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FarmLink Research Report 2015

The effect of grazing and burning stubbles on grain yield and quality in no-till and zero-till controlled traffic farming systems in SNSW

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Project Partners

FarmLink · CSIRO

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GRDC Grains Research & Development Corporation

Trial Site Location

5 km SSE of Temora

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Introduction

Keywords: stubble retention, sheep, livestock, N cycling

Take home messages

- Grazing stubbles with sheep speeds up N cycling and reduces N tie-up by the stubble. When yield is N limited, this increases grain yield and quality.
- Burning stubble decreased the amount of water stored over the summer fallow and the crops used by 8 to 21 mm, but this did not always decrease yield due to frost damage, N limitation or adequate subsequent recharge.
- Over the six year experiment, grazing and then retaining (not burning) stubble has been the most profitable treatment.

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 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 production allow paddocks to be spelled from crop production, increase soil nitrogen and reduce crop weeds and diseases. The presence of both livestock and crops also diversifies the 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, remove residue cover and trample soils, but there is little contemporary research evidence to support this view. We report results from a long-term experiment designed to test whether sheep grazing in no-till and zero-till farming systems damage soil and reduce 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). In this paper we present results from the experiment for the years 2013-2015 where we expanded the experiment to compare a disc opener against two tine openers, and include a summary of gross income from 2010-2015.

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 two stubble grazing treatments;

1. Nil graze
2. Stubble graze

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

i. Stubble retention
ii. Stubble burn

In 2013 these treatments were 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 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. Both tine openers were attached to FlexiCoil 250 kg break-out tines on a linkage mounted plot-seeder on 305 mm row spacing, 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 and followed a canola-wheat-wheat rotation. Following harvest in each year (late November-early December), large weaner ewes grazed stubbles in treatment 2. 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 herbicide.

Gravimetric soil water content and mineral N were measured from intact soil cores taken to 1.8 m in the knife point plots only in late March-early April. Soil water was measured prior to sowing and at harvest using a neutron moisture meter (NMM) (10 to 160 cm depth).

Grain yields was 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 2014 grain prices delivered Temora (Table 1). Inputs and non-tonnage dependent operations in all treatments were identical, therefore only gross income is calculated in the economic analysis.

Binned grade	Price ($/t)
APH2	$307
H1	$292
H2	$286
AUH2	$268
APW	$267
HPS1	$258
ASW	$256
AGP	$250
SFW1	$237
CSO1-A	$426

Table 1. Grain prices used for calculating gross income for different treatments.

Results

2013

In 2013 there was 135 mm of summer fallow rainfall and 227 mm growing season rainfall. At the start of the growing season, there was no difference in mineral N between any of the stubble management treatments. Retained stubble treatments had an additional 21 mm of water compared to burning in Phase 2 (P=0.035) and there was no effect of grazing. In Phase 1 neither effect was significant.

All treatments were dry-sown between 24 April and 1 May, Phase 1 was sown to Hyola 575 canola and Phase 2 to Gauntlet wheat. Rain that germinated seed fell on 8 May. Phase 1 was top-dressed with 90 kg/ha ammonium sulfate and 160 kg/ha urea, Phase 2 was top-dressed with 160 kg/ha urea. Yield results were influenced by severe frosts on 15, 16 and 18 October during which screen temperature fell to -2.6°C, -1.8°C and -3.6°C respectively. In both phases of the experiment, treatments in which stubble was burnt suffered less frost damage and this translated into higher yields (Table 2). In both phases, treatments in which stubble was grazed yielded more than where it was not grazed, and this effect was greater in the unburnt treatments but still significant in the burnt treatments.

	2013 wheat yield (t/ha)		2013 canola yield (t/ha)	
	Burn	Retain	Burn	Retain
Treatment	(30% frost damage)	(59% frost damage)	(43% frost damage)	(59% frost damage)
Nil graze	3.3	2.2	1.0	0.7
Stubble graze	3.6	3.0	1.1	0.9
P value	<0.001		0.014	
LSD (P<0.05)	0.2		0.1	

Table 2. Grain yield and frost damage for the different grazing and stubble treatments in Phase 1 and Phase 2 in 2013.

There was a significant main effect of opener type in both Phase 1 (canola) and Phase 2 (wheat) with the single disc yielding more than the spear point which yielded more than the knife point (Table 3).

	Grain yield (t/ha)	
Opener type	Phase 1 (canola)	(Phase 2 wheat)
Single disc	1.05	3.1
Spear point	0.93	2.9
Knife point	0.85	2.8
P-value	<0.001	<0.001
LSD (P=0.05)	0.07	0.12

Table 3. Grain yields for different opener types averaged across all stubble treatments in Phase 1 (canola) and Phase 2 (wheat) in 2013.

There was a significant interaction between opener type and grazing on canola oil content in Phase 1 (Table 4).

	Canola oil %		
	Opener type		
Grazing	**Disc**	**Spear**	**Knife**
Nil graze	42.5	40.6	42.0
Stubble graze	42.2	40.0	41.0
P-value	0.005		
LSD	1.1		

Table 4. Canola oil content for different opener types and grazing treatments in Phase 1 in 2013.

In Phase 2 wheat protein content reflected yield results according to protein dilution and ranged from 12.4% in highest yielding treatments to 14.6% in lowest yielding treatments. There was no significant effect of any treatment on test weight (mean 77.4 kg/hL) or screenings (mean 14.4%).

2014

In 2014 there was 158 mm summer fallow rainfall and 238 mm growing season rainfall. There was no effect of grazing on stored soil water, but burning stubble decreased the amount of soil water the crop used by 14 mm in Phase 1 (P<0.001) and 13 mm in Phase 2 (P=0.002). Grazing stubble increased the amount of mineral N available prior to sowing in Phase 2 (Table 5), particularly when stubbles were not burnt, but there were no significant effects in Phase 1 (mean value 127 kg/ha).

Graze	Burn	Retain
Nil graze	137	104
Stubble graze	150	155
P-value	<0.001	
LSD	10	

Table 5. Soil mineral N measured to 1.75 m depth in Phase 2 of the experiment in 2014

All treatments were sown into a moist seed bed on 1 & 2 May 2014. Phase 1 was sown to Lancer wheat and Phase 2 to Stingray canola. Both phases were top-dressed with 160 kg/ha urea on 23 July 2014. Due to a malfunction in the metering system of the disc seeder, crop establishment was not uniform across the opener treatments. In Phase 1 there were only 30 plants/m^2 of wheat in the disc treatment vs 125 and 129 plants/m^2 in the knife and spear point treatments respectively (P<0.001, LSD=7). In Phase 2 there were only 8 plants/m^2 of canola in the disc treatment vs 36 and 32 plants/m^2 in the knife and spear points respectively (P<0.001, LSD=4). Consequently, the disc treatment was excluded from all further analyses in 2014. All treatments suffered damage from stem frost in July and August but there was no effect of any treatment on extent of damage.

In Phase 1 machine harvest there was no significant effect of stubble treatment (either grazing or burning) or interaction with opener type on grain yield (mean yield 3.7 t/ha). However, based on hand harvests, burning stubble reduced yield from 4.4 t/ha to 4.0 t/ha (P=0.029) which reflects the observed difference in water use. Grazing stubble increased protein from 13.8 to 14.7% (P=0.016) and increased screenings from 4.3 to 6.0 % (P=0.006) but there was no effect of burning or opener type.

In Phase 2 burning stubble decreased canola yield from 2.1 to 2.0 t/ha (P=0.022) and there were no effects of grazing or opener type. Burning stubble and grazing stubble also decreased canola oil from 43.1 to 42.4 % (P<0.001).

2015

In 2015 there was 221 mm of summer fallow rainfall and 360 mm growing season rainfall. In phase 1 (wheat stubble) grazing decreased the amount of water stored during the summer fallow by 6 mm (P=0.006) and burning by 8 mm (<0.001) but there was no interaction between the two. However, despite having accumulated more soil water during the summer fallow, there was no significant effect on soil water use during the growing season. In Phase 2 (canola stubble) burning reduced the amount of water stored during the summer fallow by 20 mm, but there were no differences in seasonal water use.

Grazing stubble almost doubled the amount of mineral N available prior to sowing (Table 6) in Phase 1. This result was verified by surface N measurements taken immediately before and immediately after stubble grazing, which showed that mineral N in the Stubble Graze Stubble Retain treatment was twice that in the Nil Graze Stubble Retain treatment. When stubble was retained, burning increased the amount of soil mineral N available by 15 kg/ha. There were no significant effects of grazing or burning in Phase 2 (mean 157 kg/ha N).

Both phases were sown to Lancer wheat into a moist seed bed on 24 April 2015. In Phase 1 stubble grazing reduced plant establishment from 124 to 114 plants/m^2 (P=0.011) and plant density was also slightly lower in the disc (98 plants/m^2) in comparison to the knife point (126 plants/m^2) and spear point (134 plants/m^2, P=<0.001, LSD=9). In Phase 2 plant density was also lower in the disc treatment (99 plants/m^2) compared to the knife point (137 plants/m^2) and spear point (130 plants/m^2, P<0.001, LSD=10)

Most treatments in both phases had sufficient soil mineral N (allowing for in-season mineralisation of 40 kg/ha N) to achieve district average yield of 4 t/ha (Table 6), and given the El Nino that was in place during winter and associated dry spring forecast, neither phase was top-dressed. As a result, in Phase 1 grain yield and protein was driven by soil mineral N availability in the different treatments (Table 6) and grazing stubble increased both yield and protein. Likewise in Phase 2 grazing stubble increased yield from 5.1 to 5.4 t/ha (P=0.009) and protein from 8.9% to 9.4% (P=0.007) and burning had no significant effect. Opener type had no significant effect in Phase 1, but the disc yielded less (4.8 t/ha) than the knife point (5.5 t/ha) and spear point (5.4 t/ha, P<0.001, LSD=0.1).

Graze treatment	Stubble treatment	Soil mineral N to 1.75 m (kg/ha)	Grain yield (t/ha)	Grain protein (%)
Nil graze	Retain	77	4.0	8.7
	Burn	92	4.5	7.9
Stubble graze	Retain	151	5.2	9.2
	Burn	146	5.1	9.1
P-value		<0.001	0.005	0.006
LSD (p=0.05)		4	0.2	0.3

Table 6. Soil water depletion, soil mineral N to 1.75 m, grain yield and protein for Phase 1 in 2015.

Gross Income

Averaged across both phases for the six years of this experiment, the grazing and then retaining (not burning) stubble treatment has the highest gross income (Table 7). Even if no value is placed on grazed stubble, the stubble-graze stubble-retain treatment still grossed $45/ha per year more than the nil graze stubble retain treatment. Assuming the grazed stubble is valued as outlined in the methods section (averages $133/ha across both phases in all seasons), this economic advantage increases to $178/ha.

Graze treatment	Stubble treatment	Gross income ($/ha/year)	
		Assuming grazed stubble has no value	Assuming grazed stubble has value as per methods
Nil graze	Retain	$1,153	$1,153
	Burn	$1,179	$1,179
Stubble graze	Retain	$1,197	$1,312
	Burn	$1,193	$1,307

Table 7. Gross income per year averaged across both phases for all years (2010-2015) of the experiment

Conclusion

Over the six years that this experiment has been running, grazing and retaining (not burning) stubble has been the most profitable treatment. This is partly due to the grazing value of the stubble ($133/ha) and partly due to higher yields in that treatment which have largely been due to higher N availability. Since 2013 the graze and retain treatment has consistently delivered higher yields, whilst burning has only been of benefit due to frosts in 2013 and the wet growing season of 2015.

Based on these results, mixed farmers can safely continue grazing stubbles provided they control all weeds with herbicides promptly, and don't graze below 70% cover. N fertiliser inputs may be able to be reduced, and grain yields increased if measures are taken to ensure that stubbles are grazed thoroughly and evenly down to threshold levels e.g. strip grazing with electric fences etc.

In this experiment where in-crop weed populations are low, there has been no consistent advantage of either the disc or tine openers (with or without grazing). This will continue to be monitored over the next few years.

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