GRAZING SHEEP ON STUBBLES – CONDOBOLIN RESULTS 2009-10

Neil Fettell[1,2] and Ian Menz[1]
[1]Industry & Investment NSW, Condobolin Agricultural Research & Advisory Station, PO Box 300, Condobolin NSW 2877
[2]Agronomy and Soil Science, University of New England, Armidale NSW 2351

Key words
Grazing, stubble, soil water, infiltration, yield

Take home messages

- Grazing livestock can compact surface soil and reduce infiltration rates, but their biggest impact on fallow efficiency is through stubble removal.
- Stubble improves summer fallow efficiency primarily by increasing infiltration; it slows but does not stop evaporation, and this is only beneficial where rainfall events occur close together or if it aids crop establishment.
- Despite high rainfall during the 2009-10 fallow period at Condobolin, there was little response in soil water storage to the grazing and stubble treatments.
- Wheat yield in 2010 was reduced by very heavy grazing but not by moderate (more typical) grazing.

Background

Crop yields can be increased in low rainfall areas if more 'out of season' (fallow) rainfall is stored prior to seeding. No-till, controlled traffic systems are expected to improve water storage by increasing infiltration, reducing run-off and slowing evaporation. However, for mixed farmers, grazing crop stubbles can add to animal production and with the current high prices for lamb and mutton, livestock can be a major contributor to farm income. Grazing can also assist with summer weed control, which can be difficult and costly with herbicides when weeds are under water stress. In more intensive systems, grazing of winter crops is also economically attractive. Therefore, a key management decision for mixed farmers is whether to graze crops and crop stubbles and if so for how long and how intensively.

Past research has shown that stock apply similar pressures on the soil to unloaded vehicles. Treading by livestock can reduce soil porosity and infiltration rate, and increase soil bulk density and soil strength, although these effects are mainly in the soil surface (top 5-10 cm). Despite these effects, rarely have reductions in crop performance following grazing been reported in the literature, possibly because effects are too small in magnitude or depth to influence plant growth significantly. The risk of compaction can be reduced by removing stock during wet conditions and maintaining soil organic matter. Because compaction from livestock is shallow it may not be long-lasting and can be rectified by natural processes or tillage. However, tillage operations on soils compacted by livestock may require extra draught, which will increase fuel consumption.

A field trial have been established at Condobolin as part of the GRDC-supported Water Use Efficiency initiative to measure the impact of grazing within cropping systems on soil properties, water dynamics and crop yield.

Condobolin Trial

Methods

Eight treatments were imposed after the 2009 harvest on a paddock which carried just under 3 t/ha of wheat stubble. The soil is a typical clay loam and the site is relatively flat. There are eight treatments, each replicated four times, and the variables are;

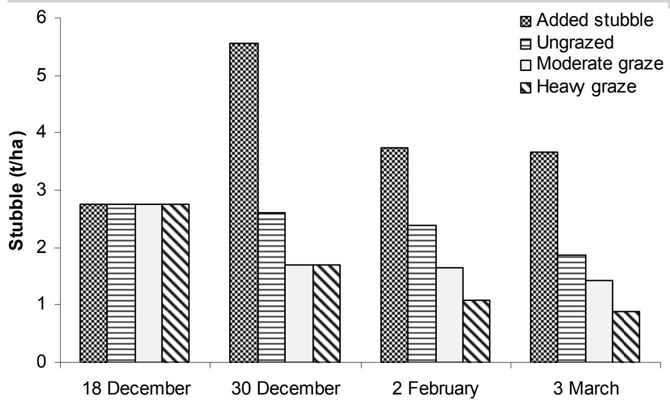
1. Grazing intensity, using adult sheep (nil, moderate, or heavy)
2. Stubble amount (as is, or added or removed depending on the season)
3. Weed control (all herbicide, or partly reliant on grazing).

Plots are relatively large and individually fenced. Fences are removed prior to seeding and all operations are conducted using commercial equipment and +/- 2 cm GPS guidance and controlled traffic. Treatments will be imposed on the same plots over four seasons. Regular measurements include stubble cover, soil water to 1.4 m (64 neutron tubes), infiltration capacity (drip infiltrometer), bulk density, soil strength, soil mineral nitrogen and crop growth and yield.

Results to date

Initial grazing treatments were imposed in December 2009, prior to any rain. Subsequent summer rainfall was well above average, and reduced the palatability and feed value of stubble after the first grazing. Weeds were controlled by herbicides in all treatments, following district practice in 2009-10. The amount of stubble remaining on the soil surface at each measurement date is shown in Figure 1. Additional stubble was added to one treatment to give over 5 t/ha. In the ungrazed plots, stubble levels declined slowly as a result of rainfall and subsequent breakdown, reaching 1.9 t/ha in early March. Grazing reduced stubble levels to 1.7 t/ha at the end of December and to 1.4 t/ha in March with moderate grazing and 0.9 t/ha for heavy grazing. The sheep flattened the remaining stubble and loosened the soil surface.

Figure 1. Changes in stubble cover during the 2009-10 summer at Condobolin



Soil water has been measured regularly using a neutron moisture meter and Table 1 shows the amount of water stored over the fallow period for each treatment. Rainfall over this period totalled almost 350 mm, well above average, resulting in significant water storage. While storage under the high stubble, ungrazed treatment appeared higher, none of the treatment differences were significant. Fallow efficiency averaged 36%, above common values, and likely a result of the rainfall being received in large falls. It is also possible that some water moved below the root zone as the 130-140 cm depth was close to the drained upper limit for an extended period. If so, this would have minimised treatment differences in soil water storage.

Table 1. Fallow water storage to 140 cm depth and grain yield responses to stubble level and grazing at Condobolin, 2009-2010

Treatment	Available water	Yield
	4 May 2010 (mm)	(t/ha)
Ungrazed, (2.6 t/ha stubble)	127	4.62
Ungrazed, (5.6 t/ha stubble)	135	4.72
Moderate graze (1.7 t/ha stubble)	123	4.69
Heavy graze (1.0 t/ha stubble)	122	4.40
LSD (P=0.05)	NS	0.16

The site was sown to Livingston wheat using a tined seeder with presswheels, and crop growth, water use and grain yield were measured. There was no yield difference between the two ungrazed stubble levels or from light grazing, where yield averaged 4.67 t/ha (Table 1). However, the heavily grazed treatment was significantly lower yielding at 4.40 t/ha. It also had a lower biomass but ear numbers and harvest index values were similar. The reason for the yield depression is not readily apparent. Crop establishment was similar (86 plants/m^2) for all treatments as was crop water use. Soil tests and grain protein measurements will be examined for possible nutritional effects.

Conclusions

These results support earlier research findings that light-moderate grazing of stubble by sheep is unlikely to be detrimental. Stubble can be beneficial for water storage, particularly where summer rainfall intensity is high, unstable soil surface structure results in low infiltration rates, and slopes are sufficient to encourage run-off. The minimum amount of cereal stubble required to minimise run-off (and hence water erosion) is thought to be around 2 t/ha or 70% cover. The moderate graze treatments in this trials had close to this level, whereas heavy grazing reduced the level to less than 1 t/ha for much of the fallow period. Stubble grazing should be managed to retain at least 2 t/ha of stubble, and can provide useful feed to stock while maintaining fallow efficiency and subsequent crop yields.

Acknowledgements
Assistance from the staff of the Research Station and from James Hunt and Tony Swan of CSIRO is gratefully acknowledged.

Management Practice

SOIL COMPACTION TRIALS

Cathy Paterson and Wade Shepperd
SARDI, Minnipa Agricultural Centre

Key message

- Compacted layers exist in EP soils, but there is no economic advantage in mechanically intervening.
- Any benefit from deep ripping alone is most likely for 2 years.
- Deep ripping is a high risk option in below average years.
- Sandy soils are more responsive to deep ripping.

Why do the trial?

During the 2003 EPFS farmer meetings, 14 groups nominated soil compaction as an issue which needed further research. Consequently, the EPFS project supported farmers from Buckleboo, Ceduna, Streaky Bay, Piednippie and Koongawa to set up or monitor their own deep ripping demonstrations so they could investigate whether soil compaction was causing them production losses (EPFS Summary 2003, p. 121). In addition, the project undertook a soil compaction survey across a range of soil types on upper Eyre Peninsula (EP) during 2004 (EPFS Summary 2005, p. 117). SAGIT funded this project to build on a soil compaction survey conducted in 2004 and to develop a more detailed understanding of soil types and management systems that have caused soil compaction on Eyre Peninsula.

The results from 2006 can be found in the EPFS Summary 2006 pp. 160-162 and the results from 2007 can be found in the EPFS Summary 2007 pp 159-161.

How was it done?

Three replicated trials were established in 2006 (Piednippie, Warramboo, Minnipa Agricultural Centre (MAC)) with a further 3 established in 2007 (Cummins, Wangary, Wharminda).

Treatments

In 2008, the treatments in the small plot experiments were:

- Control – district practice;
- Deep ripping prior to seeding in 2006 with a custom made ripper (Minnipa, Piednippie and Warramboo);
- Deep ripping prior to seeding in 2007 with a custom made ripper (all small plot sites);
- Deep ripping prior to seeding in 2008 with a custom made ripper (all sites)
- Deep working (up to 20 cm during the seeding pass with knife points);
- Rotational tillage (15 cm for Cummins, Wangary and Wharminda and 20 cm for Piednippie and Warramboo)

Site Details in 2008

Sites established in 2006

Warramboo - Sown 20 May with Clearfield Janz wheat and 18:20:00 fertiliser, both @ 60 kg/ha and Urea Zinc coat @ 16 kg/ha. Deep ripped to 45 cm.

Minnipa - Sown on 26 May with Yitpi wheat @ 60 kg/ha, fertiliser 18:20:00 @ 60 kg/ha. Deep ripped to 45 cm.

Piednippie - Sown 22 May with Gladius wheat and 18:20:00 fertiliser, both @ 60 kg/ha and Urea Zinc coat @ 16 kg/ha. Deep ripped to 25 cm.

Sites established in 2007

Cummins - Sown 21 May with Gladius wheat @ 80 kg/ha, fertiliser 18:20:00 @ 100 kg/ha. Deep ripped to 45 cm.

Wangary – Sown 21 May with Gladius wheat @ 80kg/ha and 20:10:00:12 fertiliser @ 150 kg/ha. Urea top dressed 25 July and 20 August @ 45 kg/ha. Deep ripped to 35 cm.

Wharminda - Sown 20 May with Gladius wheat and 18:20:00 fertiliser, both @ 65 kg/ha. Deep ripped to 35 cm.

Deep ripping was applied prior to seeding and deep working treatments were applied during the seeding pass.

Measurements included; plant establishment, dry matter - early and harvest, soil characteristics, soil profile description, soil constraints, yield, harvest index, and grain quality.

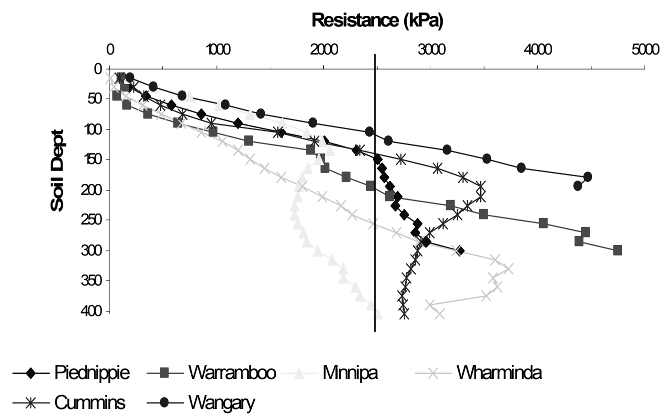
What happened?

In 2008 growing season rainfall was well below average for all sites, in addition to this strong wind events in the upper EP area after seeding caused damage to emerging crops.

Soil strength

Soil resistance of 2500 kPa at field capacity is the level at which plant root growth is restricted. All small plot trial sites reached soil resistances of more than 2500 kPa within 25 cm, whilst Minnipa reached this limit at a depth of 40 cm (Figure 1).

Figure 1 Soil resistance measurements taken at field capacity for all trial sites. Soil resistance over 2500 kPa will restrict growth of roots.



Soil Moisture

No soil moisture measurements at maturity were taken due to rainfall events in November and December.

Sites established in 2006

During the first year of the trial at *Warramboo* there were no differences between any treatments. In 2007 fresh deep ripping increased yield by over 50% compared to the district practice control. In 2008 fresh deep ripping and the 2007 deep ripping increased yield by 21%. There was no response to any other treatment (Table 1). The low plant populations were due to stock grazing this trial early.

Piednippie has shown no response to any treatments in either 2006 or 2007, but in 2008 fresh deep ripping increased yield by 17%. There was no response to any other treatment (Table 1).

The broad scale trial at *MAC* had poor emergence in the rotational and deep worked treatments because wheat seed fell down to the bottom of the workings and the soil developed large clods. There was a reduction in yield in the rotational (59%), deep worked (34%) and the fresh deep ripped (28%). The deep worked and the rotational treatments were downgraded to APW1 due to higher screenings. There was a 12.5% increase in the 2006 deep ripping treatment (Table 1).

Sites established in 2007

Cummins showed no yield response to any treatments applied in 2007. In 2008 there was a 16% increase in the 2007 deep ripping, while the rotational tillage and deep working caused a yield decrease of 6% and 2% respectively (Table 1). The high screenings and low test weight are a result of the dry spring.

Wharminda showed a 24% increase in yield to deep ripping in 2007, but there was no yield response in 2008. All treatments that involved deeper working, either pre-sowing or during sowing resulted in lower screenings and therefore a higher recieval grade (Table 1).

In 2007 deep ripping and deep working increased yield at *Wangary* by 41% and 28%. There was no response to any treatment in 2008 to any measurements taken.

Table 1 Summary of deep ripping trial results from all sites, 2008

Site	Treatment	Emergence (plants/m^2)	Test Weight (g/hL)	Screenings (%)	Protein (%)	Yield (t/ha)	Pay Grade
Warramboo	Control	67 a	80.73 a	2.58 a	11.96 b	0.43	H2
	Deep Ripped 06	77 a	79.93 a	2.94 a	12.45 ab	0.39	H2
	Deep Ripped 07	71 a	79.47 a	3.06 a	12.6 ab	0.52	H2
	Deep worked	72 a	80.36 a	3.34 a	12.03 ab	0.42	H2
	Rotational	62 a	80.46 a	3.14 a	12.3 ab	0.37	H2
	Deep Ripped 08	65 a	80.76 a	2.65 a	12.06 a	0.52	H2
LSD (P=0.05)		*19.41*	*1.13*	*0.88*	*0.61*	*0.09*	
Piednippie	Control	140 a	80.48 a	3.56 a	11.5 b	1.37	H2
	Deep Ripped 06	145a	80.87 a	3.61 a	11.43 b	1.38	APW1
	Deep Ripped 07	131	81.96 a	3.31 a	11.55 b	1.5b	H2
	Deep worked	142 a	81.01 a	3.74 a	11.43 b	1.43	APW1
	Rotational	132 a	81.06 a	3.7 a	11.47 b	1.35	APW1
	Deep Ripped 08	126 a	81.86 a	2.72 b	11.88 a	1.6	H2
LSD (P=0.05)		*21.95*	*1.91*	*0.49*	*0.28*	*0.16*	

MAC	Control	164 a	82	3	15.5	0.32	H1
	Deep ripped 06	164 a	82	2	14.93	0.36	H1
	Deep Ripped 08	158 a	82	3	15.7	0.23	H1
	Deep Worked	140 b	82	5	14.3	0.21	H1
	Rotational	127 b	80	7	14.17	0.13	AGP1
LSD (P=0.05)		*13.51*	*ns*	*3.38*	*0.59*	*0.06*	
Cummins	Control	180	67	22	17	1.99	FED1
	Deep ripped 07	173	68	22	17	2.31	AGP1
	Deep Ripped 08	176	66	22	17	2.03	FED1
	Deep Worked	176	66	22	17	1.87	FED1
	Rotational	178	68	22	17	1.95	FED1
LSD (P=0.05)		*ns*	*ns*	*ns*	*ns*	*0.35*	
Wharminda	Control	65 a	75.7 b	11.65 ab	11.73 a	0.38	FED1
	Deep ripped 07	71 a	78.45 a	9.06 a	10.76 a	0.43	AGP1
	Deep Ripped 08	69 a	78.38 a	9.78 ab	10.76 a	0.43	AGP1
	Deep Worked	83 a	76 ab	10.42 ab	11.58 a	0.45	AGP1
	Rotational	71 a	77.73 ab	9.12 b	11.13 a	0.42	AGP1
LSD (P=0.05)		*17.76*	*2.55*	*2.36*	*0.72*	*ns*	
Wangary	Control	146	66	6	13	2.76	FED1
	Deep ripped 07	161	67	6	13	2.76	FED1
	Deep Ripped 08	144	68	6	14	2.81	APG1
	Deep Worked	151	66	6	13	2.76	FED1
	Rotational	152	66	6	13	2.69	FED1
LSD (0.05)		*ns*	*ns*	*ns*	*ns*	*ns*	

What does this mean?

With the below average rainfall in 2008, crops growing with a compacted layer below the surface may not have been restricted with the amount of water they were able to extract. Modelling in WA has shown that in dry years there is no adverse effect from compacted layers due to little subsoil moisture being available for the crop. This is supported by trials in WA that have shown that in areas with less than 325 mm annual rainfall the response to deep ripping is inconsistent. The soil profile may not become wet at depth so even root systems restricted by compacted layers may have access to all available soil moisture.

There were no yield benefits from any treatments at Wangary and Wharminda, even though the deep ripping operation would have ameliorated the compacted layer. The deep working and the rotational working depth would have also disrupted the compacted layer at these sites.

Piednippie and Warramboo both showed a response to deep ripping operations performed in 2007 and 2008. Any benefits from deep ripping appear to only last for a maximum of two years as there was no response to the deep ripping operation from 2006.

The timing of deep ripping and deeper working is critical. If the soil is too dry (for heavy soils), as was the case at MAC, large clods will form and can adversely affect seeding. The reduced emergence rate at MAC would have contributed to the reduction in yield for both the rotational and deep worked treatments.

Deep ripping is a costly and time consuming exercise, so it is important that the benefits are large and long lasting. From the trial results over the last three years the sandy soils are more responsive to deep ripping. However, there is no economic incentive to change management practice to reduce the effect of compaction on these soil types because any benefits measured were below the cost of deep ripping.

Note that all the seasons over which this project has been conducted have had well below average rainfall. We would expect responses to deep ripping to be larger in higher rainfall years but these increases would have to be sufficiently large to cover the poor benefits in low rainfall years.

However, amelioration of compacted layers can occur naturally, albeit quite slowly, in our soils. No-till, high productivity and controlled traffic can enhance this rate of natural recovery. Our trials suggest that productivity may improve on many soils of the EP if these compacted layers are naturally ameliorated, even if the cost of mechanical intervention was not justified.

Acknowledgements

Thanks to Kay Brace, Trent Brace and the staff at MAC for all their technical assistance during the year. Thanks to Sam Doudle, Nigel Wilhelm, Neil Cordon and Brendan Frischke for their advice during the term of this project. Finally, but most importantly, a big thankyou to the Montgomerie, Puckridge, Veitch and Masters families and MAC and ABB staff for the provision of the trial sites during the last three years.

Clearfield – registered trade mark of BASF Corporation

Research Category: Searching for answers

Trial Information

Location
Cummins
Rainfall
Av Annual: 425 mm
Av GSR: 344 mm
2008 Total: 317.7 mm
2008 GSR: 217 mm
Yield
Potential: 2.1 t/ha(W)
Actual: 2.31 t/ha
Paddock History
2007: Wheat
2006: Wheat
2005: Canola
Soil Type
Sandy Clay Loam
Diseases
Nil
Plot size
20 m x 1.6 m x 4 reps
Yield Limiting Factors
Dry spring

Location
MAC
Minnipa Ag Bureau
Rainfall
Av Annual: 368 mm
Av GSR: 242 mm
2008 Total: 251.4 mm
2008 GSR: 139mm
Yield
Potential: 1.2 t/ha (W)
Actual: 0.36 t/ha
Paddock History
2007: Canola
2006: Wheat
2005: Wheat
Soil Type
Red calcareous sandy clay loam
Diseases
Nil
Plot size
350 m x 9 m x 3 reps
Yield Limiting Factors
Low soil moisture levels at sowing, wind damage, dry spring

Location
Piednippie, John & Ian Montgomerie
Group: Streaky Bay Ag Bureau
Rainfall
Av Annual: 368 mm
Av GSR: 280 mm
2008 Total: 308.5 mm
2008 GSR: 218 mm
Yield
Potential: 2.24 t/ha (W)
Actual: 1.6 t/ha
Paddock History
2007: Barley
2006: Barley
2005: Wheat
Soil Type
Sandy Loam/loamy sand/calcrete rock
Diseases
Rhizoctonia
Plot size
20 m x 1.6 m x 4 reps
Yield Limiting Factors
Rhizoctonia, dry spring, wind damage

Location
Warramboo, Trevor, Leon and Simon Veitch
Rainfall
Av Annual: 325 mm
Av GSR: 235 mm
2008 Total: 225.8 mm
2008 GSR: 144.7 mm
Yield
Potential: 1.1 t/ha (W)
Actual: 0.5 t/ha
Paddock History
2007: Wheat
2006: Wheat
2005: Wheat
Soil Type
Deep siliceous sand
Diseases
Rhizoctonia
Plot size
20 m x 1.6 m x 4 reps.
Yield Limiting Factors
Moisture stress, non-wetting sand, *Rhizoctonia*, accidental early grazing, galah damage, wind damage

Location
Wangary, Peter and Chris Puckridge
Rainfall
Av Annual: 500 mm
Av GSR: 380 mm
2008 Total: 448 mm
2008 GSR: 293 mm
Yield
Potential: 4.4 t/ha (W)
Actual: 2.8 t/ha
Paddock History
2007: Canola
2006: Wheat
2005: Canola
Soil Type
Sandy loam over buckshot
Diseases
Blackleg
Plot size
20 m x 1.6 m x 4 reps
Yield Limiting Factors
Dry spring, wind damage

Location
Wharminda, John Masters
Group: Wharminda Ag Bureau
Rainfall
Av Annual: 327 mm
Av GSR: 302 mm
2008 Total: 221.7 mm
2008 GSR: 145.4 mm
Yield
Potential: 1.2 t/ha (W)
Actual: 0.45 t/ha
Paddock History
2007: Wheat
2006: Grass free pasture
2005: Barley
Soil Type
Siliceous sand over clay
Diseases
Rhizoctonia
Plot size
20 m x 1.6 m x 4 reps
Yield Limiting Factors
Non-wetting sand, moisture stress, wind damage, Galah damage

For further information

Cathy Paterson
Research Officer,
SARDI, SA No-Till Farmers Association,
Minnipa Agricultural Centre
Ph: (08) 8680 5104

Wade Shepperd
Technical Officer,
SARDI, SA No-Till Farmers Association,
Minnipa Agricultural Centre
Ph: (08) 8680 5104

SARDI SOUTH AUSTRALIAN RESEARCH AND DEVELOPMENT INSTITUTE
SAGIT
GRDC Grains Research & Development Corporation