How important is straw for yield of no-till crops on heavy soils in the low rainfall southern Mallee?

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Aim

To test if no-till crops grown on clay soils in the low rainfall, southern Mallee environment would yield better if more straw could be retained on the soil surface from the previous crop.

Take home messages

- *Wheat grain yield in 2007 was increased by 0.2t/ha after the addition of 5.0t/ha of wheat straw*
- *Straw is important for decreasing evaporation and conserving moisture in topsoil, particularly after canopy closure and when the crop is senescing*
- *The additional moisture available under straw significantly increased dry matter production after GS65*
- *Inter-row sowing reduces straw burial.*

Method

This experiment was carried out at the BCG Farming Systems trial site, a long-term site at which the performance of four different farming systems has been compared since 2001. The systems represented at the site include; No-Till, Reduced-Till, Fuel Burner and Hungry Sheep. *(For further information about the Farming Systems trial, please refer to other Systems site articles in this manual)*. Each system has five plots and is managed by a local farmer champion. A feature of the early years of the trial was the relatively poor performance of the No-Till system, which is championed by a Wimmera farmer. Although much of the poor economic performance could be attributed to crop choice, the No-Till champion also proposed that the yield gains that might be expected from implementing No-Till in other areas were limited by the combination of low rainfall, high evaporation on clay soils, and the inability of crops to produce stubble loads similar to those in the Wimmera (4-8t/ha).

In 2006 plots were split in half and different tillage practices were implemented on each half eg. one half sown as no-till the other sown conventionally.

To address the question of whether increased straw could increase subsequent yield, straw treatments were applied to two Reduced-Till and three No-Till plots. Wheat straw at 5t/ha was applied to a randomly selected half of each plot, with the other half retained as a control. Straw treatments were applied in windrows during January and by March 2007 the straw was spread over the plot by hand raking.

Soil water content and available nitrogen were measured pre-sowing (2006 and 2007) and post-harvest (2007) from soil cores taken to a depth of 1m (segmented at depths of 0-10, 10-40, 40-70 and 70-100cm). Volumetric water content was calculated using the soil bulk density for the site and available nitrogen was measured as nitrate + ammonium.

Four of the five plots were sown to wheat or barley in May 2007. The No-Till champion left one plot as chemical fallow (Table 1). Crops were sown with knife points and press wheels at 305mm row spacing.

All five plots were included in the analysis up to May 2007. After that time, only those plots sown to a crop were included; the chemical fallow plot was not analysed.

Measurements of the residual straw, including the applied straw and that remaining from 2006, were taken on three occasions throughout the year.

In 2008, three out of the five plots were sown to crop, one to wheat and two to barley (Table 1).

Table 1. Sowing details for 2007 and 2008 including the farming system, plot number and cultivar for each plot analysed (the analysis was carried out on the 2007 crops).

System	Plot	2007 crop	2008 crop
Reduced Till	19	Barley *Gairdner*	Chemical Fallow
Reduced Till	24	Wheat *Silverstar*	Barley *Gairdner*
No-Till	6	Chemical *Fallow*	Wheat *Correll*
No-Till	16	Barley *Sloop Vic*	Barley *Sloop Vic*
No-Till	27	Barley *Sloop SA*	Chemical Fallow

Crop emergence was counted for the four plots with crop by 20 June 2007.

Ground cover was captured and recorded by digital photographs taken at waist height at emergence, GS30, GS65 and GS92 (just prior to harvest). The ground cover data was analysed to determine if there were any significant differences between the proportion of stubble and resultant crop (Figure 1a).

Crop dry matter was measured at growth stages GS30, GS65 and GS92 on both halves of the plots. Dry matter of the applied straw and the control treatments was measured three times during the year (two weeks after a significant rainfall event) to assess speed of breakdown between the treatments. Soil water content (0-5cm and 5-10cm) was also taken under the same transects diagonally across each plot half to measure the effect of stubble on crop dry matter and yield production.

In 2007, grain yields were measured with six plot harvester swaths per plot (1.6m in width).

Plots were sown again in 2008 to measure any residual effect of the 2007 crop and applied stubble. The statistical analysis carried out for this project was ANOVA.

Results

In 2006, soil measurements showed reasonably large differences between the plot halves before the treatments were applied. To account for this, soil nitrogen and water were analysed in terms of change since sowing 2006 to harvest 2007, rather than the total values.

Between April 2006 and March 2007, there was a significantly greater change in available soil water ($P<0.05$) in the 10-40cm layer in plots with applied straw (Table 2). In absolute terms, straw plots had significantly less ($P<0.05$) mineral nitrogen to a depth of 70cm (Table 2).

Table 2. Effect of straw treatment on soil water and mineral nitrogen between 7 April 2006 and 27 March 2007. Note: between 29 January 2007 and 27 March 2007 there was one rainfall event of 30.5mm rain (on 21 March 2007).

Depth (cm)	Soil water (mm)			Soil mineral nitrogen (kg/ha)		
	Control	Straw	LSD	Control	Straw	LSD
0-10	+16.1	+17	NS	-0.5	-7.1	6.7
10-40	+3.2	+11	6.2	+20.9	+18.6	NS
40-70	-1.5	+5.5	NS	+4.7	+1.6	NS
70-100	+3.4	+5	NS	-1.7	-1.7	NS
Total 0-100cm	+21.3	+38.2	NS	+22.0	+11.5	NS
Absolute values (27 March 2007)						
Total 0-70cm	+21.3	175	NS	115	89	25

The application of straw changed the soil surface condition of those plots to which it was applied throughout the growing season. Straw-treated plots had more ground cover in mid-June with 55 percent of soil exposed compared with 80 percent soil exposed in the control (Figure 1a).

More stubble dry matter (from the previous year's crop) was maintained on straw plots throughout the season (Figure 1b), decreasing during September and also decreasing in the control treatment with sowing-related burial.

There was significantly more soil water measured under straw treatments at 0-5cm depth in late August and again at 0-5cm and 5-10cm in November (Figure 1c). The November increase in soil water resulted from rain in early November after crop maturity (Figure 1d).

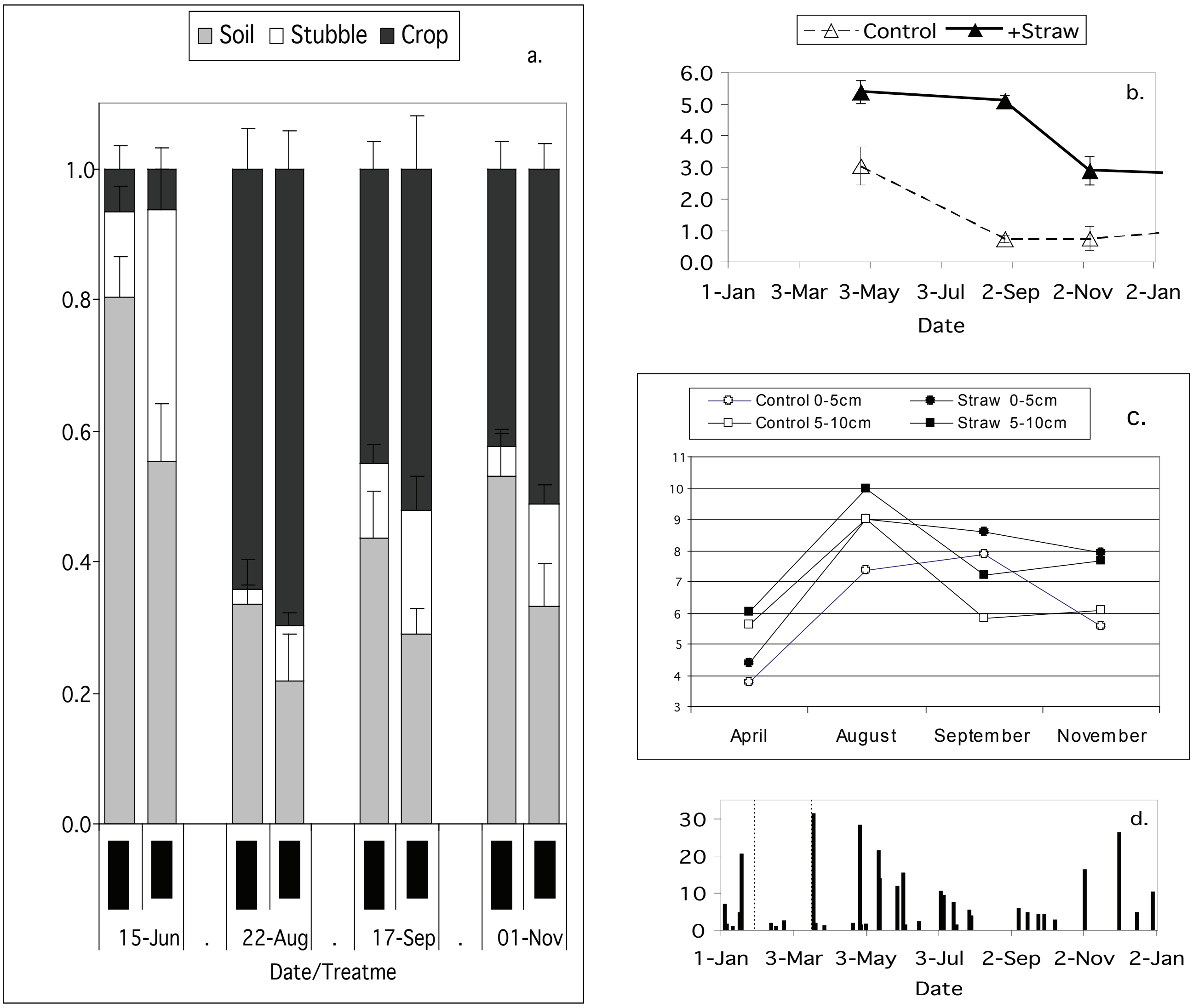

Figure 1a-d. 2007 results (a) Proportion of crop, soil and straw as ground cover in control and crops with 5t/ha of straw (+ straw); (b) Stubble dry matter in control and straw treatments; (c) Surface soil water 0-5 and 5-10cm under control and straw treatments; and (d) Rainfall events during the study, with the period during which straw was applied in windrows and spread marked by dashed lines.

The 2007 plots with added straw yielded significantly more than those without applied straw 1.1t/ha and 0.85 t/ha respectively, (Table 3). There was no difference in dry matter at GS 99 between the straw treatment and the control.

Table 3. 2007 growth and yield components of cereal (barley and wheat) crops from the control plots and those with straw applied at 5t/ha.

Measurement	Treatment (plots 19, 24, 27)*			
	Timing	Control	Straw	LSD
Plant density (plants/m^2)	GS30	138	145	NS
Dry matter (g/m2)	GS30	99	89	NS
	GS65	351	326	NS
	GS99	416	472	NS
Change in dry matter between GS65 and GS99		+65	+146	68
Spike DM (g/m2)	GS65	47	42	NS
	GS99	162	198	NS
Spikes/m2	GS65	283	301	NS
	GS99	309	383	NS
Yield (hand) (g/m^2)	GS99	124	154	NS
Yield (machine) (t/ha)		**0.85**	**1.11**	**0.08**
Protein (machine) (%)		16.7	14.2	NS
N removal (machine) (kg/ha)		22.7	25.2	NS
Grain weight (machine) (mg)		34.3	34.8	NS
Harvest index (hand)		0.31	0.33	NS

** Plot 6 was a chemical fallow; Plot 16 was left out of the analysis due to a re-sowing error that resulted in the plot developing later than the other plots.*

The average yield for 2008 under the straw treatment was 0.42t/ha, while the average in the control plots was 0.23t/ha. In 2008, the straw plots yielded significantly more, on average 77 percent more (P=0.012), but yields were very low across the site, ranging from 0.005-1t/ha for applied straw plots and 0.003-0.6t/ha for the control plots. There were no significant differences in soil moisture in 2008 between the two plot halves where the treatments had been put in place in the previous year.

Interpretation

The trial highlights a biophysical factor affecting no-till cropping on heavy soils constrained by low rainfall in the southern Mallee. Amounts of straw residue similar to that produced by a 3t/ha crop increased yields in no-till cereal crops in 2007, but the crops themselves did not produce sufficient straw residue to have the same effect again in 2008.

Straw increased soil water in the 10 – 40cm layer and early in the season reduced surface soil mineral nitrogen, but crops had similar nitrogen removal in grain. Lack of straw residue caused by low rainfall and hence crop yield may in turn lead to increased evaporation and reduce yield in no-till cereal crops in the area of study.

The main effect of the straw on crop growth came around and after anthesis (flowering, GS65). This timing reflects the water conservation effect of straw, probably mostly before anthesis, because there was little spring rainfall. Differences in soil water storage were measurable both 10-40cm soon after applying the straw (Figure 1c) and at the surface through the season, even after a relatively dry period during spring. The straw was able to conserve more moisture in the topsoil (up to 4mm) from April to September. While this is not a huge amount, there were many small spring rainfall events which had a cumulative effect on soil water and resulted in an extra 0.2t/ha in crop yield from the stubble-applied plots. Previous studies have measured water under stubble treatments (relative to a control) stored at up to 1.5-2.0m but generally in higher rainfall zones and/or after a long fallow period (O'Leary and Connor 1997a).

The seasonal patterns of ground cover (Figure 1a) and stubble dry matter (Figure 1b) demonstrate the variable importance and effects of straw residue in this environment. Exposed topsoil results in moisture losses through evaporation. Stubble made up a large proportion of ground cover as the crop established but became less important for retaining soil water, with a large crop canopy after good winter rains. This highlights the fact that the greatest effect from straw came after GS65 and before harvest because this period had the greatest increase in growth. Straw again became important in spring as the crop senesced and more soil was exposed to evaporation.

Soil throw during sowing was an important factor reducing straw ground cover, although straw that was under and/or mixed with loose soil may still have been a barrier to evaporation. There was some stubble at sowing in control plots from the 2006 crop, but little of this remained in late August (Figure 1b), possibly because of disturbance/burial during the sowing process and subsequent decomposition and low initial stubble levels.

Better balance of nitrogen supply as a result of straw application and resultant pre/post-anthesis growth was unlikely as a mechanism for yield increase in 2007 but did have measurable effects. Small reductions in soil mineral nitrogen were measured early in the season (Table 2), where straw was applied, but overall nitrogen nutrition was adequate relative to yield. Net nitrogen removal in grain was slightly higher in the straw treatments, with increased yield offsetting decreased protein.

While there was no extra straw spread in 2008, the residual straw from 2007 did have a positive effect on the final yield in 2008. There was an average of almost 0.2t/ha extra grain yield in 2007 where straw was applied compared to the control. The positive effect on crop growth came from moisture retention during the growing season under the residual straw. When taking into account the increase yield from the straw plots, consider that pre-existing soil nitrogen and water differences were lower for the straw plots when measured in 2006.

In 2008 the level of residual straw was minimal, so the effect that was seen in 2007 (from 5t/ha applied straw) was not observed in 2008 because the straw had broken down.

Application

Physically spreading straw over a broadacre scale is not an efficient or a viable option for farmers. Moisture conservation in dry years can be achieved by retaining the previous year's stubble and minimising burial and breakdown of that residue, and assisting in this process could be inter-row sowing. This is important for maximising the effects of the small amounts of straw residue available in these environments.

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