4.5 Long-term comparison of stubble management strategies - Perth, Tas

Location: "Oakdene" Perth, Tas

Authors: Geoff Dean, Angela Smith

Researchers:
Geoff Dean, Brett Davey - SFS/TIAR, Regan Parkinson TIAR

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Take home messages:
Summary of findings:

- Five stubble management strategies were compared: fully retained, cut and baled, burnt and incorporated with Lemkin or offset discs.
- Grain yield from the burnt plots was significantly higher compared with stubble retained (fully retained and cut and baled) and both incorporation treatments were significantly higher yielding than where stubble was fully retained. It is likely that this effect is a result of increased stubble from retained treatments leading to poorer plant establishment.
- Fully retained stubble resulted in significant soil improvements ie increased soil moisture (particularly early in the season), higher invertebrate and microbial populations and improved soil physical characteristics.
- Rain at the end of the season may have masked potential yield benefits from improved soil moisture with retained stubble treatments.

Background/Aim:
The generally greater crop yields in higher rainfall areas result in additional stubble loads compared with the major grain growing areas of Australia. Direct drilling with tyned drills into retained stubble is invariably restricted with stubbles in excess of 5 t/ha. Burning of stubbles prior to sowing the next crop has environmental and other disadvantages, notably the loss of organic matter and some nutrients (N and S). Four trials across SE Australia (Victoria x2, Tasmania, S.A.) were funded by GRDC in 2005 to evaluate different stubble management options. GRDC funding finished at the end of June 2008 and NRM –North recognised the benefits of continuing the trial with funding for a further 2 years.

The aim of this trial was to compare the long term effects of different stubble treatments on crop establishment, growth, grain yield and quality. The sustainability of the treatments was evaluated with comparison of soil physical, chemical and biological data. Some long term benefits from full retention of stubble are already evident with significant increases in earthworms and a trend towards decreased resistance to root penetration.

Trial information:
After discussion with key farmers the stubble treatments chosen for the trial were:

- Fully retained
- Offset discs (fully retained and incorporated with offset discs)
- Lemkin discs (fully retained and incorporated with Lemkin discs). In previous years a stubble digester had been applied prior to incorporation to assist in stubble breakdown. However this season there was insufficient time between harvest and sowing (Feb) to warrant this application.
- Cut and baled (stubble cut low with windrower and removed)
- Burnt (a 'cool burn' mid autumn)

The trial was sown on 29th February with Mackellar wheat at 85kg/ha with DAP at 100kg/ha using an Excel EI853 8m single disc drill with Simplicity air cart. The previous crop in the trial was tickbeans. Plots were 50m long x 8m wide and there were four replicates in a randomised complete block design. Broadleaf (Lontrel) and grass selective (Monza) herbicide were applied. Two fungicides (Tilt @ 250ml/ha) were applied as well as two urea topdressings (75kg N/ha each). As this was a dual purpose crop, grazing (with ewes) occurred over late autumn and winter.

Measurements taken included:
Ground cover, establishment counts (average of 20/plot), soil temperature (3 readings/plot), soil moisture content (10 samples/plot), penetrometer (5 readings /plot) and weed counts (10/plot). For the fully retained and burnt treatments further assessments of invertebrate populations and soil biomass were conducted: Pitfall traps (2 per plot) were constructed from plastic tubs containing ethylene glycol, inserted at ground level. Spade tests (average of 5 holes/plot) were dug to assess changes in populations of worms. Microbial biomass carbon -the mass of microbes present in soil, is expressed as µg/g dry soil and was conducted by Biosciences Research Division, Rutherglen, Victoria. Plots were machine harvested on 21th January 2009.

Growing season rainfall (Jan-Nov):
386 mm (including 30mm irrigation in March)

Results and discussion:

The season:

To assist in establishment, the crop was watered with 30mm of irrigation in addition to rainfall. Autumn irrigations are by necessity low input in case waterlogging in a wet winter is exacerbated. There was no significant rainfall until mid June and overall a very dry winter. There were soaking rains in September which turned the season around but the pressure was back on with only 7 mm of rainfall being recorded in October (the pivot irrigator had been moved to another circle). The dry conditions were further compounded by two frosts between -3 and -4°C on October 22nd and 23rd. There were crop saving rains in November.

Plant establishment:

A significant proportion of the straw from 2007-08 was removed by grazing, resulting in minimal sowing problems, but as in previous years, there was a higher stubble load in the fully retained plots and to a lesser degree the cut and baled treatment (Table 1). This is reflected in significantly lower establishment where stubble was retained, particularly where fully retained. Plants in the fully retained plots were also visually less vigorous over winter.

Table 1: Effect of stubble treatments on surface straw, plant density and soil temperature, at Perth 2008-09.

Treatment	Surface straw scores 0 - 5 (none - high)	Plant density 1 Apr (plants/m²)	Soil temp 1 Apr at 5 cm (°C)
Burnt	0.0	145.1	14.93
Offset discs	0.0	125.1	14.33
Lemkin	0.0	139.4	14.63
Cut + baled	1.0	124.4	14.64
Fully retained	4.6	110.2	12.89
F prob	**<0.001**	**<0.001**	**<0.001**
LSD P=0.05	**0.39**	**11.03**	**0.294**
CV%	**22.2**	**5.6**	**1.3**

Soil temperature:

The lower plant establishment and ground cover scores also broadly correlate with soil temperature and reflect the degree of shading. The treatment with the highest straw cover (fully retained) resulted in significantly lower soil temperatures compared with other treatments (Table 1). Removal of stubble through burning and to a lesser degree by baling and burying with the Lemkin resulted in the highest soil temperatures at 5cm depth, five weeks after establishment. For the extreme treatments, burnt and fully retained, further measurements were taken on 22nd July (Table 2) and end of September (data not presented) but there were no significant differences.

Table 2: Effect of stubble treatments on soil temperature (22 July) and soil properties (bulk density, soil moisture) after establishment Perth, 2008-09.

Treatment	Soil temp 22 Jul at 5cm (°C)	Bulk density 0-40cm (g/cm³)	Soil moisture 0-40cm (g H_2O / g soil)	Bulk density 40-80cm (g/cm³)	Soil moisture 40-80cm (g H_2O / g soil)
Burnt	7.27	1.27	0.17	1.33	0.28
Fully retained	7.12	1.18	0.23	1.31	0.30
F prob	**0.306**	**0.049**	**0.008**	**0.401**	**0.13**
LSD P=0.05	**0.456**	**0.086**	**0.025**	**0.094**	**0.033**
CV%	**1.8**	**2.0**	**3.6**	**2.0**	**3.3**

Table 3: Effect of stubble treatments on soil moisture content at stem elongation (2 Sep) and flowering (17 Nov) and dry matter production at flowering, Perth, 2008-09.

Treatment	Soil moisture 0-10cm 2 Sep (%)	Soil moisture 0-20cm 17 Nov (%)	Dry matter produced 17 Nov (t/ha)
Burnt	11.22	10.06	15.47
Fully retained	12.65	11.64	14.54
F prob	**0.067**	**0.31**	**0.328**
l.s.d. (P=0.05)	**1.677**	**4.117**	**1.897**
cv%	**4.0**	**16.9**	**7.7**

Soil moisture:

Soil moisture content in the top 40cm of the soil profile after establishment was significantly higher where stubble was fully retained compared with burnt (P=0.008), but at the lower depth (40-80cm) there was no significant difference (Table 2). Further measurements in the top 10cm of the soil profile (Table 3) showed the difference in moisture content was close to significant at the start of stem elongation, (P=0.067). However, measurement in mid November (end of flowering) showed no significant difference in moisture content and this probably relates to rainfall in early November masking soil moisture differences.

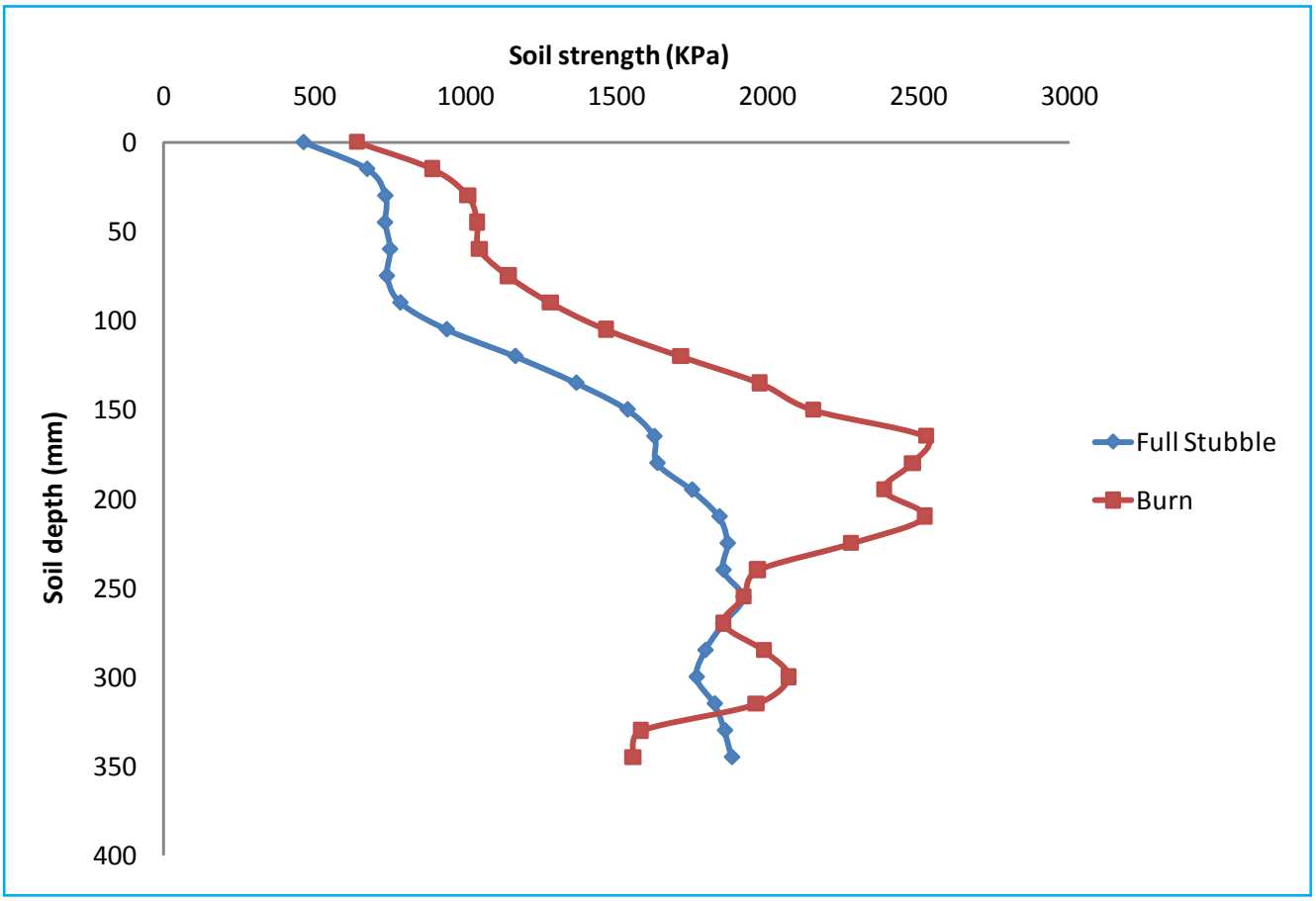

Figure 1: Effect of stubble management treatments on soil strength (KPa) at Perth, 2008-09

Soil bulk density and penetrometer measurements:
Soil bulk density is an indictor of how friable or loose the soil is with higher values suggesting the soil is more compacted. Seven weeks after sowing, bulk density in the top 40cm of the soil profile was significantly lower where stubble was retained compared with burnt (P=0.049) but at the lower depth (40-80cm) there was no significant difference (Table 2).

Penetrometer tests measure the force to push a metal rod into the soil and the resistance force provides an indication of ease of root penetration. At the start of crop stem elongation the fully retained plots had considerably less penetration resistance down to the B horizon at nearly 25 cm (Figure 1). Although it may partly relate to increased soil moisture, this improvement in soil structure has occurred after only 3 years of retained stubble versus burnt stubble.

Dry matter production:
Dry matter cuts were taken at flowering (GS65). Although the fully retained treatment produced lower biomass than burnt plots this effect was not significant (Table 3). This was surprising given the visual differences between treatments, however, with only two treatments it can be difficult to show statistical differences.

Weed populations:
With the early sowing there was ample opportunity for in-crop germination of weeds. Prior to spraying there were very large populations of Vulpia spp (silvergrass) and as in previous years there were considerably higher densities where stubble was removed (cut and baled), (Figure 2). There were however also large variation within and between plots (eg ranging from 0 to 2000 plants/m^2 in the same plot) and there were no significant differences between the other treatments. The higher populations in the cut and baled compared with fully retained may be the result of greater shading and possibly more compounds such as acetic acid being leached from fully retained plots resulting in reduced germination of weeds.

Ryegrass populations tended to be highest where stubble was retained but only the fully retained plots were significantly higher than where stubble was burnt or incorporated. Overall, grass weed populations tended to be lower where seed was removed through burning or burying. In contrast fababean seed responded positively to incorporation with significantly higher plant densities in both incorporation treatments compared with burnt and cut and baled.

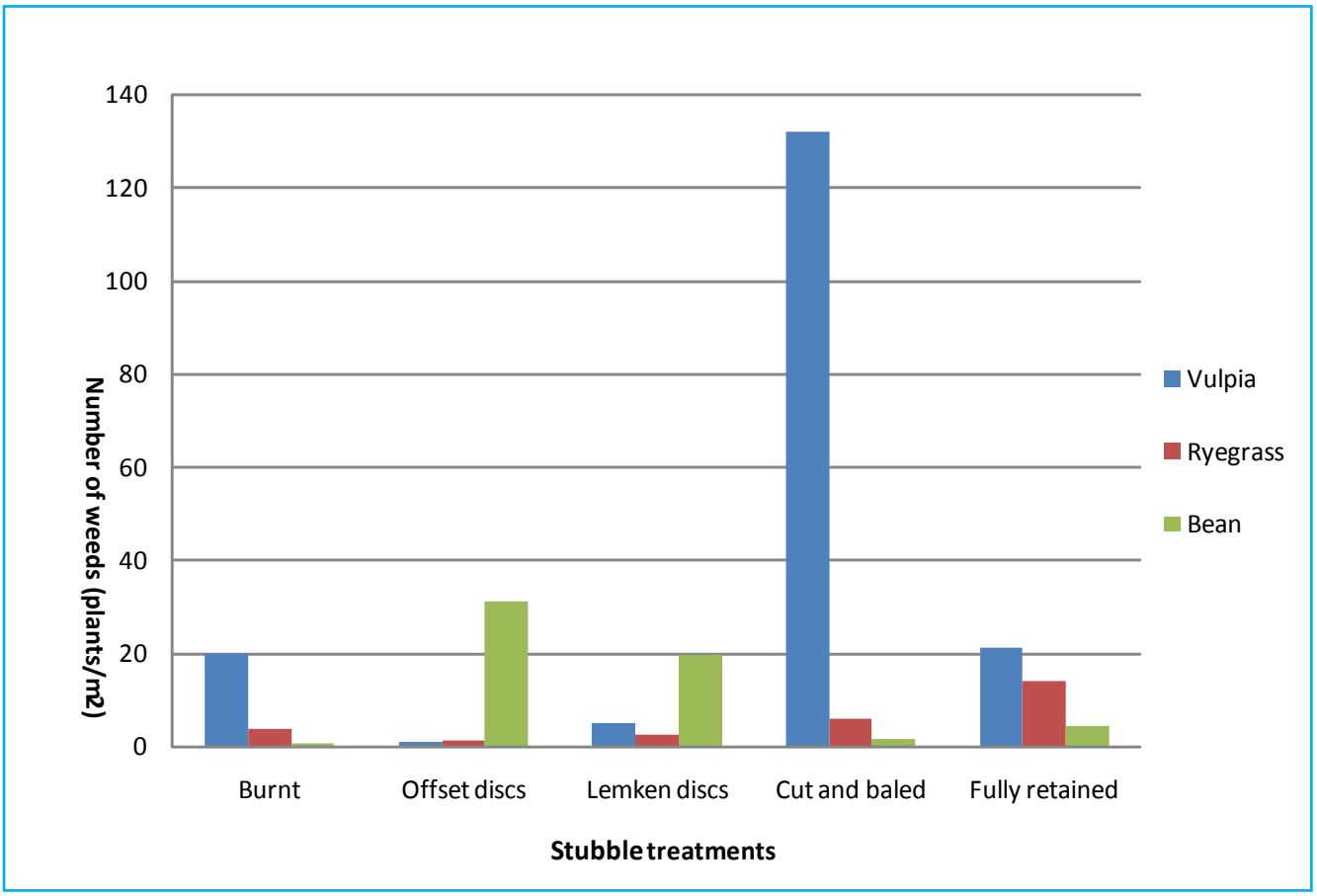

Figure 2: Effect of stubble treatments on weed populations (plants/m^2) of Vulpia, ryegrass, and fababean at Perth, 2008, l.s.d. = 92.6, 8.73, 17.14 respectively.

Subclover, canola and spear thistle plants were counted in small numbers but there were no significant differences between treatments and data is not presented.

Invertebrate populations and soil microbial biomass:
Spade tests showed significantly higher worm numbers where stubble had been fully retained compared with burning (Table 4). Slug populations in fully retained plots were significantly higher and close to significantly higher (P=0.073) for the tile and pit-fall traps respectively (Table 4). A number of other insects were captured eg gnats, flies, crickets, spiders and earwigs but there were no significant differences and populations were generally low (data not presented).

According to the research laboratory, microbial biomass carbon figures from this site were relatively low (Table 4), but this probably relates to the dry conditions. Despite this there was significantly higher biomass carbon in the top 10cm of the soil profile from fully retained plots compared with burnt plots.

Grain yield:
Overall, harvested grain yields were reasonable given three years of below average rainfall, the dry winter and an exceptionally dry October (Figure 3). Yields from the burnt plots were significantly higher than where stubble was retained (fully retained and cut and baled) and both incorporation treatments were significantly higher yielding than where stubble was fully retained. It is likely that the relatively wet finish to the season diminished the benefit of stored soil moisture with stubble retention. As in all previous trials, plant establishment was significantly lower with stubble fully retained and it would appear these effects carry through to harvest. In 2007-08 there was also poorer establishment of tickbeans but no significant treatment effects on grain yield. There was, however, a trend (P=0.11) towards the fully retained treatment significantly out-yielding the burnt treatment. The difference in ranking across years may relate to the greater ability of tickbeans to fill the canopy spaces caused by poorer germination.

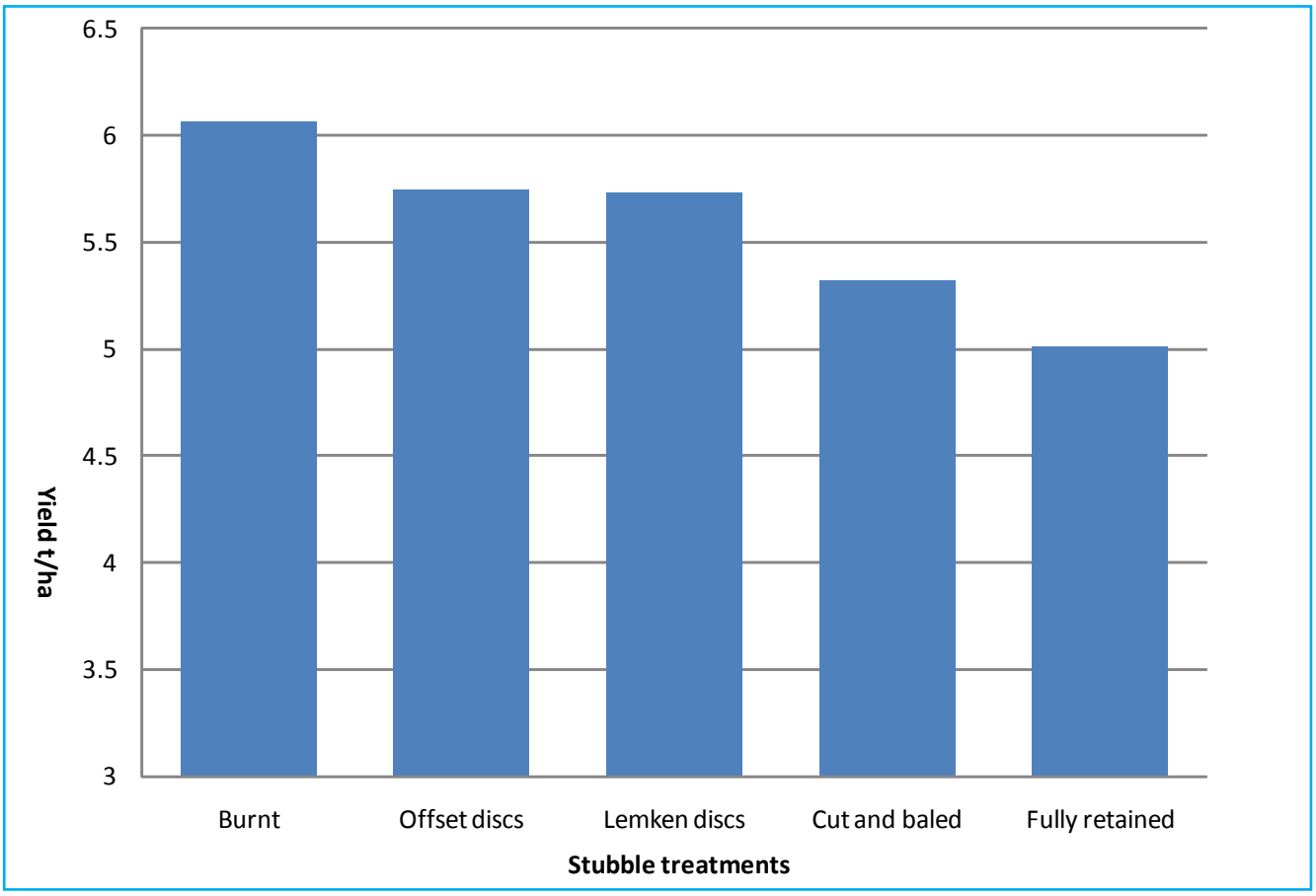

Figure 3: Effect of stubble treatments on yield (t/ha) at Perth, 2008-09, l.s.d. = 0.47.

Lower soil temperature over winter and other factors e.g. low N, acetic acid release from stubble may also reduce yield potential by decreasing plant vigour. There were also slight differences in maturity with fully retained plots being several days slower to ear emergence. Consequently the timing of frost events at flowering may result in differences in severity. To quantify these effects, six quadrats (0.25m2 each) were taken prior to plot harvest to assess yield components, however, samples are still being processed.

Summary:
Five stubble management strategies were compared: fully retained, cut and baled, incorporated with offset or Lemkin discs and burnt. There was a significant effect of stubble management on grain yield. Stubble retention (cut and baled and fully retained treatments) resulted in lower grain yields compared with plots where stubble was burnt. This effect probably relates to differences in plant establishment. Increased stubble ground cover resulted in reduced and less vigorous establishment. This may be a direct function of poor seed soil contact as in the case of fully retained plots but also through increased shading which in turn significantly reduces soil temperature.

There are, however, already obvious long term benefits in soil improvement when stubble is fully retained. Fully retained treatments increased soil moisture early in the season, increased invertebrate (particularly earthworms) and microbial populations and decreased resistance to root penetration through lower bulk density of the soil. These soil improvements may have resulted in greater yield if there had not been rain at the end of the season, which assisted grain fill in the crop. Similarly, without the initial irrigation, plant establishment in the plots were stubble was not retained is likely to have been poorer. Soil improvements with different stubble management treatments should continue into the future, where benefits in yield should be realised, particularly in seasons with a drier finish.