Maintaining profitability in retained stubble systems on upper Eyre Peninsula

A joint EPARF and GRDC funded project.

Guideline 2: Cereal stubble management at harvest

Most growers on upper Eyre Peninsula implement conservation farming systems with stubble retention and reduced tillage, which has increased soil moisture conservation and improved timeliness of sowing. Retaining cereal stubbles in current farming systems has also reduced soil erosion risk due to lower levels of soil disturbance and higher levels of soil surface cover, especially where livestock are still a major component of the farming system[1].

Retaining cereal stubble can have benefits to the farming systems, but there may also be some disadvantages. Cereal stubble management at harvest can impact on timeliness and cost of harvest, soil erosion over summer, soil moisture conservation, nutrient status, weed control, frost risk, and pest and disease levels. Cereal stubble management treatments imposed at harvest at Minnipa have been; harvesting at high and low heights, removing stubble and stubble harvested high then worked in the following autumn. At Minnipa, research has shown stubble management at harvest and the seeding position in the following season have not impacted on crop production and grass weeds over several seasons with relatively high stubble loads[2].

What are the benefits of retaining standing stubbles?

- ✓ **Lower erosion risk over summer**
- ✓ **Maintaining or improving soil structure and soil health**
- ✓ **Maintaining or improving nutrient retention**
- ✓ **Valuable source of feed for livestock**
- ✓ **Increased water infiltration and soil moisture retention**
- ✓ **Potential to implement integrated weed management strategies at harvest e.g. windrows, chaff dumps**

What are the potential disadvantages of retaining stubbles?

- x **A reduction in herbicide efficacy**
- x **Nutrient tie up by stubble, especially nitrogen at crop establishment**
- x **Delayed seeding, uneven seeding depth and reduced establishment due to blockages during seeding**
- x **Increased risk of frost in prone areas with high stubble loads**
- x **Increased stubble borne disease inoculum**
- x **Increased pests such as mice and snails**

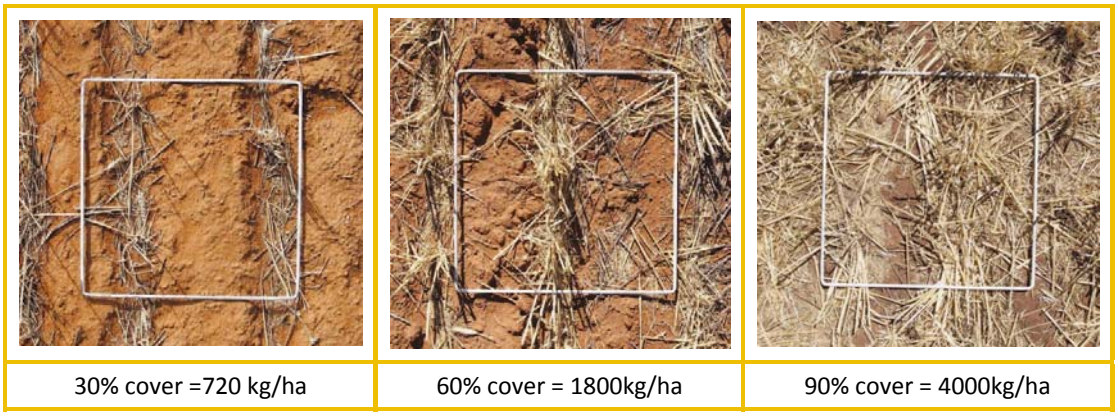
The decision to maintain stubble at harvest will depend on;

- seeding equipment and row spacing – ability of machinery to deal with stubble loads and maintain an even seeding depth
- paddock rotation - cropping growers may desire lower stubble to reduce seeding issues and increase herbicide efficacy and weed control, but a pasture and livestock rotation may desire higher standing stubble for more feed and protection
- harvesting speed – if harvesting low may need to reduce speed
- grass weed control – if narrow windrow burning or using a chaff cart, need to harvest as low as possible and slower to maximise ryegrass weed seed collection
- frost risk - lower risk in areas of paddock with less retained stubble
- paddock disease levels and risk if cropping again, e.g. cereal stubble borne diseases
- high numbers of snails or mice - cutting stubbles low as possible results in less habitat and harvesting slower will reduce grain losses and a feed source for mice
- other stubble management options for snails may be implemented over summer in standing stubble, e.g. slashing, rolling or cabling, to dislodge snails and kill them in high temperatures (over 35^{o}C for several consecutive days).

When should I change stubble management at harvest in my system?

All growers implement some form of stubble management at harvest depending on the farming system, harvest timeliness and equipment, seeding equipment and set up, rotation and weed issues. If the paddock is to be cropped again a lower stubble height may be implemented compared to a pasture and livestock phase, whereas a higher stubble may improve harvest timeliness and provide more feed and protection for livestock, and lower soil erosion risk. Grass weed issues, especially ryegrass, may require the use of non-herbicide weed management systems such as concentrating residues into narrow windrows, paddock burning or chaff carts.

Field experiments on Minnipa Agricultural Centre (MAC) showed that stubble management at harvest and seed row position in the following season have had little impact on crop production, weeds, disease or pests. In the seasons tested, above average stubble loads were produced (Table 1)[2]. Stubble management treatments imposed at harvest were; (i) Stubble removed after mowing to ground level, (ii) Stubble harvested low (15 cm) (iii) Stubble harvested high (30 cm)/standing (district practice) or (iv) Stubble harvested high then cultivated with offset disc in April. Plots were sown the following season as either; (i) Inter row (between last season's crop rows) or (ii) On row (in same position as the previous crop rows).



30% cover =720 kg/ha	60% cover = 1800kg/ha	90% cover = 4000kg/ha

Figure 1 Standing stubble % cover and stubble kg/ha estimates *[Source: Stubble Management – A Guide for Mallee Farmers, Mallee Sustainable Farming 2013]*

Table 1 Grain yield of wheat as affected by stubble management and seeding alignment, and initial stubble loads[2]. *Values for stubble treatments are averaged over seeding alignment treatments and for seeding alignment are averaged over stubble treatments.*

2013-15 Stubble treatments	2014 stubble (t/ha)	2014 wheat yield (t/ha)	2015 stubble (t/ha)	2015 wheat yield (t/ha)	2016 stubble (t/ha)	2016 barley yield (t/ha)	2017 standing stubble (t/ha)	2017 stubble on ground (t/ha)	2017 Stubble (t/ha)
Stubble standing high	3.4	2.40	5.8	1.19	4.3	2.14 a	1.58 a	2.80 b	4.38 a
Stubble standing low	3.8	2.45	6.9	1.28	5.1	2.24 a	0.93 c	3.68 a	4.60 a
Stubble cultivated	3.4	2.58	4.3	1.26	4.0	1.99 b	1.39 b	1.64 c	3.03 b
Stubble removed	-	2.62	-	1.20	0.6	1.91 b	0.15 d	1.28 c	1.43 c
LSD (P=0.05)	*ns*	*0.08*	*ns*	*ns*	*0.6*	*0.14*	*0.21*	*0.8*	*0.42*
Inter row		2.55		1.24	3.3	2.11	0.96	2.51	3.47
On row		2.47		1.22	3.6	2.02	1.06	2.19	3.25
LSD (P=0.05)		*0.06*		*ns*	*ns*	*ns*	*ns*	*ns*	*ns*
*No extra N				1.22	3.3	2.06	0.98	2.38	
*60 kg/ha N				1.25	3.6	2.08	1.05	2.32	
LSD (P=0.05)				*ns*	*ns*	*ns*	*ns*	*ns*	

**N applied as 2015 and 2016 treatment, not applied in 2017 due to dry seasonal conditions*

Stubble architecture, seed row position or extra nitrogen did not affect wheat yield. In 2015 removing or cutting stubble low both decreased yellow leaf spot. In several seasons removing or low cut stubble lowered snail numbers compared to high cut stubble. Stubble management or seed row position had little effect on grass weed numbers in crop[2]. There have been no differences in soil moisture at seeding due to stubble management carried out at the previous harvest.

Previous research at Minnipa showed a yield benefit (0.08 t/ha in average of 0.98 t/ha) in retaining stubble rather than burning with narrow row spacings (less than 23 cm) in low rainfall seasons (2005-2008)[3]. In the higher rainfall season of 2009 burning the 3.0 t/ha stubble resulted in a 0.2 t/ha yield increase and higher protein[4].

Herbicide efficacy

In different stubble management systems the activity and resulting weed control from herbicides can be influenced by the amount of stubble by reducing herbicide contact and the binding of chemical to plant residues. The level of binding influences the solubility index or the movement of the herbicide through the soil profile with rainfall events. Soil texture and soil chemical properties can also affect chemical movement and availability in the soil profile.

At Minnipa, over three seasons different stubble management options have been implemented at harvest including; traditional spread stubble, harvest windrows, total stubble removal by burning and chained stubble, to trial differences in stubble management and herbicide efficacy. In all seasons of this work most herbicide treatments have lowered all grass weed types compared to the untreated control. The 2015 and 2016 results suggest that under the production regimes of upper EP, stubble management; standing stubble, burnt windrows, slashed stubbles and stubble removal by whole paddock burning is unlikely to impact on the performance of pre-emergent herbicides targeting grassy weed control, with adequate water rates[5] (see Herbicide efficacy in cereals guideline for more detail). However, these trials did not place the herbicide packages “under pressure” because grassy weed populations were quite low. Under low populations of barley grass weaker herbicide options may perform adequately compared to high weed population situations.

Herbicides are only one tool for weed control; adopting an integrated weed control package that includes non-chemical control, and if possible, two consecutive seasons of grass weed control to lower barley grass weed seed banks is recommended.

If using herbicides with activity that may be affected by stubble load, in situations with greater than 50% stubble cover, then consider stubble load management in grassy paddocks to maximize the herbicide activity and grass weed control in-crop. The herbicides which may be influenced by high stubble loads include trifluralin, triallate, pyroxasulfone, prosulfocarb and metalochor products.

Other management options to increase herbicide activity in paddocks with high stubble loads include increasing herbicide and water rates, using nozzles to increase spray coverage, and reducing the height of the spray boom or stubble height so herbicides reach the soil surface easier and cover the soil more evenly.

Nutrients

The management of cereal stubble can affect microbial activity and the cycling and supply of nutrients, especially nitrogen and phosphorus to growing crops[6]. The immobilisation of nitrogen will occur with the breakdown of cereal stubble due to the C: N ratio, which may lead to nitrogen deficiency in crops in retained stubble systems in cold wet conditions, often at the start of the growing season. Research at Karoonda in the SA Mallee with four different stubble management treatments (no stubble, standing, incorporated and surface at harvest 2014) showed no effect of 2014 stubble management on wheat yield in 2015[4], reflecting results at Minnipa[2].

Weed management

Managing grassy weeds and herbicide resistance may influence stubble management. Burning stubble for weed management is an option growers are using in the SA/Vic Mallee region[7]. Another harvest stubble management option for ryegrass management is harvesting residues into narrow windrows, which are subsequently burnt. Narrow windrow burning has been highly adopted as a weed management tool in the SA/Vic Mallee region[7]. Other weed management options for stubble at harvest are using chaff carts which can provide a valuable livestock feed option, and baling the stubble.

If narrow windrow burning for ryegrass weed management, the main issues to consider are;

- Harvest stubble low - 'beer can height and stubble cut lower than the windrow'
- Ideally burn with a light cross wind of 8-10 km/hr
- Timeliness of burning – as soon as possible when safe conditions occur in Autumn
- Harvest first two laps around paddock and burn first as a fire break
- If windrows get summer rainfall leave 2 to 3 weeks to dry out to achieve temperatures of greater than 400°C for 10 seconds for ryegrass weed seed kill[8]
- Burning stubble will result in a loss of nutrients especially nitrogen, and some phosphorus, potassium and sulphur. In a low rainfall area (Condobolin, NSW) with 2.3 t/ha of stubble average losses were estimated to be 9 kg/ha N, 0.2 kg P/ha, 4 kg K/ha and 2 kg S/ha[9].

Soil moisture

The GRDC Water Use Efficiency project found that stubble residues had only a minor impact on moisture retention; and stubble architecture, standing or slashed, had negligible impact on moisture conservation[9]. Residues slow the flow of water on the soil surface, allowing more time for infiltration as well as slowing soil evaporation following the rainfall event. However if conditions remain dry for an extended period, total evaporation will be unaffected by residues[10].

For a single rainfall event that creates a 'pulse' of soil water, residue retention will only delay the loss of the infiltrated water by evaporation. If pulses overlap, water can move further down in the soil in the system with residue, and this leads to stored soil water if pushed beyond the evaporation zone of the soil profile[11]. There have been no differences in soil moisture at seeding at Minnipa from 2014-16, due to different stubble management practices at the previous harvest[2].

Frost

The GRDC Frost Initiative has found retaining stubble (more than 2.5 t/ha) can increase risk of frost damage, making the frosts colder and longer, with lower temperatures at head height. The retained stubble reduces the heat radiating from soil at night, resulting in less warming of the crop canopy[12]. The research in WA's central and southern wheat belt indicates removing or lowering stubble loads to about 2 t/ha (approximately 70% ground cover) using burning or raking can boost wheat yields in frost-prone, low-lying areas[12].

Livestock

The impact of livestock on paddock health in low rainfall faming systems has been assessed at Minnipa over eight seasons. The stubble management systems implemented at harvest have been the same, but one system is grazed over summer and during the pasture phase. Grazing sheep have not damaged soil health over eight years of crop and pasture rotations. Higher input, improved self-regenerating medic pasture increased biomass production and carried a higher stocking rate, twice that of a low input system[13]. Other benefits in the grazed treatments included fewer summer weeds (less spraying required), reduced snail numbers and the added benefit of value-adding to stubbles by grazing. Grazing at the rates imposed has not detrimentally reduced the groundcover due to flattening of the stubble, with a 5% and 1% reduction in groundcover for the low input grazed and high input grazed treatments respectively, and therefore has not increased erosion potential. In a low rainfall mixed farming system livestock can help better manage the economic impacts of seasonal variability[13].

Break crops

Sowing break crops into standing cereal stubble provides early protection of both small plants and soils from wind damage. Research in the Mid North (Clare, SA) showed sowing pulses into standing cereal stubble can benefit yield, but no yield response has occurred at Minnipa so far. However, in 2011 substantial differences in growth were achieved at Minnipa from stubble management; increased pea growth and height occurred in standing cereal stubble which may aid harvestability of field peas, particularly in shorter seasons with less biomass[14]. Similar results were achieved at Hart with lentils sown in stripper and medium height standing stubble. Stubble resulted in taller and more erect plants with higher pods, improving harvestability[15].

Stubble borne diseases

Stubble borne diseases such as Take all, Crown rot, Yellow leaf spot, Eyespot and White grain in wheat, and Barley scald, Barley net and spot form of blotch, will all have increased inoculum levels in an infected paddock with the retention of stubble. If the disease level is an issue, a break from cereal in an infected

paddock or stubble removal will reduce numbers of airborne spores present in that paddock in the subsequent year. Removing and cutting stubble low decreased yellow leaf spot in the following wheat crop compared to high cut stubble in a trial at Minnipa in 2015[2], which was the only season the disease level was an issue.

Pests

Retaining stubbles within crop rotations may increase pests, especially snails and mice as it provides food and shelter. Higher cut stubble resulted in increased snail numbers compared to removing or cutting cereal stubble low at Minnipa[2]. Narrow windrows attract snails over summer due to the protection and lower temperatures, resulting in good control of adult snails when burning the rows in autumn.

What stubble management do I choose?

Stubble management at harvest within a farming system will depend on harvest equipment, weed management, timeliness of operations, rotation, pest and disease levels, seeding equipment and desired levels of ground cover.

Produced July 2016

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This guideline has been developed for the Eyre Peninsula Agricultural Research Foundation as part of the Maintaining profitable farming systems with retained stubble - upper Eyre Peninsula (EPF00001), funded by the Grains Research and Development Corporation (GRDC). The initiative involves farming systems groups in South Australia, Victoria, southern and central New South Wales and Tasmania collaborating with research organisations and agribusiness to explore and address issues for growers that impact the profitability of cropping systems with stubble, including pests, diseases, weeds, nutrition and the physical aspects of sowing and establishing crops in heavy residues.