# Report Four

## Contribution of sheep in no-till and zero-till systems

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## Take Home Messages

- Grazing stubble with sheep speeds up N cycling and reduces N tie-up by the stubble. When yield is N limited, this can increase grain yield and quality.
- Over the seven year experiment, grazing and retaining stubble has been the most profitable treatment, with an annual Gross Income 172 higher than un-grazed, stubble retain (assuming a grazing value of the stubble) or $55 higher if no grazing value assumed.
- Over the seven years, there was on average a 0.5 t/ha reduction in wheat grain yield in the 2nd wheat crop where stubble was retained and not burnt – mostly related to N tie-up.

## Background

A livestock enterprise, particularly 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, with sheep able to consume and give value to by-products from cropping (crop residues, weather damaged and spilt grain, early vegetative crop growth) whilst the legume-based pastures used for sheep production spell paddocks from crop production, increase soil nitrogen and reduce crop weed and disease burden. The presence of both livestock and crops also diversifies the farm business, offsetting climate 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 and trampling soils. However, there is little contemporary research evidence to support this view. We report results from a long-term experiment (established in 2009) testing the impact of sheep grazing no-till and zero-till farming systems on soil conditions and crop yields. Results from the first four years of this experiment (2009-2012) are available online www.farmtrials.com.au/trial_details.php?trial_project_id=16648). Results from 2013-2015 were presented in the FarmLink 2016 annual report. This paper updates the results with 2016 data including a summary of grain yield and gross income from continuously cropped treatments between 2010 and 2016.

## Methodology

The experiments were located on a red chromosol soil 5 km SSE of the township of Temora in SE NSW (519 mm average annual rainfall, 313 mm average Apr-Oct rainfall, 206 mm Nov-Mar rainfall) and consists of three stubble grazing treatments;

1. Nil graze (NG)
2. Stubble graze (SG)
3. Winter graze and stubble graze (WGSG)

These were applied in a factorial design with two stubble retention treatments;

i. Stubble retention (SR)

ii. Stubble burn (SB)

Between 2013 and 2016 these treatments were also split for three different seeding furrow opener types;

A. Deep knife-point (AgMaster 12 mm - disturbs soil below seed)

B. Spear-point (Keech - does not disturb soil below seed)

C. Single disc (Excel with Arricks Wheel residue managers)

These treatments were applied in two different phases in adjoining areas of a farmer's paddock which had been in 4 years of 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 16 m – incorporating three individual plot-seeder runs of 1.83 m width and 1.5 m of permanent tram tracks) were established which allowed all operations to be conducted using controlled traffic. All plots were fenced so they could be individually grazed by sheep. Between 2009 and 2012, all plots were sown with deep knife points attached to FlexiCoil 250 kg break-out tines on a linkage mounted plot-seeder on 305 mm row spacing. From 2013, both spear Keech points and deep knife points were attached to the FlexiCoil, and the discs were mounted on a trailing bar with air-seeder also on 305 mm row spacing. Crops were sown from mid-April to early May in all years of the experiment which followed a canola-wheat-wheat sequence.

In 2016, phase 1 was sown to Hyola 650TT canola on the 27th April at 3.1kg/ha with MAP & impact @ 40kg/ha, following pre-emergent application of propyzamide @ 1L/ha, Dual Gold ® @ 250ml/ha, Lorsban ® @ 1L/ha and Fast-tac Duo ® @ 150ml/ha. In-crop herbicides included Atrazine 900WG @ 1.1kg/ha, Lorsban @ 1L/ha and Venom @ 200ml/ha. Phase 2 was sown to Lancer wheat at 80kg/ha with MAP & impact @ 40kg/ha, following pre-emergent applications of Sakura ® @ 118g/ha, Avadex Xtra ® @ 2L/ha, Lorsban ® @ 1L/ha and Fast-tac Duo ® @ 150ml/ha.

From late June to mid-July each year, large weaner ewes grazed in treatment 3 (winter and stubble graze - WGSG). The amount of plant dry matter was assessed pre and post grazing. In 2016, the wheat treatment was grazed between Z29-31 and the canola between 6 leaf and bud emerged on wet soil (not saturated) for the equivalent of between 500-700 DSE/ha/days (7-8 sheep for 15-21 hours).

In 2016 in phase 1, Prosaro® was applied at 450ml/ha with Transform® @ 100ml/ha at 20% flowering with a 2nd application of Prosaro® @ 450ml/ha on the 20th September. In phase 2, broadleaf weeds were sprayed with a mix of Paridgm® @ 25ml/ha, Ally® @ 5g/ha, MCPA lve @ 500ml/ha and Lontrel Advance® @ 75ml/ha after grazing. Prosaro® was sprayed @ 300ml/ha with Transform® @ 100ml/ha on the 23rd August. Nitrogen was top-dressed on both phase 1 and 2 as urea at 100kg/ha on the 29th June and 120kg/ha on the 29th July.

Grain yields were measured using a plot header harvesting only the inside 4 rows only of each seeder run to remove edge effects from rows adjacent to tram tracks. Grain yields were also measured by hand harvesting large areas (>1.0 $m^2$) of crop and threshing which also allowed total dry matter production, harvest index and amount of the residue returned to plots to be calculated. Grain protein, moisture and test-weight were estimated from NIR, and screenings as per receival protocols. Binned grades were determined from quality parameters, and prices determined using 2016 grain prices for the day of harvest. Inputs and non-tonnage dependent operations in all treatments were identical, therefore only gross income is calculated in the economic analysis.

Following harvest in each year (late November-early January), large weaner ewes grazed the stubble residues in both treatments 2 and 3 (SG and WGSG treatments) for an average period of 2263 DSE/ha/days. In 2016-17, four medium sized weaners (55kg) grazed the canola stubble and five weaners grazed the wheat stubble for 4.5days (2000-2500 DSE/ha/days). The amount of stubble present in plots was measured before and after grazing to calculate how much sheep had consumed. Stubble was analysed for feed quality (metabolisable energy), and the number of grazing days was calculated based on one dry sheep equivalent (DSE) consuming 7.6 MJ of energy per day. Grazing value was priced assuming an agistment rate of $0.4/DSE/week. Sheep were not removed from the plots if it rained during grazing.

The stubble burn treatments were applied in mid-to late-March of each year. Summer weeds that emerged at the site were promptly controlled with herbicides.

## Results 2016

In 2016 there was 103mm of summer rainfall (Dec 2015-March 2016), 591mm growing season rainfall (April-Oct inclusive) and a total annual rainfall of 704mm. Between the 30th April and the 9th May, 65mm of rain fell resulting in an even germination and good incorporation of the pre-emergent herbicides. In May 2016, the average canola plant population was 34 plants/m2 across all treatments with fewer plants established using the disc opener and where the stubble was burnt (Table 1). The reduction in canola emergence in the disc and burn treatments may have been due a combination of herbicide damage, Dual Gold ® washing into the sown row in treatments where there was little or no stubble. There was also some effect from insects in the burn treatments, primarily from pasture cockchafers and bronze field beetles. However, in all treatments there were sufficient plant numbers for maximum grain yield.

| Opener | Canola emergence (plants/m2) | Stubble treatment | Canola emergence (plants/m2) |
|---|---|---|---|
| **Disc** | 30 | **Burn** | 29 |
| **Knife** | 38 | **Retain** | 39 |
| **Spear** | 34 | | |
| **LSD (p=0.05)** | **5** | | **6.5** |

*Table 1: Canola plant populations ($m^2$) across all grazing treatments for each opener type and for each stubble type in May 2016.*

There was no effect of grazing and stubble on wheat emergence in May 2016 (mean population 143 plants/m2). However, there were more plants emerged with the disc seeder (Table 2), but with slower emergence and reduced early vigour (data not shown).

| Opener | Wheat emergence (plants/m2) |
|---|---|
| **Disc** | 154 |
| **Knife** | 136 |
| **Spear** | 139 |
| **LSD (p=0.05)** | **8.1** |

*Table 2: Wheat plant populations ($m^2$) across all grazing treatments for each opener type in May 2016.*

The treatments influenced soil mineral nitrogen (kgN/ha) in both phase 1 and 2 in March 2016. The NG treatment had less mineral N (phase 1 @ 90 kg/ha or phase 2 @ 87 kg/ha) compared to either the SG or WGSG treatments @ 120 to 144kgN/ha (Table 3). Thus retaining stubble reduced Min-N available at sowing by 30-50 kg/ha.

<table>
<tr><th>Graze treatment</th><th>Stubble treatment</th><th colspan="2">Phase 1- Canola 2016<br>Soil mineral N<br>(kg/ha) Graze x stubble<br>Graze treat</th><th colspan="2">Phase 2- Wheat 2016<br>Soil mineral N<br>(kg/ha) Graze x stubble<br>Graze treat</th></tr>
<tr><td rowspan="2">Nil graze (NG)</td><td>Retain</td><td>96</td><td>90</td><td>75</td><td>87</td></tr>
<tr><td>Burn</td><td>83</td><td></td><td>100</td><td></td></tr>
<tr><td rowspan="2">Stubble graze (SG)</td><td>Retain</td><td>104</td><td>120</td><td>125</td><td>134</td></tr>
<tr><td>Burn</td><td>136</td><td></td><td>144</td><td></td></tr>
<tr><td>Winter & Stubble</td><td>Retain</td><td>149</td><td>144</td><td>130</td><td>132</td></tr>
<tr><td>(WGSG)</td><td>Burn</td><td>139</td><td></td><td>134</td><td></td></tr>
<tr><td>LSD (p=0.05)</td><td></td><td>No interaction</td><td>26</td><td>No interaction</td><td>26</td></tr>
</table>

*Table 3: Soil mineral N (kgN/ha) in phase 1 (canola) and phase 2 (wheat) between 0-175cm in March 2016.*

By the 14th July, across all treatments, there was approximately 1.1t/ha of wheat or canola DM. The sheep in the WGSG treatments removed between 450 to 500kg/ha of plant dry matter in both phases 1 and 2 (canola and wheat), but grazed the disc treatment more heavily in phase 1. The sheep had also removed approx. 20% of the buds from the canola plants and had trampled both the wheat and canola plots (Figure 1).


*Figure 1: Pre and post winter graze in phase 2 in July 2016.*

At anthesis in phase 1, the average canola DM yield was 5.1t/ha. There was no significant difference in canola plant DM between grazing treatments except in the WGSG disc treatment which had reduced biomass (3.8t/ha cf 5t/ha; data not shown). In phase 2, there was no difference in wheat DM between openers, but wheat DM was reduced in both the NG stubble retain and SG stubble retain treatments and increased in the WGSG treatment compared to the NG stubble burn treatments (Table 4).

There was no difference in canola grain yield, oil content or gross income between any of the treatments (Table 5) or between opener types (Table 7).

| **Graze Treatment** | **Stubble Treatment** | |
|---|---|---|
| | Burn | Retain |
| **Nil graze (NG)** | 9.0 | 7.9 |
| **Stubble graze (SG)** | 9.3 | 8.3 |
| **Winter and stubble graze (WGSG)** | 9.9 | 10.2 |
| **LSD (P=0.05)** | 0.85 | |

*Table 4: Wheat dry matter (t/ha) at anthesis (28th September - 5th October) in the graze and stubble treatments in phase 2 across all opener types.*

| **Graze treatment** | **Stubble treatment** | **Grain yield (t/ha)** | **Oil (%)** | **Gross Income ($/ha)** |
|---|---|---|---|---|
| **Nil graze (NG)** | Retain | 3.2 | 49.1 | $1775 |
| | Burn | 3.3 | 49.2 | $1805 |
| **Stubble graze (SG)** | Retain | 3.4 | 48.7 | $1873 |
| | Burn | 3.1 | 49.0 | $1708 |
| **Winter & Stubble graze (WGSG)** | Retain | 3.4 | 49.1 | $1865 |
| | Burn | 3.1 | 49.0 | $1694 |
| **LSD (p=0.05)** | | ns | ns | ns |

*Table 5: Canola grain yield, oil % and gross income from phase 1 in 2016.*

However, where the 2nd wheat crop was sown in phase 2 in 2016, there was significantly more wheat grain yield in both the NG burn and the SG burn treatments compared to all other treatments which translated to higher gross incomes (Table 6). The average wheat grain protein concentration across the entire experiment was 8.5% with no significant difference between openers, however, the protein concentration in the WGSG treatment was significantly lower than the NG and SG burn treatments (Table 7). Wheat protein concentrations in all treatments were low, indicating that the crop was nitrogen limited in this wet year. The wheat grain yield was slightly higher when sown with the knife opener compared to the disc (Table 7).

| Graze treatment | Stubble treatment | Grain yield (t/ha) | Protein (%) | Gross Income ($/ha) |
|---|---|---|---|---|
| Nil graze (NG) | Retain | 5.3 | 8.7 | $899 |
| | Burn | 5.8 | 8.7 | $980 |
| Stubble graze (SG) | Retain | 5.5 | 8.5 | $934 |
| | Burn | 6.0 | 8.6 | $1024 |
| Winter & Stubble graze (WGSG) | Retain | 5.3 | 8.4 | $891 |
| | Burn | 5.2 | 8.3 | $876 |
| LSD (p=0.05) | | 0.3 | 0.26 | $49 |

*Table 6: Wheat grain yield, protein % and n the wheat in phase 2 in 2016.*

| Opener | Wheat Grain Yield (t/ha) | Canola Grain Yield (t/ha) | Wheat Gross Income ($/ha) | Canola Gross Income ($/ha) |
|---|---|---|---|---|
| Disc | 5.4 | 3.1 | $916 | $1721 |
| Knife | 5.6 | 3.2 | $951 | $1762 |
| Spear | 5.5 | 3.4 | $934 | $1876 |
| LSD (p=0.05) | 0.14 | ns | $23 | ns |

*Table 7: Grain Yield and Gross Income across all treatments by opener type in 2016*

## Results for 2010-2016

Across the seven years of the experiment in both phases, there has been a significant decrease in wheat grain yield (~0.5 t/ha) when stubble was retained rather than burnt in the nil graze treatments. (Tables 8 and 9). In 2012, 2015 and 2016, this resulted in a 0.5t/ha reduction in grain yield and was associated with lower soil N concentrations and presumably increased N tie-up by the retained stubble (Table 8). The soil mineral N concentration was always 15 to 20 kgN/ha lower in March of each year in the NG stubble retain compared to the NG stubble burn treatment (data not shown). The combined effect of lower soil mineral N concentrations and lower air temperatures (i.e. frost) in 2013 in NG stubble retained treatment resulted in a 1.6t/ha decrease in wheat grain yield in phase 2 compared to the NG stubble burn treatments (Table 9). The 0.6t/ha decrease in grain yield in the SG stubble retain compared to the SG stubble burn treatment was also due to frost (Table 9).

| Graze treatment | Stubble treatment | Canola 2010 | Wheat 2011 | Wheat 2012 | Canola 2013 | Wheat 2014 | Wheat 2015 | Canola 2016 |
|---|---|---|---|---|---|---|---|---|
| NG | Retain | **4.2** | 4.6 | 4.4 | **0.7** | 3.8 | 4.1 | **3.2** |
| | Burn | **4.0** | 4.6 | 5.0 | **1.0** | 3.8 | 4.6 | **3.2** |
| SG | Retain | **4.3** | 4.5 | 4.8 | **0.9** | 3.7 | 5.3 | **3.3** |
| | Burn | **4.2** | 4.6 | 4.7 | **1.1** | 3.8 | 5.2 | **3.3** |
| WGSG | Retain | **3.9** | 5.2 | 4.5 | **0.7** | 3.4 | 3.6 | **3.1** |
| | Burn | **4.1** | 5.3 | 4.9 | **0.7** | 3.2 | 3.9 | **3.2** |

*Table 8: Grain yield between 2010 and 2016 in Phase 1 sown with knife point.*

| Graze treatment | Stubble treatment | Canola 2010 | Wheat 2011 | Wheat 2012 | Canola 2013 | Wheat 2014 | Wheat 2015 | Canola 2016 |
|---|---|---|---|---|---|---|---|---|
| NG | Retain | **6.3** | 3.4 | 4.5 | **2.0** | 2.0 | 5.5 | **5.2** |
| | Burn | **6.2** | 3.5 | 4.8 | **3.4** | 2.0 | 5.3 | **5.7** |
| SG | Retain | **6.2** | 3.3 | 4.8 | **3.0** | 2.2 | 5.6 | **5.3** |
| | Burn | **6.4** | 3.3 | 4.9 | **3.6** | 2.0 | 5.7 | **6.1** |
| WGSG | Retain | **6.5** | 3.1 | 4.7 | **2.4** | 1.5 | 3.9 | **5.1** |
| | Burn | **6.5** | 3.1 | 4.7 | **2.7** | 1.7 | 3.8 | **5.0** |

*Table 9: Grain yield between 2010 and 2016 in Phase 2 sown with knife point.*

In most cases, (2012, 2013, 2015), the wheat grain yield in the 2nd wheat crop in the SG stubble retain treatment has been significantly higher than in the NG stubble retain treatment (Tables 8 and 9). Grazing stubble increased the soil mineral N available prior to sowing and in 2015 phase 1, it was almost doubled. This result was verified by surface N measurements taken immediately before and immediately after stubble grazing, which showed that mineral N in the SG stubble retain treatment was twice that in the NG stubble retain treatment, an effect that persisted through the summer fallow.

## Gross Incomes

Averaged across both phases for the seven years of this experiment, grazing and then retaining the stubble generated the highest gross income (Table 10). If the grazing was valued assuming one dry sheep equivalent (DSE) consumed 7.6 MJ of energy per day at an agistment rate of $0.4/DSE/week, the grazing value of the stubble was $117/ha/year with an additional increase of $55/ha/year due to higher yields and higher N availability.

| Graze treatment | Stubble treatment | Assuming grazed stubble has no value | Assuming grazed stubble has a value* |
|---|---|---|---|
| **Nil graze** | Retain | $1,231 | $1231 |
| | Burn | $1,269 | $1269 |
| **Stubble graze** | Retain | $1,286 | $1403 |
| | Burn | $1,277 | $1397 |
| **Winter Graze** | Retain | $1170 | $1287 |
| | Burn | $1196 | $1313 |

*Table 10: Gross income per year averaged across both phases for all years (2010-2016) of the experiment*

**Grazing value of the summer stubble only in both SG and WGSG treatments. No grazing value was calculated for the grazing in winter.*

## Conclusion

In 2016, the average canola grain yield was 3.1t/ha with an oil content of 49% and a gross income of $1787, with no significant difference between treatments or openers. In 2016, wheat grain yield and gross income was higher in both the nil graze and stubble graze treatments where stubble was burnt than where stubble was retained.