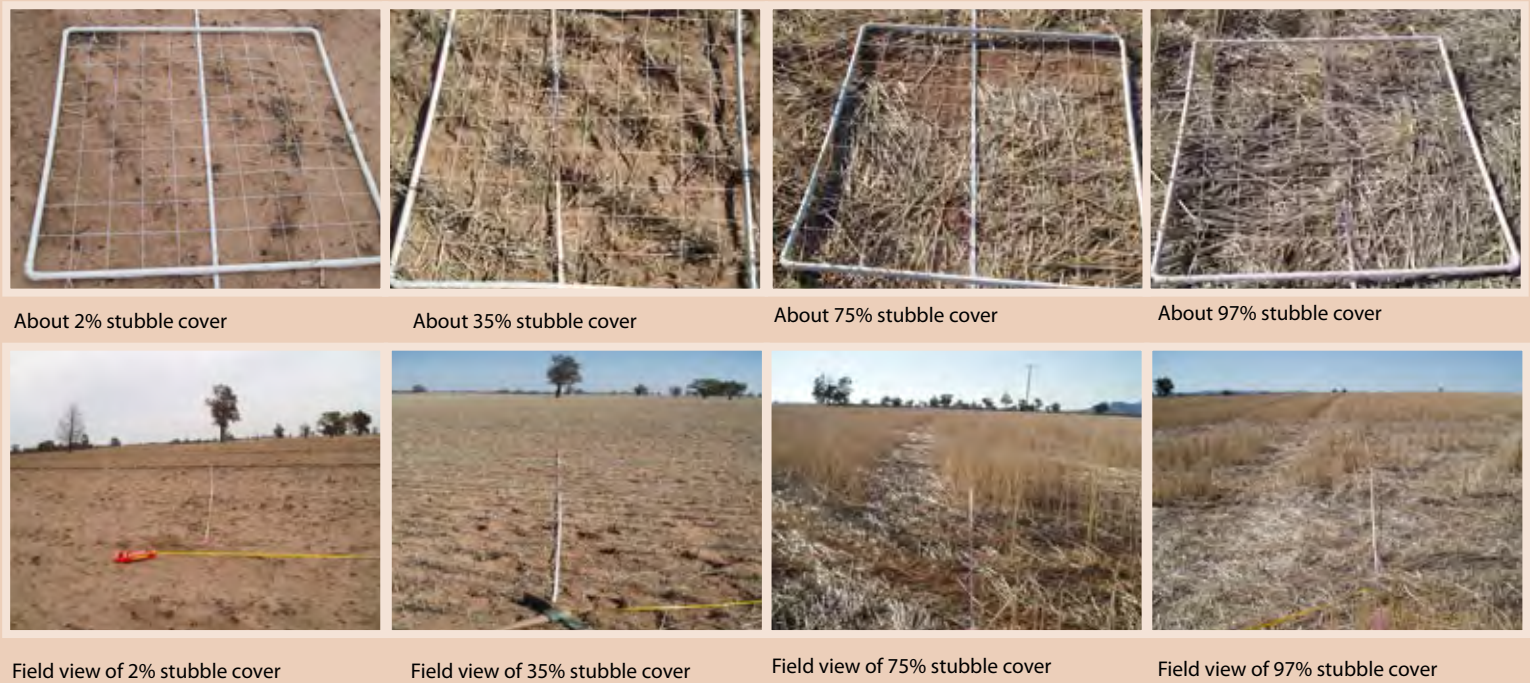


Figure 2. Estimating ground cover of stubble. *Source: A Bowman and B Scott, NSW DPI (2009).*

Figure 3. Stubble management options.

1. *Cutting height and the spread pattern of the stubble are the main management decisions at harvest.*
2. *Choppers and spreaders cut straw finely and spread it across the full width of the header cut.*
3. *Disc machinery can result in "hair pinning" – stubble is bent rather than cut and pushed into the sowing groove with the seed, reducing seed/soil contact.*
4. *Row cleaners such as the Aricks® wheel move stubble away from disc openers, preventing hair-pinning.*
5. *Sowing into standing stubble is easier if tramlines and inter-row sowing are used.*
6. *Stubbles can be a useful feed source for livestock. Monitor stock conditions and stocking rates. Don't overgraze paddocks and expose them to soil erosion risks.*
7. *Disc harrows can be used to smash stubble. Summer growing weeds can be cut out using a disc chain.*
8. *Offset discs can be used to chop and bury stubble.*
9. *The Stubble Cruncher® knocks down and cuts stubble, reducing straw length and improving the rate of stubble decomposition.*
10. *Effective weed monitoring and timely control of weeds is crucial where stubbles are retained.*
11. *Inter-row sowing allows crops to be sown into standing stubble and high stubble loads without needing to chop, spread or burn stubble.*
12. *The trash cutter lays stubble down across the front of the self-sharpening coulters that cut the stubble into short pieces and spread it evenly across the surface.*

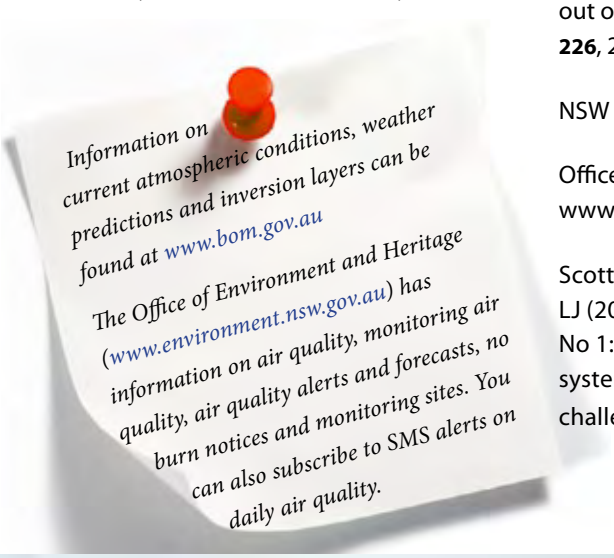
Watch the weather

Stubble smoke in the atmosphere can adversely affect human health. Smoke from burning contains mainly carbon dioxide (CO_2), carbon monoxide (CO), nitrogen dioxide (NO_2) and numerous volatile organic compounds and particulate matter. Fine particulates with a diameter of less then 2.5 micrometres can impact on human health, while some of the organic compounds produced are carcinogenic.

Research shows that total particulate matter is greater with smouldering burns than flaming burns, but levels are influenced by oxygen supply, size and type of fuel load, fuel chemistry and moisture, alkali metal content and firing technique.

Most stubbles are burnt during autumn, normally a time of calm, clear days and cold or frosty nights. Light winds are often present and inversion layers sit close to the ground 'trapping' the smoke. Temperature inversion layers occur when a layer of warmer air sits above a layer of cooler air. Hot air is less dense than cold air, and normally the warm air at the surface rises slowly taking smoke and air pollutants with it.

If burning stubbles, adopt best management practices to achieve an effective burn, while minimising the impact of smoke.



Further information

Bureau of Meteorology: www.bom.gov.au

Grains Research and Development Corporation (2011). Stubble management fact sheet: www.grdc.com.au

Kondinin Group (2010). Taking the trouble out of stubble management. *Farming Ahead* **226**, 26-45: www.kondinin.com.au

NSW Rural Fire Service: www.rfs.nsw.gov.au

Office of Environment and Heritage: www.environment.nsw.gov.au

Scott BJ, Eberbach PL, Evans J and Wade LJ (2010). EH Graham Centre Monograph No 1: Stubble retention in cropping systems in Southern Australia: Benefits and challenges: www.grahamcentre.net

New research findings

Recent research by Clive Kirkby, a CSIRO and Graham Centre PhD student, found that incubating soil with straw results in a significant amount of new straw carbon being sequestered. But the mineralisation of existing soil carbon (old humus-C) can be accelerated when fresh straw is added to the soil (the priming effect). The effect can be so strong the net result (difference between new straw-C sequestered and old humus-C mineralised) can be negative. This means, there may be less carbon than before the straw was added.

The priming effect is particularly strong in nutrient-poor soils. Adding nutrients during the decomposition phase increases the amount of fresh straw-C converted into new humus-C, so adding supplementary nutrients always increases the rate of humification (proportion of fresh straw-C converted to humus). The research showed the actual amount of C sequestered with supplementary nutrients was 3–10 times as much as without supplementary nutrients.

Rural Fire Service

During the statutory Bushfire Danger Period, 1 October to 31 March, the NSW Rural Fire Service (RFS) regulates the lighting of fires through fire permits and total fire bans. The Bushfire Danger Period may vary depending on local conditions.

If burning stubbles, do so responsibly and be aware of weather conditions. Consider the following when including stubble burning in any management program:

Fire permits and total fire bans

Fire permits impose conditions on the way a fire can be lit and maintained, and can only be issued by authorised permit issuing officers. Permits have standard conditions but issuing officers can also add any conditions deemed necessary.

To apply for a permit or discuss permit requirements and conditions contact the local RFS or NSW Fire Brigade station.

Any day where a fire is likely to escape and be difficult to contain will have a total fire ban declared.

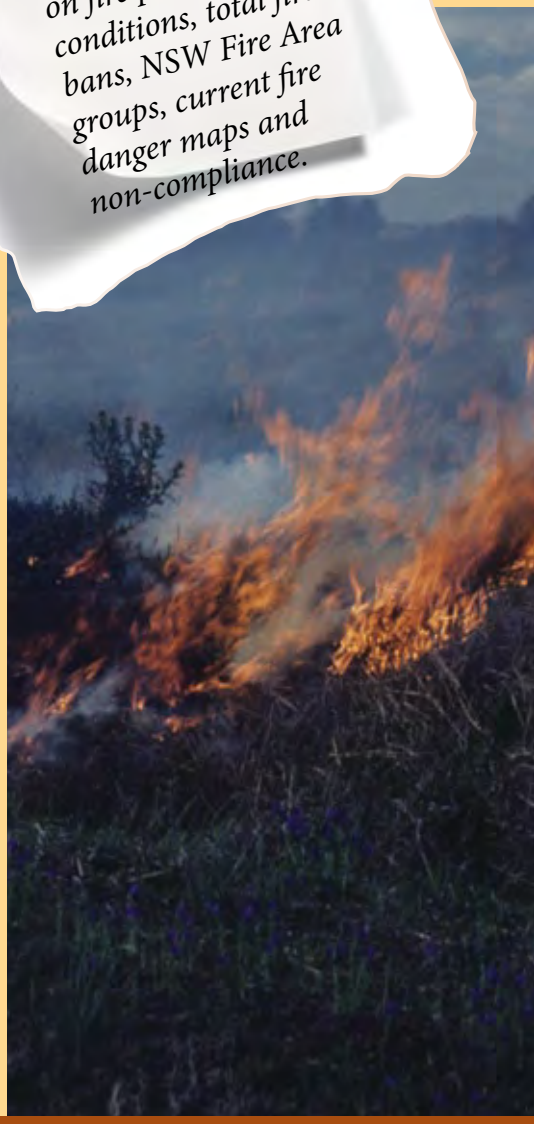
Non-compliance

Anyone found to be in breach of the NSW Rural Fires Act 1997 (RF Act) and its regulations may face substantial fines and prison terms of up to 12 months. For example, a fine up to $5500 and/or 12 months jail applies for lighting a fire on a total fire ban day. Fines up to $100,000 and/or 14 years in jail apply if the fire escapes and damages or destroys life, property or the environment.

Always notify neighbours before burning stubbles. This regulation is enforced for the entire year and failure to do so could result in a penalty notice being issued to the value of $550.

People seeking compensation for losses sustained from a fire can also bring a civil law suit against anyone responsible for the fire.

Visit www.rfs.nsw.gov.au for more information on fire permits and conditions, total fire bans, NSW Fire Area groups, current fire danger maps and non-compliance.



Acknowledgements

Brendan Scott and Helen Burns, Graham Centre, Phil Bowden and Alison Bowman, NSW DPI, Tony Pratt and Rashid Quasrani, formally NSW DPI, Jack Desbiolles, Institute for Sustainable Systems and Technologies, University of South Australia, GRDC, Office of Environment and Heritage, NSW Rural Fire Service, Murrumbidgee Catchment Management Authority, Kondinin Group.
Photo credits: Sheila Lee, Tony Pratt, Phil Bowden, Ben White and Warwick Holding.
Editor: Toni Nugent. Layout: Sharon Kiss.

Contact us

www.grahamcentre.net

T: +61 2 6938 1667 or +61 2 6938 1681

Charles Sturt University

NSW GOVERNMENT Department of Primary Industries

The Graham Centre is an alliance between Charles Sturt University and the NSW Department of Primary Industries