

Good Stubble, Bad Stubble - More Profit, Less Profit

John Small, Central West Farming Systems

Take home Messages

- CWFS regional site trials during 2013 and 2014 suggest stubble loads greater than 3 t/ha can limit yield.
- “No till with no stubble is no good” on hard setting red brown soil types. The delimita is that the annual incorporation of stubble just prior to sowing by cultivation or removal by burning would result in the loss of significant long term benefits to soil health.
- “If you do not measure it you cannot manage it!” Field measurements of stubble are the starting point for deciding what to do.
- Options to manage stubble loads above 3t/ha need to be made seasonally. Good planning may allow other agronomic and farm efficiency outcomes to be achieved at the same time.



Background

Stubble retention research is not new. The publication Scott et al “Stubble Retention in Cropping Systems in Southern Australia: Benefits and Challenges” (2010) cites research back to 1978. The focus of recent research is concentrating on maintaining profitable retained stubble systems rather than investigating agronomic and economic benefits of stubble retention.

The herbicide “glyphosate” was patented by Monsanto in the early 1970s as the active ingredient in the herbicide Roundup®. Roundup® was introduced to the consumer market in 1974 as a broad-spectrum herbicide and since 1980 has quickly become one of the best selling herbicides in Australia and worldwide. When its patent expired in 2000 the number of glyphosate based products grew dramatically and the cost of the product fell dramatically. The development and adoption of stubble retained farming systems has been and continues to be reliant on the development of glyphosate and different formulations of glyphosate based chemistry.

Major agronomic drivers for the adoption of stubble retained farming systems has been minimising soil erosion risk and within season benefits of soil moisture, particularly at sowing. Economic drivers for stubble retention have been lower input costs for machinery (less horsepower per hectare), improved efficiencies and timeliness of operations. Most research cited by Scott reports that the presence of stubble in-crop has a negative impact on yield as opposed to stubble removed farming systems. Cameron et al reports similar findings.

Looking to the future and based on a quick review of papers delivered at GRDC updates in recent years, it is reasonable to suggest that the decision to retain stubbles in a cropping business will continue to be driven by limiting soil erosion and degradation, maximising sowing soil moisture and improved machinery efficiencies and timeliness of operations. These overarching benefits may be tempered, however, as seasonally tactical stubble management approaches are required for managing herbicide resistance, lowering input costs or production risk and reliably improving yield under certain conditions.

Stubble retention reduces yield but not profit

In a GRDC update paper presented at West Wyalong (29.07.2014) “Lifting productivity in retained stubble farming systems” by James Hunt, et al, a review of local research demonstrated that most of the benefits of stubble retention (no erosion or run-off) are achieved at stubble loads of 2-3 t/ha. The paper proposed that retaining cereal stubble above 2-3t/ha past sowing is unlikely to provide any yield benefits and in favourable seasons (>250 mm growing season rainfall) can reduce yield (Figure 1). The dilemma is that the annual incorporation of stubble prior to sowing by cultivation or removal by burning would result in the loss of significant long term benefits to soil health. Many would question whether this approach to stubble management maintains a stubble retained farming system.

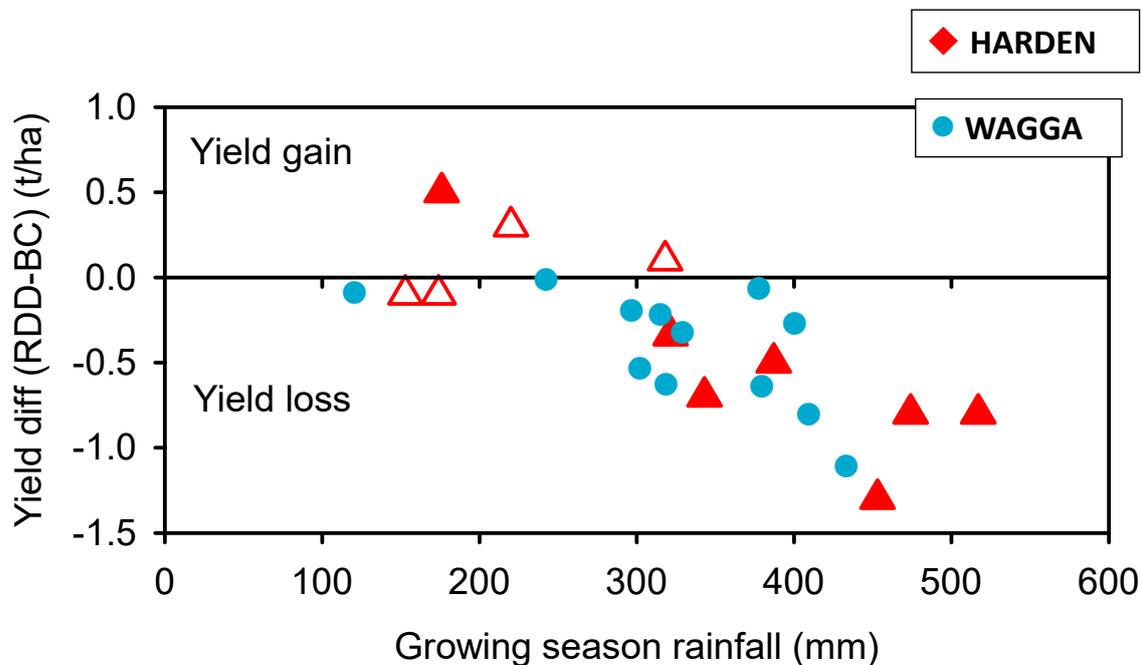


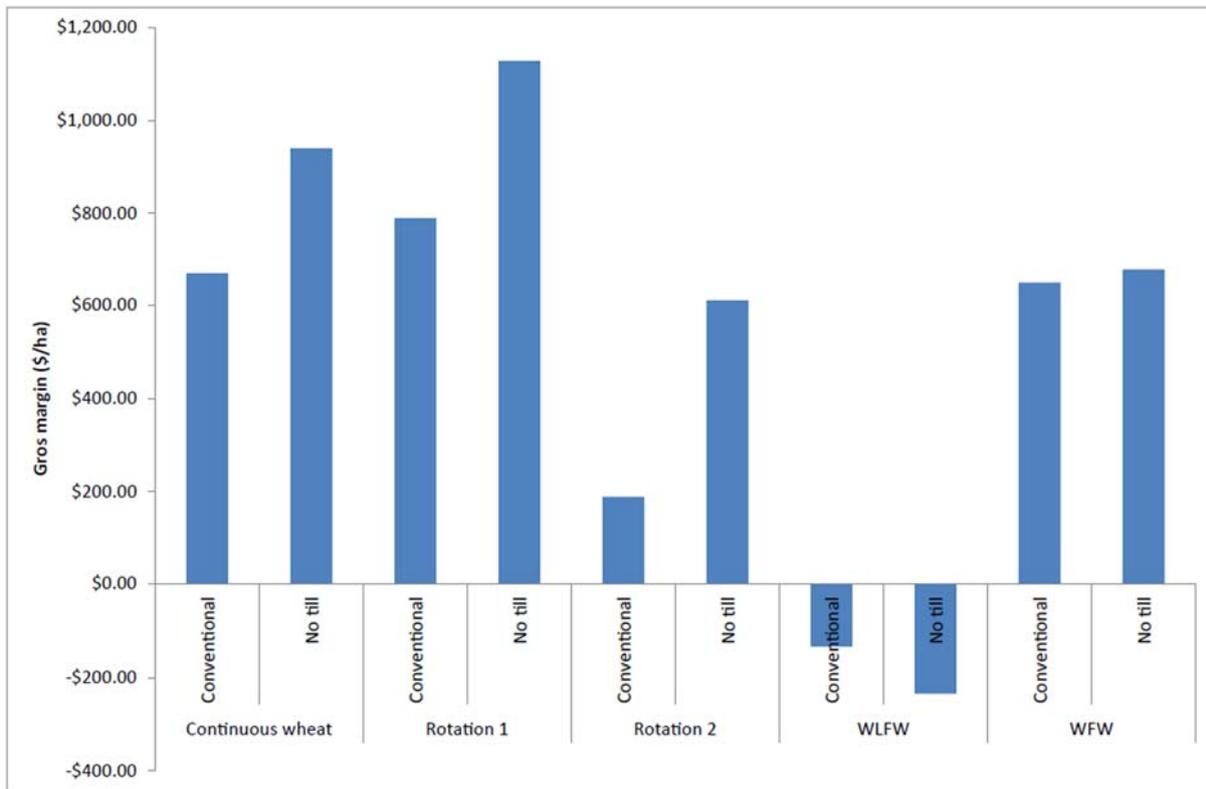
Figure 1. The relationship between growing season rainfall and the yield difference between stubble retained direct drill (RDD) treatments vs. burn and cultivate (BC) treatments from long term sites at Wagga (NSW DPI) and Harden (CSIRO). Figure courtesy of John Kirkegaard, CSIRO

The Merriwagga tillage and rotation trial was established in 1999 and is currently managed by AgGrow Agronomy and Research on behalf of Merriwagga growers and research partners Central West Farming Systems. Since 1999 continuous stubble retention has been more profitable than annual cultivation in all unaltered rotations. Long term stubble loads have not been collected at Merriwagga but given the environment and yields achieved at Merriwagga a 2-3 t/ha stubble load was unlikely to be present at sowing in the great majority of years. Growing season rainfall would also have been less than 250 mm in most years, meaning yield penalties from retaining stubble are unlikely (Figure 1). It cannot be determined whether active stubble management in the high stubble years would have resulted in higher yields or profits. It is observed that in the Merriwagga environment stubble retention is more profitable than the alternate annual tillage system.

For further insights into the trial refer to information below.

The Merriwagga tillage and rotation trial established in 1999 aimed to compare five different cropping rotations using no-till farming techniques and conventional farming methods. The trial is situated 10km west of Merriwagga, NSW. Soils are red sandy loams with an underlying calcareous clay with a pH of 5.5-6.5 and have a tendency to erode with wind and water. Each plot is 1 ha, each treatment is replicated three times and the total trial area is 30 ha. The 2014 Merriwagga trial report highlighted some clear trends after 16 years:

- When using contract rates growing crops with no-till techniques has been on average 15% cheaper. In every rotation tested the no-till system has resulted in a higher cumulative gross margin than the conventional rotation. Contract rates are different to the costs a typical farmer would apply but it does allow for a very good comparison of real costs associated with each farming system.
- The most profitable rotation has been two cereals followed by a break crop of either peas, lupins or canola under a no-till system (Refer figure 2). Interestingly, a continuous wheat rotation no-till is a close second. It is an interesting discussion and beyond the scope of this paper as to why, despite the agronomic risks, the continuous wheat rotation performs so well in the drier Merriwagga environment.
- Generally no-till farming methods compared to cultivation have maintained or increased yields in continuous cropping rotations. The exception is where a fallow exists in the rotation and in this case cultivation has increased yield in most but not all years.



Rotation 1 and rotation 2 are two cereals followed by a break crop such as peas but are not in years. Rotation 1 was in lupins in 2014, rotation 2 is due for a break crop 2015.

WFW is wheat-fallow-wheat

WLFW has been wheat-fallow-wheat since 2005 but alternates with the wheat-fallow-wheat rotation above.

Therefore the years when this rotation is sown to wheat the WFW is fallow.

Figure 2. Cumulative gross margin results from Merriwagga long term trial 1999-2014.

CWFS trials to date

CWFS has conducted eighteen trials at its regional sites that investigate the impact of different stubble treatments (burning, cultivation or standing stubble) have on the yield of wheat, barley and canola, refer figure 3 for a summary impact of stubble loading on yield. The trials with wheat and barley have also evaluated any varietal responses within crop species to the impact of the different stubble treatments.

During 2013 CWFS conducted trials at six locations - Tottenham, Euabalong, Weethalle, Rankins Springs, Wurrinya and Tullamore. During 2014 CWFS again conducted trials at six locations - Nyngan, Alextown, Gunning Gap, Lake Cargelligo, Ungarie and Tullamore. In 2015 similar trials are currently established at Weethalle, Tottenham, Wurrinya, Mumbil Tank and Tullamore; stubble treatments tested are standing, burnt, cultivated and harrowed (knocked over not incorporated into soil).

Of the eighteen trials, eight have been established in commercial paddocks with stubble loading of less than 3 t/ha and six have shown no yield response to cultivation or burning stubble late in fallow. Two sites, Tullamore (2013) and Lake Cargelligo (2014) both showed a yield response to cultivation. Both sites suffered compacted soil, at Tullamore due to heavy grazing and Lake Cargelligo due to soil type and lack of ground cover over fallow. A yield response was also observed at Tullamore to burning, most likely related to its effect on the established windmill grass present.

Of the 10 trials with stubble loading greater than 3 t/ha an improvement in yield in either the burnt or cultivated treatment has been observed at six trials. It should be noted that a yield improvement in both treatments was only observed at two trials. The four trials where no response to either treatment was observed were the 2014 Alextown and Ungarie cereal trials and the 2014 Rankins Springs and Wurrinya canola trials, all of which suffered moderate to severe frost damage.

An important issue highlighted by the cereal trials is that no treatment changed the variety yield ranking. Stubble modification did not improve a poor variety's performance. The best option in terms of yield was to simply grow the variety with the highest yield potential for the sowing window.

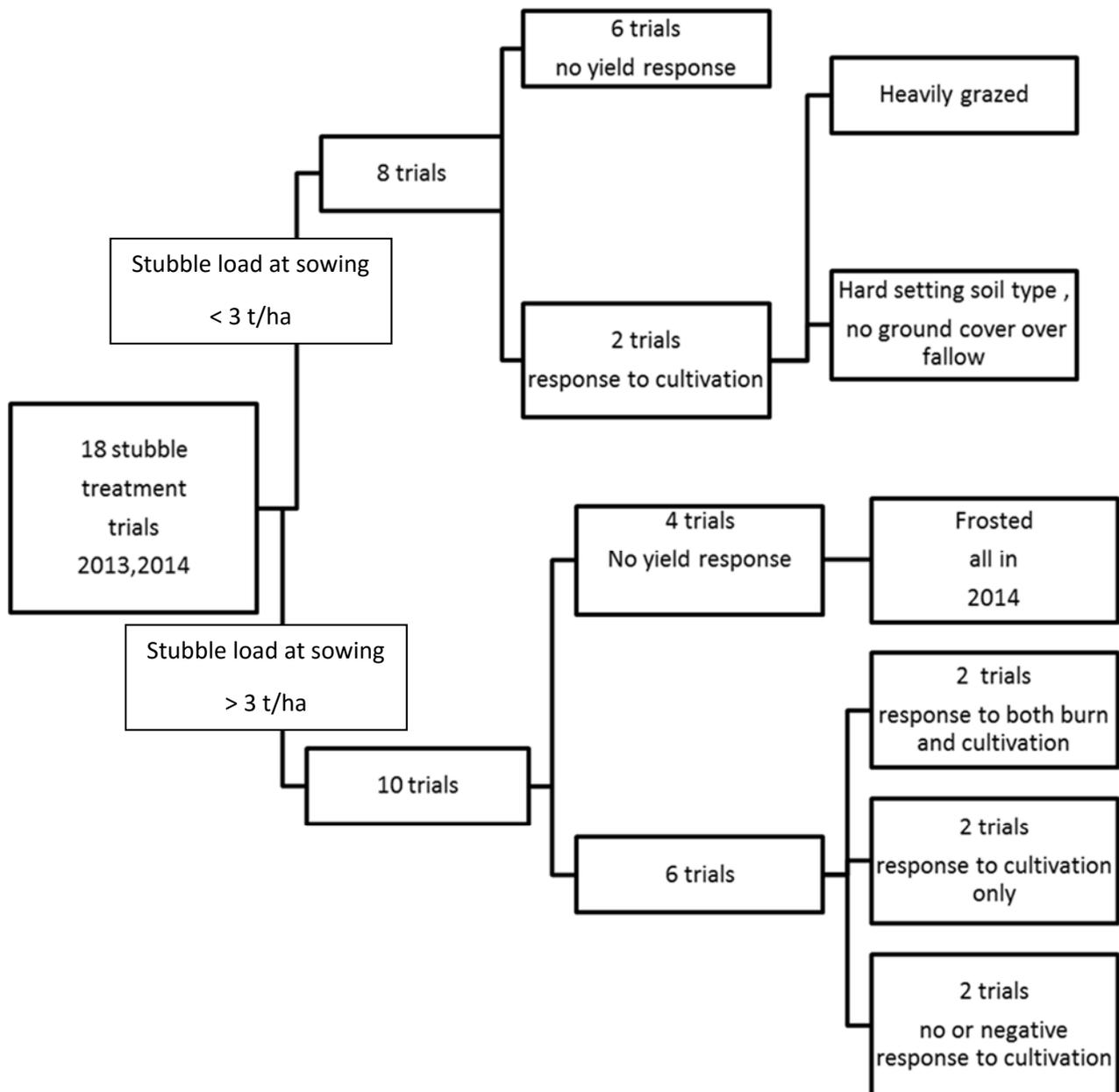


Figure 3. Summary of eighteen CWFS trials investigating late in fallow stubble treatments on yield of wheat, barley and canola.

How can stubble loads greater than 3 t/ha be managed?

There are seven options to reduce stubble load between harvest and sowing. The decision will be impacted by many interactive factors that produce a range of potential risks or rewards as shown in figure 4.

1. At harvest with the header.
2. Left undisturbed during the fallow, the do nothing option.
3. Cultivated into the soil during the fallow.
4. Mechanically managed but retained on the surface during the fallow (e.g. flail mulched, slashed, harrowed, crushed, rolled).
5. Burnt.
6. Removed (e.g. baled).
7. Grazed during the fallow.

CAUTION: Do not place stubble management in front of fallow management i.e. control of summer fallow weeds. Subsoil moisture trumps stubble loading as a driver for future yields!

Also important are those paddocks which for some reason end up with no ground cover and are compacted (e.g. end of pasture phase, during drought periods or other natural disasters). Local farmer experience (particularly on red brown earths), CANFA experience and Neville Gould's summary "No-till with no stubble, no good" (this summary is also supported by Pittelkow et al) show in these instances cultivation is the best option to return the system to production.

Golden rules for CWFS districts for fallow stubble:

Ground cover minimises soil erosion. Summer rainfall stored as soil moisture during the fallow is a major driver of subsequent crop yield.

The presence and architecture of stubble may impact weed germination and spraying results, mice populations, fire risk and in a mixed farming business feed budgets for livestock during the fallow. These impacts need to be actively managed to minimise impact on profit. The seasonal timing and distribution of fallow rainfall will call for different annual management response.

The presence and architecture of stubble at the end of fallow will affect sowing conditions. Target and manage what characteristics you desire.

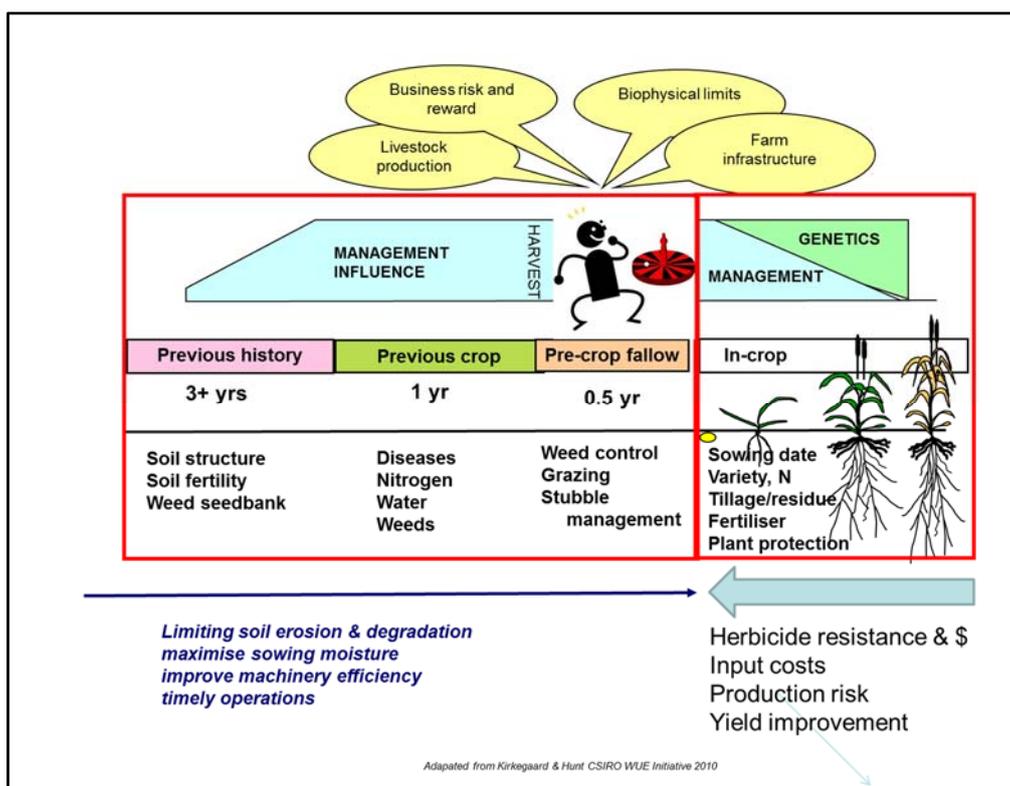


Figure 4: Management considerations in deciding how to manage stubble.

Summarising available options

At harvest with the header

Golden rules for CWFS districts at harvest:

Ensure harvest is completed ASAP to avoid weather damage. Harvesting costs vary considerably from farm to farm but generally a header at harvest is an expensive option to "groom or mulch" crop residue. "Groom" only for an economic or agronomic outcome that cannot be achieved once harvest is complete such as weed seed management.

A/ CWFS harvest height trial at Weethalle 2013, 2014. - A replicated trial concluded that stubble height did not influence fallow efficiency in dry seasons.

B/ CWFS windrow burning trial at West Wyalong in 2013 that compared the impact on paddock performance of windrowing and burning to manage rye grass seed bank in comparison to harvesting at a traditional harvest height.

Key outcomes of this trial were:

- Well managed windrow burning effectively reduces the ryegrass seed bank.
- To effectively establish windrows requires forward planning and potentially slows harvest and increases harvest cost.
- Burn as early as conditions allow. Make it a priority job.
- Small rainfall events may germinate weeds in burnt areas that require attention before the whole paddock area.
- More work needs to be done over a number of seasons to quantify any impact on fallow efficiency.

C/ Farmlink “The cost of harvesting low” data compiled by Paul Breust for wheat cv. Suntop in 2014 at different harvest heights. Values are means of three replicates taken from John Deere 9770 STS yield monitor and all differences are significant ($P < 0.05$).

Cut height	Efficiency (ha/h)	Speed (km/h)	Fuel (l/h)	Fuel (l/ha)	Efficiency (t/h)	Yield (t/ha)
Short (15 cm)	5.7	6.2	54.3	9.6	14.0	2.05
Tall (60 cm)	9.5	10.6	51.2	5.4	28.8	2.19
% decrease harvesting short	41%	42%	-6%	-78%	51%	6%

D/ CWFS stubble trials at Weethalle and West Wyalong 2013. At both sites plots with taller stubble required spraying for weeds prior to plots with shorter stubbles. Effectively this resulted in an extra spray during the fallow in a dry summer.

The do nothing option

To date this is the business as usual for many farmers and they are balancing the short term loss of potential yield against the long term benefits of organic matter in their farming business. Such decisions are extremely valid despite being extremely difficult to ever accurately quantify long term benefit of short term losses. Every business is different and in the end the decision relates more to the aspirations and attitudes of the individual.

From an agronomic viewpoint this option requires careful consideration of how high stubble loads impact on the efficacy of fallow herbicide sprays and pre-emergent in-crop herbicide. Herbicide options will become more limiting and potentially expensive. Higher water rates which add to the expense of spraying should also be considered. The use of “stubble movers” on sowing rigs maybe needed to produce ideal sowing conditions.

Cultivated into the soil during the fallow

- Advantages of cultivation:
- Weed seed burial of difficult to control or herbicide resistant surface germinating weeds e.g. fleabane.
- Renovation of tram tracks.
- Management of a fallow weed blow out where early summer rain has germinated weeds and subsequent hot conditions made herbicide control difficult and expensive, such as in the 2014-2015 summer.
- Reduction of fire risk. The wide spread adoption of stubble retention during the summer fallow has increased the fire risk across the landscape as well as allowing fires that start the opportunity to spread rapidly. During the 2015 CWFS survey of fallow management practice, the cultivation of heavy stubble paddocks along public roadways where fires may start was a consideration. Also on mixed farming operations the cultivation of strategic paddocks to provide a livestock refuge was also practiced.
- Incorporation of lime and other soil ameliorants.
- Reduction in some pest and disease populations. Careful consideration to the biology of the specific pest or disease is required to ensure a positive outcome is achieved.
- Accumulation of immobile nutrients such as phosphorus on the surface layers in paddocks with a long history of no-till has been widely reported. Soil tests from some CWFS regional sites support these reports. During 2015 CWFS is conducting initial trials to investigate if cultivation effectively redistributes immobile nutrients back through the profile for crop use.

Disadvantages of cultivation:

- Most likely the most expensive in terms of cash cost, impact of soil structure and potential for wind or water soil erosion.
- Seasonal conditions, either dry or wet, may reduce the number of days with optimum seed bed moisture.
- Potential for increasing the spread of weed seeds, soil borne pests and diseases within paddocks and between paddocks. This is an important consideration when contractors are used for one-off tillage operations. A strict biosecurity plan may reduce the risk.
- Reduction in population of soil based predators such as Carabid beetles, spiders and ants.
- Likely to encourage weeds that require burial to trigger germination e.g. black oats. Burial of weed seeds which reduces natural attrition and efficacy of pre-emergent herbicides such as trifluralin, Sakura and Boxer Gold.

For further information, refer to GRDC projects DAN152 and ERM00003.

Mechanically managed but retained on the surface during the fallow (e.g. Flail mulched, slashed, harrowed, crushed and rolled)

During the 2015 CWFS survey of fallow management practice the idea of mechanical stubble management with no soil disturbance was observed amongst growers, particularly in the eastern CWFS districts.

Advantages:

- Potentially the cheapest in terms of cash cost if the motivation is to physically keep the stubble in the paddock.
- Limited impact on soil structure.
- Maintain ground cover.
- Can easily be adopted in controlled traffic farming systems.
- May encourage quicker biological decomposition.

Disadvantages:

- Laying stubble over may lower the efficacy of pre-emergent herbicides.
- Laying stubble over may lead to “hair pinning” issues with disc seeders.
- The use of “stubble movers” on sowing rigs maybe needed to produce ideal sowing conditions.
- Depending on machinery choice may leave “lumps” of stubble or windrows in the paddock.

Bill Long from Ag Consulting Co. (www.agex.org.au/.../innovative-stubble-management-seeding-begins-harvest/) promotes the idea of double cut stubble using the header a second time after harvest is complete, resulting in a greater chaff fraction and less straw and allowing faster breakdown of stubble residues following harvest. The concept is that it is best to keep as much stubble standing rather than laying over to increase herbicide efficacy during crop establishment. Standing stubbles also act as a barrier to soil throw between rows, reducing the chance of crop damage from high herbicide concentrations.

Burning

Often seen as the cheap option but the cost of burning stubble needs to be considered both in terms of dollar labour cost and lost nutrients. Costs of compliance with burning regulations, WHS and insurance should not be underestimated. It is also a good last minute option where despite good planning stubble is still interfering with sowing. Burning potentially may lower populations of pests such as mice particularly if a baiting program is used immediately post-burn.

Removal (e.g. baled)

Baling straw post harvest can be profitable in some seasons. Unfortunately if drought conditions are driving straw demand the benefits of baling to remove stubble loads above 3 t/ha may not be needed. The impact of machinery used for baling on soil conditions and compaction needs to be carefully considered. Unless carefully planned, opportunistic baling to reduce stubble loads may create as many long term problems as it solves.

Grazed during the fallow

In mixed farming operations summer stubble is an important feed resource. CWFS and Farmlink research during both the Water Use Efficiency project and this project confirms that when correctly managed, sheep grazing stubbles during the fallow have no significant impact on subsequent crops.

Critical success factors for stubble grazing are:

- Sheep's mouths removing ground cover damage soil rather than soil compaction by feet.
- Ensuring at least 2 tonnes per hectare of stubble cover remains (70% cover). The cost and risk of going below this threshold in periods of drought will be different for each business. Therefore general rules of thumb are unsuitable.
- Do not let grazing compromise summer weed control. Spray weeds before grazing.
- Closely monitoring condition of sheep. Once split grain, husks and palatable weeds are eaten the feed value of standing straw alone maybe not sufficient.

If you do not measure it, you cannot manage it!

If different stubble loadings, for example above 3 t/ha at sowing and below 3 t/ha at sowing, are going to be managed differently in an attempt to improve yield then stubble loads need to be accurately known at a paddock scale. Growers need to quantify stubble loads to improve seasonal management. The idea is no different to the management of soil nutrients and soil testing, if the amount of soil N or P is not reliably known the most profitable programs cannot be reliably developed.

Bowman, 2006, suggests stubble present after harvest is about 1.5 times the grain yield for yields between 0.5 to 4 t/ha in drier areas. This rule of thumb does not account for stubble still present from crops prior to the crop just harvested. Also the amount of stubble decomposition over summer is dependent on seasonal conditions.

Mallee Sustainable Farming, Mildura, have produced a series of reference photographs that are useful in estimating ground cover percentage after different stubble management operations. The stubble management guide is available from their website (put the URL here).

At the end of the day the most reliable method of monitoring stubble loads is to representatively collect and weigh samples from across the paddock. Same as collecting soil samples, ensure the samples taken represent the paddock by taking multiple samples and avoid unrepresentative areas such as headlands, trees and small areas of distinctly different soil types, all of which will have a greater impact on crop performance than stubble load at sowing.

To take samples you will need:

- A metre square quadrant.
- Rake.
- A chaff bag or something similar to put stubble in.
- Battery powered digital scales (e.g. for calibrating air-seeder, weighing granular herbicides) or pocket spring scale (e.g. scales used for checking fish weights when fishing) that can measure in the 0 to 1 kg range.

Method:

1. When stubble in paddock is dry randomly throw quadrant. If stubble is wet samples will need to be dried.
2. Rake up all stubble (standing and lying on ground) inside quadrant, put in bag and weigh. Do not collect soil as it will quickly cause inaccurate weights.
3. Every 100 grams of stubble per square metre equals 1 tonne of stubble per hectare. i.e., 200g stubble equates to 2 t/ha, 250g equates to 2.5 t/ha, 300g equates to 3 t/ha.
4. It is reasonable to think that after some time the operator will gain an ability to know by feel and volume whether the stubble collected is above or below any pre-determined threshold weight but they should "recalibrate" themselves when conditions change.

Conclusion

In CWFS districts it appears that most of the benefits of stubble retention are achieved by retaining 3 t/ha and more than this can potentially limit yields, particularly in favourable seasons. Options exist to strategically lower stubble loads. Monitoring how much stubble is present is the starting point in deciding if action is required. Seasonal conditions and individual farm business's aspirations will dictate which option is best. If stubble removal is to be undertaken other non-agronomic advantages such as paddock layout, reduction in business risk and soil improvement opportunities may also be achieved at the same time.

References

- Angus J, Kirkegaard J, (1998) Short term benefits and costs of stubble.
- Angus J, Poss R, Kirkegaard J, (1998) Long term benefits of stubble.
- Bowman A, Scott B, (2009) Managing ground cover in the cropping zone of southern NSW.
- Conyers M, Yash D, (2014) GRDC Strategic Tillage Fact Sheet.
- Haskins B, McMaster C, Menz I, Muirhead T, (2012) Wheat Fallow efficiency by Nitrogen trial at Rankins Springs.
- Haskins B, Small J, (2014) Long Term Tillage and Rotation trial, Merriwagga 1999- 2014.
- Hunt J, Kirkegaard J (2011) Re-evaluating the contribution of summer fallow rainfall to wheat yield in southern Australia.
- Hunt J, Swan T, Kirkegaard J, Watson L, Rheinheimer B, Peoples M, Fettell N, Small J, Pratt T, Breust P, (2014) Lifting Productivity in retained stubble systems. 2014 West Wyalong GRDC update.
- Pielkow C, Liang X, Linqvist B, Jan van Groenigen K, Lee J, Lundy M, Gestel N, Six J, Venterea R, Kessel C, (2014) Productivity limits and potentials of the principles of conservation agriculture.
- Scott BJ, Eberbach PL, Evans J, Wade LJ (2010) EH Graham Centre Monograph No 1; Stubble Retention in Cropping Systems in Southern Australia: Benefits and Challenges.
- Small J, (2013) 2013 Seasonal effects of stubble treatments on *canola* establishment and grain yield in CWFS districts.
- Small J, (2013) 2013 Seasonal effects of strategic stubble treatments on *wheat, barley and oats* in CWFS districts; Year 1 of a 5 year investigation.
- Small J, Hill N (2015) 2014 Seasonal effects of strategic stubble treatments on *wheat and barley* in CWFS districts; Year 2 of a 5 year investigation.

Contact Details

John Small
Central West Farming Systems, PO Box 171, Condobolin 2877
0488 951 001, john.small@dpi.nsw.gov.au

Acknowledgements

