INVITED ARTICLE

SHEEP AND NO-TILL: NO WORRIES!

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TAKE HOME MESSAGES

- Sheep grazing on stubbles and crops do not reduce crop yields provided summer weeds are controlled and at least 70% stubble cover (2-3t/ha cereal stubble) is maintained.
- Reduced water infiltration and yield from grazing are due to removal of cover rather than compaction; sheep's mouths cause damage, not their hooves.
- Sheep do compact soil, but only at the surface; natural shrinking and swelling of soils and sowing with knife points alleviates this.
- Grazing of stubbles and crops appears to make more N available to crops, which can increase yield; the mechanisms by which this is achieved remain uncertain.

BACKGROUND

A livestock enterprise, particularly one with sheep, in conjunction with a wheat-based cropping enterprise has long formed the basis of mixed farming systems throughout south-eastern Australia. This enterprise mix is symbiotic: sheep are able to consume and give value to otherwise wasted by-products from cropping (crop residues, weather damaged and spilt grain, early vegetative crop growth) whilst the legume-based pastures used for sheep allow paddocks to be spelled from crop production, increasing soil nitrogen and reducing crop weeds and diseases. The presence of both livestock and crops also diversifies farm business, offsetting production and price risk and increasing resilience.

In recent times, much attention has been given to the potential for conservation farming practices such as no-till seeding with complete stubble retention and controlled traffic to increase crop yields and water-use efficiency. Advocates argue that the full potential of no-till and controlled traffic may not be realised if sheep are grazed on cropping country, removing residue cover and trampling soils, but there is little contemporary research evidence to support this view.

In this article, we report results from two four-year experiments designed to test whether sheep grazing in no-till farming systems damages soil and reduces crop yields.

AIM

To test whether sheep grazing in no-till systems damages soil and reduces crop yields.

METHOD

TRIAL 1: TEMORA

The first experiment was located on a red chromosol soil 5km SSE of the township of Temora in south east NSW (539mm average annual rainfall with equi-seasonal distribution) and consists of six treatments:

i. Nil graze, stubble retention
ii. Nil graze, stubble burn
iii. Stubble graze, stubble retention
iv. Stubble graze, stubble burn
v. Winter graze, stubble graze, stubble retention
vi. Winter graze, stubble graze, stubble burn

These treatments were applied in two different phases in adjoining areas of a farmer's paddock which had been in lucerne pasture since 2005. In Phase 1, lucerne was sprayed out in late spring 2008; in Phase 2, it was sprayed out in late winter 2009. Following lucerne removal, large plots (7 x 16m) were established, which allowed all operations to be conducted using controlled traffic. All plots were fenced so they could be individually grazed by sheep.

Crops (wheat and canola, Tables 1 and 2) were sown in mid-late April in all years of the experiment. Weaner ewes (3-6 per plot) were used to graze crops in treatments 5 and 6 in July, when crops were still in the vegetative stage. Following harvest in each year (late November-early December), weaner ewes grazed stubbles in treatments 3, 4, 5 and 6. Sheep were not removed from the plots if it rained during grazing. At the end of each summer fallow period, all residues were removed from a $1m^2$ area in each plot and infiltration rates measured using a drip infiltrometer. The stubble burn treatments were applied in mid to late March of each year; they had no bearing on soil water accumulation during the summer fallow period.

Soil water was monitored during the summer fallow period using time-domain reflectometry (TDR) soil water probes (Campbell Scientific CS615) at the soil surface (7.5 and 15cm depth) and a neutron moisture meter (NMM) for the subsoil (10 to 180cm depth). Summer weeds that emerged at the site were promptly controlled with herbicide.

At the end of 2009, during the first summer fallow period, 313mm rain fell, including five significant individual events (Figure 2). The subsequent summer fallow periods were exceptionally wet, with 477mm falling during the summer fallow of 2010/2011 and 462mm during 2011/2012. In-crop rainfall was 182mm in 2009, 460mm in 2010, 200mm in 2011 and 175mm in 2012. Long-term average rainfall for Temora is 330mm April-October and 216 mm November-March.

TRIAL 2: CONDOBOLIN

The second experiment was conducted on a red chromosol near Condobolin in central west NSW, where rainfall is non-seasonal and the long-term annual average is 427mm. The surface soil was a clay loam and the site had little slope.

Eight treatments, each replicated four times, were imposed after the 2009 harvest on a paddock which carried just under 3t/ha of wheat stubble, and reimposed on the same plots annually to measure cumulative responses. Plots were relatively large (10.5 x 28m) and individually fenced, the fences being erected and removed each year so that all operations except for the stubble treatments were conducted using commercial equipment and controlled traffic. Livingston wheat was sown in 2010 and 2012 and Hindmarsh barley in 2011, using a tined air seeder fitted with coulters and press wheels.

The treatment variables were:

i. Grazing intensity, using adult merino sheep to reduce stubble cover and trample the soil surface (nil, moderate, or heavy)

ii. Stubble amount (as is, added or removed) so as to give a wider range of values independent of seasonal conditions)

iii. Stubble retained throughout the season or burnt just prior to seeding

iv. Weed control (all herbicide, or partly reliant on grazing).

v. Soil water was monitored during the summer fallow and crop period, using a neutron moisture meter to 160cm and mineral nitrogen was measured to 90cm prior to seeding.

RESULTS AND INTERPRETATION

TRIAL 1: TEMORA

In the set-up year of Phase 1 (2009), winter grazing of the crop reduced yield by 0.4t/ha and protein increased accordingly. The nil graze treatment accumulated more water during the summer fallow period, following significant and intense rain in mid-February and early March (Table 1). The extra water accumulated was stored deep in the profile (Figure 1), indicating that the difference in accumulation was due to improved infiltration in the presence of stubble rather than reduced evaporation. This hypothesis is supported by measurements of soil water at the surface which showed no difference between the nil graze and winter and stubble grazed treatments (Figure 2).

Grazing reduced infiltration rates measured at the end of the summer fallow period. We hypothesise that this was due to the removal of stubble by grazing and subsequent rain-drop impact damage rather than soil physical effects due to grazing, as infiltration rates in the surrounding un-grazed farmer's field (low stubble cover ~1.6t/ha of a drought-affected canola crop) were as low (11mm/h) as those in the winter and stubble grazed treatment (16mm/h). The amount of stubble remaining in the grazed treatment (0.8t/ha) was below the 2.0t/ha or 70% cover level commonly recommended for the prevention of run-off and soil erosion on clay soils.

Despite the differences in plant available water prior to sowing in 2010, in-crop rain was sufficient to sustain crop growth and there were no significant differences in crop yield between the grazing treatments (Table 1) or stubble burn treatments (data not shown). Differences in plant-available water persisted at maturity (data not shown), but heavy rain during the summer of 2010-2011 filled the soil profile and all but removed the differences prior to sowing in 2011.

In 2011, the winter and stubble graze plots were split and winter grazing was applied to only one half of the plots. This was so soil effects from the previous year's grazing could be separated from the plant effects of grazing the crop in 2011. There was no difference in yield between these two halves of the winter and stubble graze plots (data not shown), and the winter and stubble graze treatment out-yielded the nil and stubble graze treatment by 0.6t/ha. This result was most likely due to the differences in mineral nitrogen which were measured between treatments at the start of 2010 and persisted until the last N measurement made prior to sowing in 2012. There is no clear explanation for such a large difference in N; much smaller differences which are seemingly due to N tie-up in the nil graze treatment developed in Phase 2 of this experiment (Table 2) and the Condobolin experiment (Table 3). This difference in N did not result in any variation in crop yield in 2012. Protein results are not yet available.

Table 1. Stubble remaining after grazing in December of the previous year, steady-state infiltration rate at the end of summer, soil bulk density, soil strength, plant available water (PAW) and mineral N at sowing, wheat grain yield and protein in Phase 1 of the Temora experiment which began in 2009.

	Stubble remaining after summer grazing (t/ha)	Summer infiltration rate (mm/h)	Bulk density (Mg/M³)	Soil strength (KPa)	PAW at sowing (mm)	Mineral N at sowing (kg/ha)	Grain yield (t/ha)	Grain protein (%)
2009 – Wheat (Gregory)								
Nil graze	–	–	–	–	20	143	1.6	14.4
Stubble graze	–	–	–	–	20	143	1.6	14.6
Winter and stubble graze	–	–	–	–	20	143	1.2	14.9
Sig. diff.	–	–	–	–	–	–	P<0.001	P=0.006
LSD (P=0.05)	–	–	–	–	–	–	0.2	0.33
2010 – Canola (Tawriffic)								
Nil graze	5.4	33	1.22	222	155	178	4.1	–
Stubble graze	0.8	20	1.23	365	110	205	4.2	–
Winter and stubble graze	0.8	16	1.25	516	99	279	4.0	–
P-value	–	P=0.041	P=0.549	P=0.005	P<0.001	P=0.014	P=0.62	–
LSD (P=0.05)	–	11	0.06	135	19	53	NS	–
2011 – Wheat (Bolac)								
Nil graze	8.0	102	1.35	298	201	93	4.6	13.1
Stubble graze	4.0	49	1.38	355	183	126	4.6	13.5
Winter and stubble graze	4.0	44	1.40	460	187	199	5.2	13.0
Sig. diff.	–	P=0.006	P=0.819	P=0.010	P=0.011	P=0.001	P<0.001	P=0.158
LSD (P=0.05)	–	29	NS	91	11	49	0.2	0.6
2012 – Wheat (Wedgetail)								
Nil graze	9.8	–	–	–	203	99	4.7	NA
Stubble graze	4.2	–	–	–	192	144	4.8	NA
Winter and stubble graze	3.8	–	–	–	196	168	4.7	NA
Sig. diff.	–	–	–	–	P=0.127	P=0.005	P=0.768	–
LSD (P=0.05)	–	–	–	–	NS	38	NS	–

Grazing again reduced infiltration rates in 2011, but rates in all treatments were much higher than at the start of 2010 and well in excess of rainfall rates in the region. Similarly, grazing increased soil strength in both 2010 and 2011, but not to levels detrimental to plant growth (>2000KPa).

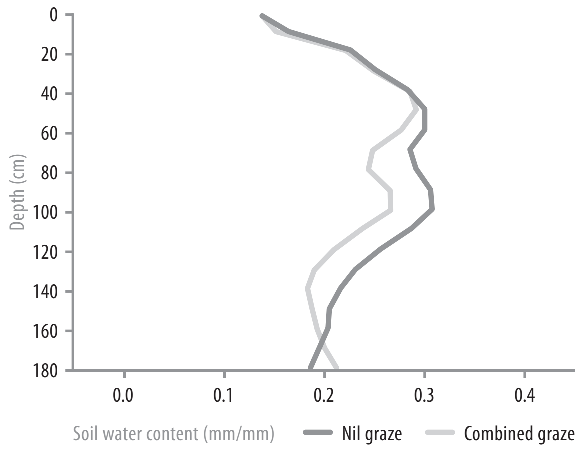

Figure 1. Volumetric soil water content down the soil profile of the nil graze and combined grazed treatments on 16 March 2010 in Phase 1 of the Temora experiment.

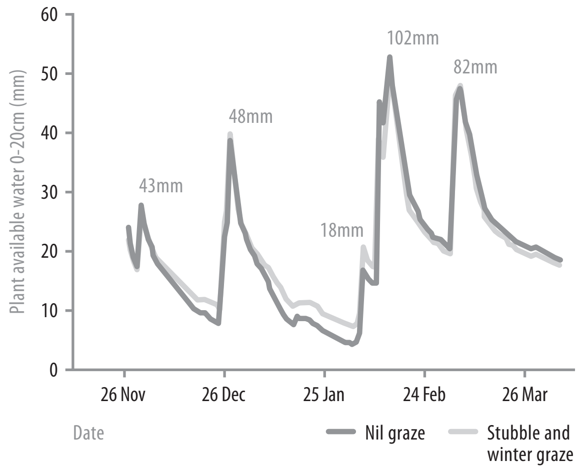

Figure 2. Plant available water as measured by FDR probes in the nil graze and stubble & winter graze treatments during the summer fallow of 2009/2010 in Phase 1 of the Temora experiment.

The numbers next to curve peaks are amounts of rainfall in corresponding events.

In the set-up year of Phase 2 (2010), winter grazing of the crop increased yield by 0.6t/ha (Table 2). There were no effects of grazing on yield in either 2011 or 2012. Grazing reduced infiltration and increased soil strength in both 2011 and 2012, but not to levels likely to reduce fallow efficiency or decrease yield.

Table 2. Stubble remaining after grazing in December of the previous year, steady-state infiltration rate at the end of summer, soil bulk density, soil strength, plant available water (PAW) and mineral N at sowing, wheat grain yield and protein in Phase 2 of the Temora experiment which began in 2010.

	Stubble remaining after summer grazing (t/ha)	Summer infiltration rate (mm/h)	Bulk density (Mg/M^3)	Soil strength (KPa)	PAW at sowing (mm)	Mineral N at sowing (kg/ha)	Grain yield (t/ha)	Grain protein (%)
2010 – Wheat (Bolac)								
Nil graze	–	–	–	–	48	185	6.9	13.6
Stubble graze	–	–	–	–	48	185	6.9	13.4
Winter and stubble graze	–	–	–	–	48	185	7.5	13.3
Sig. diff.	–	–	–	–	–	–	P=0.012	P=0.419
LSD (P=0.05)	–	–	–	–	–	–	0.4	NS
2011 – Canola (45Y82)								
Nil graze	11.5	59	NA	308	145	92	3.4	–
Stubble graze	5.5	36	NA	494	143	94	3.3	–
Winter and stubble graze	5.5	34	NA	563	135	105	3.1	–
Sig. diff.	–	P=0.022	–	P=0.002	P=0.338	P=0.696	P=0.114	–
LSD (P=0.05)	–	16	–	111	NS	NS	NS	–
2012 – Wheat (Bolac)								
Nil graze	7.4	79	1.18	150	138	73	4.8	NA
Stubble graze	3.3	36	1.28	360	140	76	4.9	NA
Winter and stubble graze	3.1	24	1.27	524	132	90	4.8	NA
Sig. diff.	–	P=0.003	P=0.059	P=0.006	P=0.438	P=0.032	P=0.451	–
LSD (P=0.05)	–	24	NS	168	NS	13	0.2	–

TRIAL 2: CONDOBOLIN

In 2009, neither grazing nor addition or removal of stubble affected summer fallow efficiency, but mineral nitrogen at sowing was lower under heavy stubble. The heavily grazed treatment yielded less than all other treatments in 2010 (Table 3). There is no obvious explanation for this result, although heavy grazing did remove stubble below recommended levels. In 2011, there was a relationship between stubble amount and fallow water storage and also with yield up to ~3.5 t/ha of stubble. However, it did not matter if the stubble was removed by sheep or by cutting and raking. This supports the hypothesis formed from results from Phase 1 of the Temora experiment that the observed reduction in fallow efficiency was due to the removal of stubble, rather than to soil physical effects due to grazing.

In 2012 a treatment which was heavily grazed, and in which summer weeds were not controlled, had accumulated less soil water and had less mineral N prior to sowing. It yielded less than all other treatments apart from the added stubble treatment. This reinforces the importance of summer weed control for maximising summer fallow efficiency and subsequent crop yield. The heavily grazed and stubble cut and removed treatments yielded marginally more than the nil graze treatment. Grain proteins indicate that this was probably due to the differences in mineral N apparent at the start of the season (Table 3).

Table 3. Stubble remaining after grazing in the previous fallow, water stored during the fallow, and mineral N at sowing, wheat grain yield and protein in the experiment at Condobolin.

	Stubble remaining after summer grazing (t/ha)	Fallow water storage (mm)	Mineral N at sowing (kg/ha)	Grain yield (t/ha)	Grain protein (%)
2010 – Wheat (Livingston)					
Added stubble	3.7	136	134	4.7	11.8
Nil graze	1.9	125	183	4.6	11.8
Moderate graze	1.4	126	157	4.7	11.8
Heavy graze	0.9	131	181	4.4	11.8
Mown	1.8	128	199	4.5	11.8
Sig. diff.	P<0.001	P=0.17	P=0.006	P<0.001	P=0.99
LSD (P=0.05)	0.2	NS	32	0.2	NS
2011 – Barley (Hindmarsh)					
Added stubble	6.4	16	108	2.5	10.7
Nil graze	3.2	-3	115	2.5	10.4
Moderate graze	2.8	-3	120	2.3	10.6
Heavy graze	2.2	-11	137	2.2	11.1
Mown & removed	0.8	-19	120	2.1	10.5
Sig. diff.	P<0.001	P<0.001	P=0.58	P=0.003	P=0.31
LSD (P=0.05)	0.4	11	NS	0.2	NS
2012 – Wheat (Livingstone)					
Added stubble	6.1	98	76	1.65	9.0
Nil graze	3.3	96	90	1.72	9.0
Moderate graze	1.6	93	103	1.78	8.9
Heavy graze	1.2	99	85	1.84	9.7
Mown & removed	0.5	90	116	1.83	9.7
Heavy graze, missed spray	1.2	74	87	1.49	9.6
Sig. diff.	P<0.001	P=0.076	P=0.049	P=0.02	P=0.04
LSD (P=0.05)	0.4	16	23	0.18	0.6

COMMERCIAL PRACTICE

Our data supports the conclusion of a recent review which found that the physical effect on soil from the trampling of grazing sheep tends to be shallow and transient, and that reduction in subsequent crop yield is rare. (www.ausgrain.com.au/Back%20Issues/196magrn10/8-concerned.pdf). However, loss of cover associated with overgrazing is clearly a risk. These findings give confidence to the hypothesis, that, provided a critical level of soil cover is maintained (>70% or 2.0t/ha of cereal stubble), livestock can be retained within modern conservation cropping systems without compromising crop performance. Further to this, livestock may continue to provide production and business risk benefits in the future. These findings are supported by paddock scale research in the Wimmera-Mallee conducted by BCG (see 'Is stubble worth the trouble? Crop stubble threshold for maximised moisture conservation', pp. 159, 'Livestock and no-till: do they mix?' pp. 183 and *BCG 2011 Season Research Results* pp. 299.

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