6.7 Comparison of Stubble Management Strategies – Perth Tasmania

Location: "Oakdene", Perth, Tasmania

Funding: GRDC

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Growing season rainfall (April-Nov): 265mm

Summary:
This is one of four trials being conducted across SE Australia to investigate options in dealing with excess stubble. Five management strategies were compared: stubble fully retained; cut and baled; incorporated with Lemkin discs; burnt; and digester applied with stubble incorporated.

Overall, early growth was a function of a number of constraints. In the fully retained stubble plots plant establishment was poor due to large straw windrows creating major problems at sowing and mice damage. In surface stubble treatments lower soil temperatures and higher populations of vulpia resulted in reduced plant vigour. Where stubble was fully retained this effect was less than when most stubble was removed through cutting and baling. Plants in full stubble plots were noticeably taller but more spindly than all other treatments presumably due to a combination of shading and/or shelter from the stubble. Cut and baled plots either largely outgrew these temperature and vulpia limitations and/or the additional conserved soil moisture enabled the plants to catch up.

Grain yield was limited by the dry conditions and in particular frost at flowering with average yields of only 0.7 t/ha. Despite the significantly lower number of ears/m2 where stubble was fully retained, it is likely that the additional soil moisture largely compensated for the reduced plant density through additional grains per plant. Alternatively with a lower plant density these plots may have received less frost damage through a delay in flowering or greater soil heat loss.

Background:
The generally higher crop yields in higher rainfall areas result in greater 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). In the case of poppy trash, the coarse nature of the stubble usually prevents a good burn, leaving this material as problematic in minimal tillage systems. Clearly alternatives to current practices should be sought, particularly if burning stubbles becomes legally restricted or banned in the future.

This is one of four trials across SE Australia (Vic x2, SA, Tas) being conducted to investigate suitable stubble management options.

The aim is to compare the effect of different stubble treatments on crop establishment, growth, grain yield and quality over a three year timeframe. The sustainability of the treatments will also be evaluated with comparison of soil physical, chemical and biological

data. All information will be subsequently pooled to assess final profitability, sustainability and limitations to adoption.

Methodology:

After discussion with key farmers the treatments chosen for evaluation were:

- Stubble fully retained (SFR)
- Stubble digester applied and incorporated with conventional discs (Digester + disc)
- Stubble incorporated with Lemkin discs (Lemkin)
- Stubble cut low (15cm) with windrower and baled (SCB)
- Stubble burnt in mid autumn to achieve a "cool burn" (Burnt)

The trial was sown on 11th May with Mackellar wheat at 120kg/ha and DAP fertiliser at 125kg/ha using a John Deere thirty foot single disc drill. The previous crops were wheat in 2005 and canola in 2004.

Plots were 50m long x 11m wide and there were four replicates in randomised complete blocks.

Nitrogen (32 kg N/ha) was top-dressed on 19th September. Hussar was applied for grass control and one aphicide but no fungicides were necessary.

As this is a long-term trial, initial benchmark data has been collected including:

- Soil basal assessments ie nutrient analysis, bulk density, particle size
- Insect, earthworm and soil biology assessments
- Plant and weed counts
- Soil moisture and temperature

Results and Discussion:

Like most of the grain growing areas of southern Australia the season was particularly challenging. Early growth was slow due to a very late break, low winter rainfall and an extended run of frosts. This was followed by Decile 1 spring and early summer rainfall and to make a bad season worse, severe frosts in October and more importantly mid-November when plants in the trial were flowering.

Plant establishment largely related to the degree of difficulty in dealing with excess stubble. Large straw windrows created a major problem for sowing the SFR plots in particular. SFR plots also provided an ideal habitat for mice as most of the stubble in the surrounding paddock had been baled and removed. Consequently plant establishment in SFR plots was significantly lower than for other treatments. There were also difficulties with incorporation of stubble using discs, resulting in lower than optimum plant numbers. As a consequence of these factors burning of stubble resulted in significantly higher plant establishment (Table 1).

One of the key points was the reduced early vigour in SCB plots with plants being noticeably shorter and less vigorous than in the disced and burnt plots. By ear emergence however this effect appeared to have been largely overcome. Plants in SFR plots grew noticeably taller but were more spindly due to a combination of shading, shelter and nitrogen tie-up.

Soil temperature: Soil temperature was measured in mid September and reflected the degree of surface stubble retention and shading (Figure 1a). The SFR treatment resulted in significantly lower soil temperatures at 10cm than all other treatments except the SCB plots. Complete removal of stubble through burning tended to result in significantly higher temperatures. The two stubble incorporation treatments were intermediate. It is also likely that the soil moisture content influences soil temperature i.e. drier soils will change temperature a faster rate.

Soil moisture: At the end of plant tillering both surface retained stubble treatments (SFC, SCB) resulted in significantly higher soil moisture content at 0-10 cm compared with the other treatments. Interestingly the Lemkin treatment also retained significantly more moisture than the burnt and disced plots, presumably due to burial of stubble at a shallower depth.

Table 1: Effect of different stubble treatments on yield components, Perth 2006.

Treatment	Plant density (/m^2)	Yield (t/ha)	1000 seed (wt/g)	Straw (t/ha)
Burnt	151	0.82	36.3	6.12
Lemkin	130	0.63	35.2	4.99
Digestor + disc	130	0.70	35.6	5.28
Cut + baled (SCB)	117	0.69	35.6	4.29
Fully retained (SFC)	484	0.65	35.1	2.70
F prob	*<.001*	*ns*	*ns*	*<.001*
l.s.d. (0.05)	*10.6*	*-*	*-*	*0.962*
cv%	*5.9*	*13.4*	*4.4*	*13.2*

At flowering, soil moisture tended to remain higher in surface stubble plots compared with burning and the SFR treatment was significantly higher at all soil depths (0-20, 20-40, 40-60cm). It could be expected that the reduced plant density of the SFR treatment resulted in greater retention of soil moisture. This may account for the only significant difference between SFR and SCB treatments, at 0-20cm depth.

With stubble buried, cultivated treatments tended to retain more soil moisture than the Burnt plots and this effect increased with soil depth so that at 40-60 cm the effect was statistically significant.

The surface depth showed fewer differences between treatments and data was a lot more variable. However with increasing depth there were greater soil moisture differences and less variation between treatments.

Weed populations: Due to the dry conditions and late break, pre-sowing weed control was poor and there were high numbers of in-crop grass weeds, predominantly vulpia and perennial ryegrass. A post emergent spray of Hussar was only marginally effective against the vulpia due to the high density.

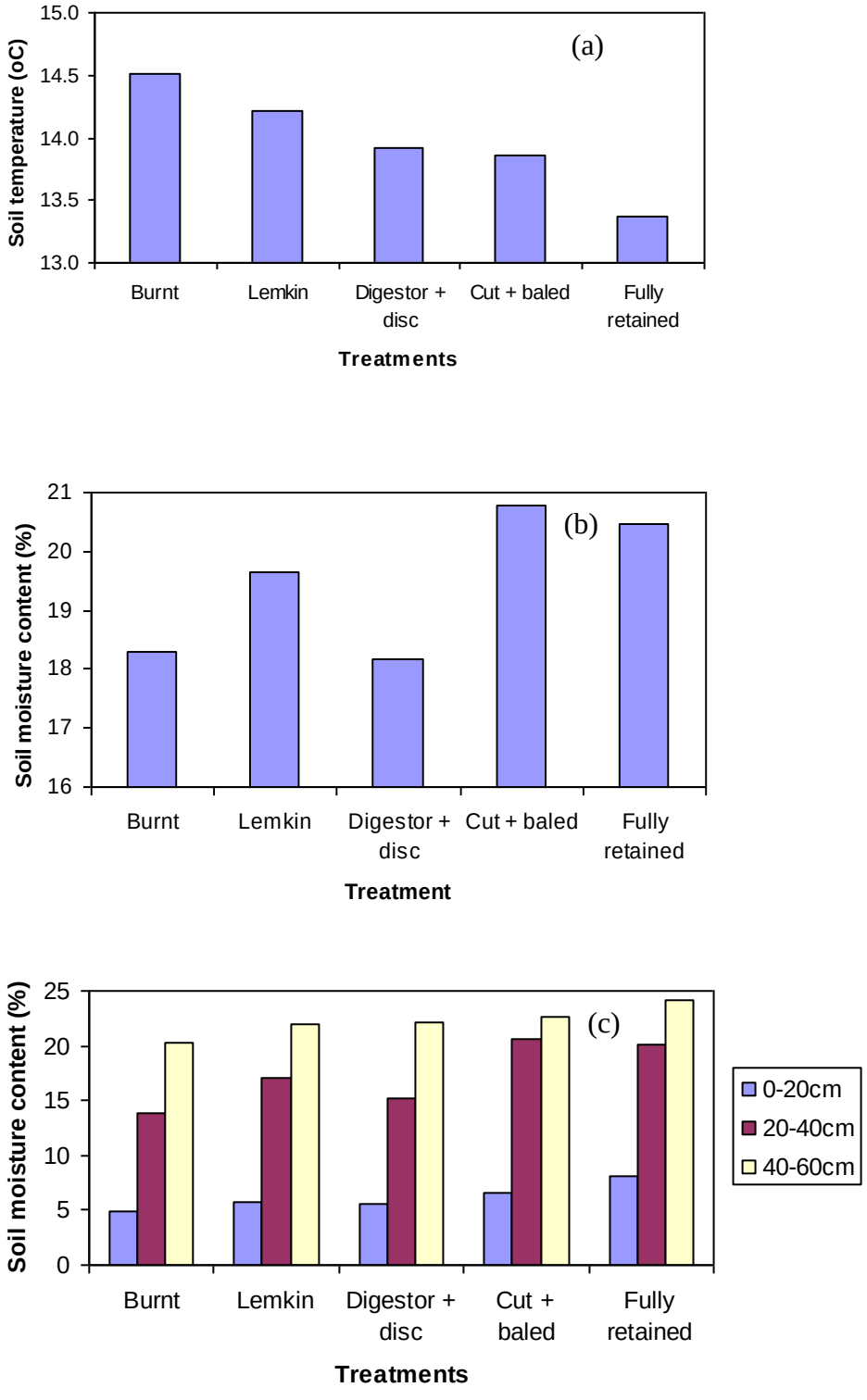

Figure 1: Effect of stubble treatments on soil physical properties at Perth, 2006. (a) Soil temperature at 10cm, l.s.d.=0.54; (b) soil moisture content at 0-10cm at end of tillering, l.s.d.=0.8; (c) soil moisture content at end of flowering at 3 soil depths: 0-20, 20-40, 40-60cm, l.s.d.=1.8, 3.6 and 1.7 respectively.

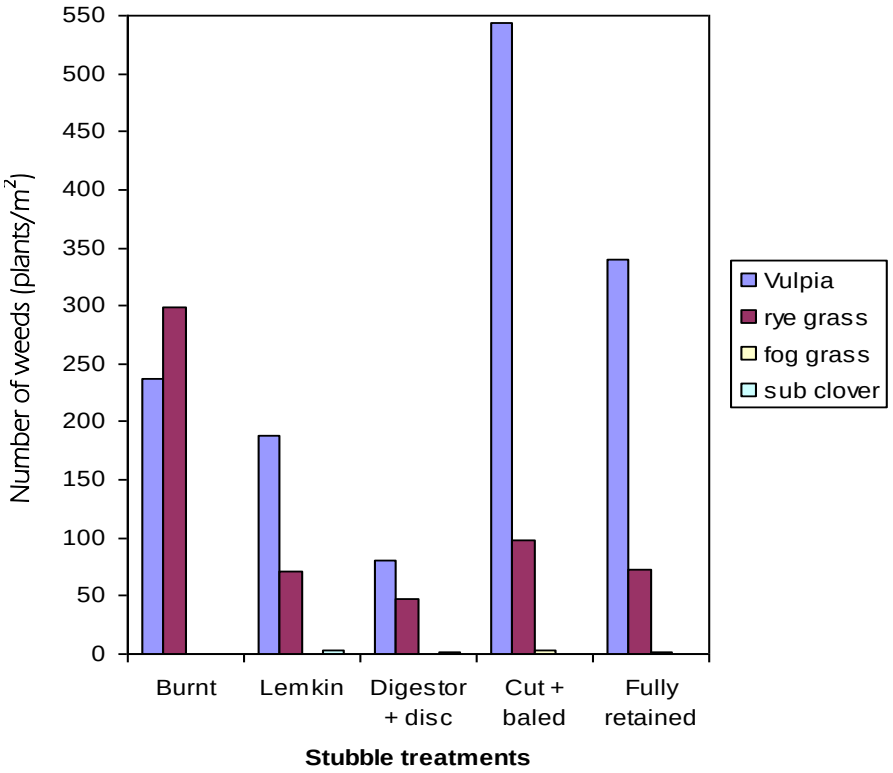

Figure 2: Effect of different stubble treatments on weed populations (plants/m2) of *Vulpia sp*, rye grass (*Lolium perenne*), fog grass (*Holcus lanatus*), and sub clover (*Trifolium subterraneum*) at Perth, 2006, l.s.d. = 292, 77, 2, and 2 respectively

Where stubble was incorporated and vulpia seed buried (Lemkin, Digestor + disc) there was significantly less vulpia establishment compared with surface stubble retention (SFR, SCB). Burning also tended to reduce the seed burden. There was a trend for greater numbers of vulpia plants in the SCB treatment compared with SFR and this may have been due to greater shading and possibly compounds such as acetic acid being leached from the standing stubble.

Ryegrass (*Lolium perenne*) was less of a problem than vulpia but was in significantly higher populations in the burnt plots prior to spraying. Germination may have been triggered by the fire in burnt plots and seed burial in plots receiving tillage. Lower vulpia populations may also have resulted in less allelopathic suppression of the ryegrass compared with surface stubble treatments. Alternatively in surface stubble plots there may have been greater shading and/or mice damage.

Fog grass (*Holcus lanatus*) plants were only present in small numbers and only in surface stubble treatments where seed had not been buried or burnt. In contrast, sub clover (*Trifolium subterraneum*) was only counted in cultivated plots, presumably due to seed at depth being brought to the surface and/or possibly less allelopathic effects from the vulpia. *Poa annua* seedlings were also counted in small number but data was very variable with no trends and is not presented.

Changes in soil fauna: The range of insects collected in pitfall traps was surprisingly limited and consisted only of slugs and worms. Numbers were variable and consequently there were no significant differences between treatments (Table 2). There was however a strong trend for a higher number of slugs in the SFR treatment compared with Burnt (P=0.10). Not surprisingly the data tends to show the greater rate of population increase of slugs compared with worms. The major fauna effect was the larger number of mice in the SFR plots as evidenced by the low plant establishment.

Table 2: Effect of different stubble treatments on soil biology properties at Perth, 2006.

Treatment	Slug numbers (/trap)	Active bacteria (ug/g)	Active fungi (ug/g)	Total bacteria (ug/g)	Total fungi (ug/g)	Dry wt (/g)
Burnt	3.25	23.20	8.30	113	212	0.97
Digestor + disc	-	28.80	12.54	99	150	0.96
Fully Retained (SFC)	8.25	32.60	11.82	132	171	0.94
F prob	*ns (0.102)*	*ns*	*ns*	*0.033*	*ns*	*0.018*
l.s.d. (0.05)	*7.452*	*-*	*-*	*21.50*	*-*	*0.016*
cv%	*42.6*	*26.1*	*19.7*	*8.3*	*71.6*	*0.7*

Bacterial biomass levels were reasonable but fungal values were low (Table 2) probably reflecting the lower tolerance of fungi to drought stress. There was considerable variation between plots with the same treatment and so there were few significant differences. The total and active bacteria counts for the SFR treatment tended to be higher than for the Digester + disc and Burnt treatments. The difference was significant for total bacteria in SFC plots compared with Digestor + disc. Active fungi tended to be higher in the Digestor + disc and SFC plots. The higher moisture of the SFR treatment (lower dry weight) was evident and this probably influenced the active fungal and bacteria biomass. There were no trends in the ratio of bacteria to fungi and data is not presented. All soil biology measurements can be expected to show greater differences after the third year of trials.

Grain yield: There were no significant differences between treatments in machine harvested grain yields (P=0.13) but there was a trend for the burnt plots to out-yield the other treatments (Table 1). Grain yields were very low (mean of 0.7 t/ha) due to the extremely dry season and frosts at flowering (the surrounding paddock was cut and baled). As a consequence interpretation of yield data is difficult. Given the dry growing conditions it is quite likely that the low plant density in SFR plots was beneficial in providing more available soil moisture later in the season. Similarly reduced plant numbers may also have resulted in less frost damage due to greater release of heat from the soil. As is commonly observed, frost damage can also be very fickle with variation of a day or two in flowering date resulting in large differences in damage.

Yield components: Sub samples were taken prior to harvest to assess the components of yield. The reduced plant density in the SFR treatment resulted in a significantly lower number of ears/m^2 but there was a large degree of compensation through a significantly higher number of ears per plant and grains per ear (Figure 3). As a consequence plot yields from SFR plots were not significantly lower than other treatments and there was only a trend towards increased yields from the burnt plots. There were no significant differences between treatments for 1000 grain weight (Table 1).

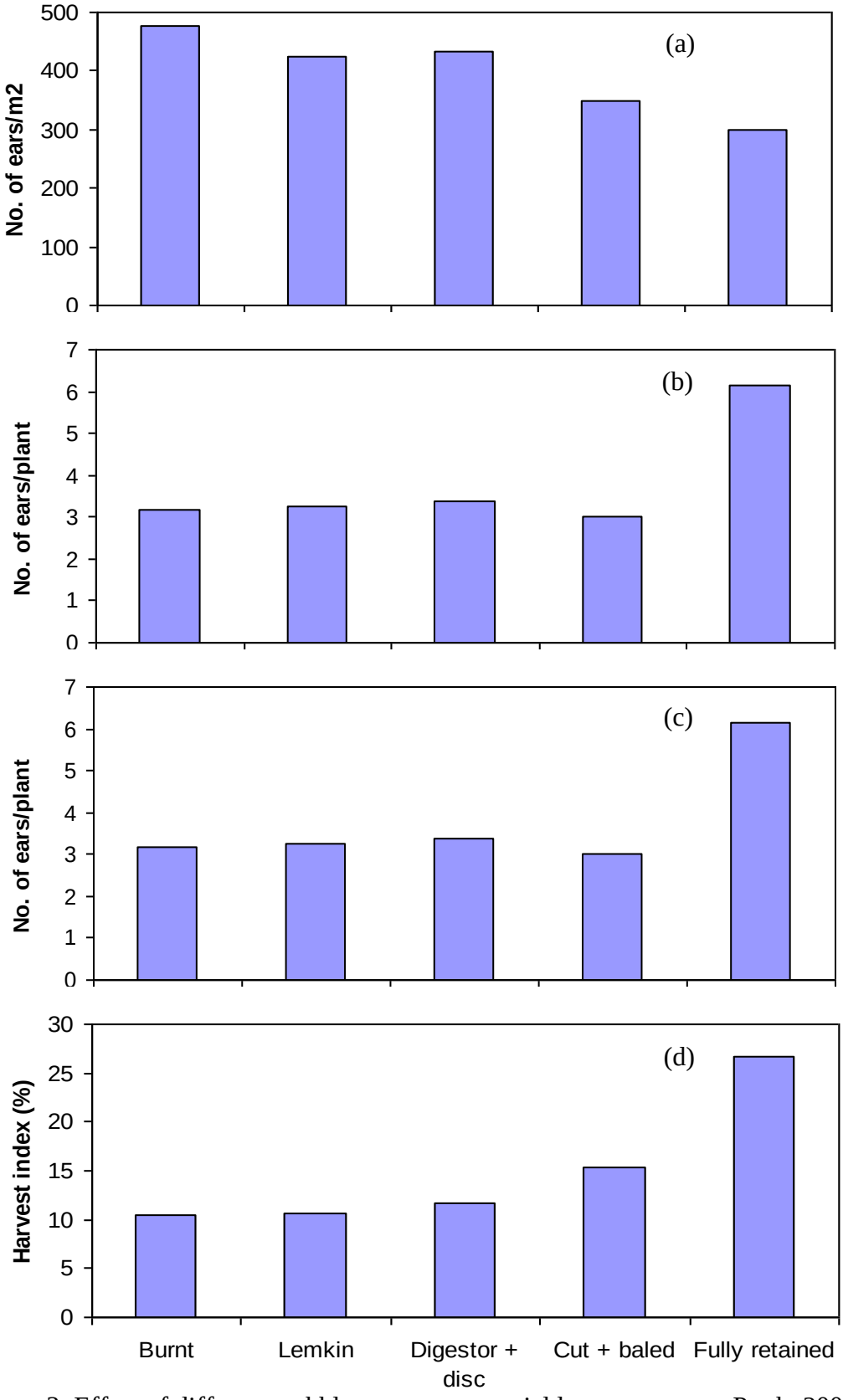

Figure 3: Effect of different stubble treatments on yield components at Perth, 2006. (a) Number of ears/m^2, l.s.d.=89; (b) Number of ears/plant, l.s.d.=1.5; (c) Number of grains/ear, l.s.d.=3.9; (d) Harvest index %, l.s.d.=8.7 .

The greater early growth of Burnt plots is shown in the significantly higher amount of straw produced (Table 1). The SFR plots were low in straw dry matter due to the poorer establishment. The reduced early vigour of the SCB treatment is evident with the amount of straw being significantly lower than for the Digester + disc and tending to be lower than the Lemkin plots. Conversely, the ratio of grain produced to total dry matter or harvest index is illustrated in Figure 3. There was a significantly higher harvest index in SFR plots reflecting the increased efficiency of production. As discussed this may be a function of greater moisture conservation. The similarity in Figures 3c and 3d shows that the harvest index related to the severity of frost damage which is a reflection of the number of surviving grains per ear. Harvest index values were very low due to the frost damage; normal values are in the range of 40-50%.

Information on grain yield is obviously limited by the extensive frost damage. However useful growth comparisons have been obtained.

The importance of stubble retention for moisture conservation has been demonstrated. At all times of testing and soil depths the full stubble retention resulted in significantly more soil moisture than the burnt treatment. Removal of most of the stubble with cutting and baling also tended to result in increased soil moisture and at flowering there was still significantly greater moisture at the 20-40 and 40-60 cm depths compared with burning of stubble. Incorporation of stubble, either with Lemkin or conventional discs also tended to result in less loss of soil moisture particularly at the greater depth (40-60 cm). As it was an exceptionally dry season the benefits of stubble retention were more fully realised. In a wet season the advantages of retained stubble would be considerably less or even detrimental in the short term.

It is worth considering that the value of retaining stubble is negated, in the short term at least, if yields are sacrificed through poor establishment and/or greater pest numbers etc. Removal of some straw from the system may be a compromise e.g. only baling the straw in the windrows. This may make the difference in being able to effectively sow with tynes. Alternatively, burning of only the windrows in late autumn may be an option, particularly if weed seeds are a potential problem.

There were some differences in soil biology, in particular weed populations. The trial is ongoing for three years after which time changes in some of the soil biology and physical properties will get interesting.

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