Sheep grazing on crop residues increase soil mineral N and grain N uptake in subsequent wheat crops

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7 December 2016
Acknowledgements

Funding
GRDC Water-use Efficiency Initiative
GRDC Stubble Initiative

Host farmers
Peter, Lynne & Jason Coleman

Co-authors
CSIRO - Tony Swan, John Kirkegaard, Laura Goward, Brad Rheinheimer, Mark Peoples

FarmLink - Tony Pratt, Kellie Jones, Paul Breust

Steering committee - Jason Coleman, Greg Condon, ChrisDuff, Derek Ingold, James Ingrey, Geoff Lane, John Pattison, Jamie Pursehouse, Michael Sinclair, Rob Taylor, Craig Warren
Grain Production in Australia

- Production (2014)
  - Wheat – 24 Mt
  - Barley – 8 Mt
  - Canola – 4 Mt
  - Pulses (chickpeas, lupins, lentils, field pea, faba bean) – 1 Mt
- Southern Australia
  - All crops grown during winter,
  - Land left fallow over summer
Australian grain production

Southern Australian mixed farming systems

• Many Australian grain farms are ‘mixed’ farms
  • Livestock enterprise (sheep)
  • Crop enterprise (wheat-based)
• Mixed farms are synergistic (pasture-crop N dynamics & business risk)
Adoption of conservation agriculture (no-till) and controlled traffic farming (CTF)

Conservation agriculture founded on three principals (FAO);

- Direct planting of crop seeds without tillage
- Maintenance of permanent soil cover especially by crop residues and cover crops
- Crop diversity

Llewellyn, RS, D'Emden, FH, Kuehne, G (2012)
Research question

Will the benefits of no-till and controlled traffic farming systems be fully realised while sheep are grazing paddocks?

- Removing cover
- Compacting soil
“Collective Inquiry”
Treatments & experimental design

- Grazing
  - Nil graze
  - Stubble graze
- Stubble retention
  - Burn
  - Retain
- Factorial randomised complete-block design in two phases

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<tbody>
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<td>Phase 1</td>
<td>Lucerne</td>
<td>Wheat</td>
<td>Canola</td>
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<td>Wheat</td>
<td>Canola</td>
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</table>
Seasonal pattern & application of treatments

- **Summer fallow**
  - Stubble burnt & soil N sampled
  - Planting
- **Growing season**
  - Harvest
  - Stubble grazed
Spraying on tramlines (CTF)
FarmLink & CSIRO Temora Stubble site 2013 – nil graze, nil burn
FarmLink & CSIRO Temora Stubble site 2013 – stubble graze, nil burn
FarmLink & Temora Stubble site 2013 – nil graze, stubble burn
Sheep grazing on crop residues do not reduce crop yields in no-till, controlled traffic farming systems in an equi-seasonal rainfall environment


- No negative effect of grazing on soil water balance provided 70% stubble cover maintained
- No negative effect of grazing on crop yield
Grazing increased soil mineral N (NO$_3$ + NH$_4$) prior to sowing

Main effect of grazing = 102 to 121 kg/ha mineral N

Soil mineral N to 1.75 m measured prior to sowing

<table>
<thead>
<tr>
<th>Phase year</th>
<th>Nil graze</th>
<th>Stubble graze</th>
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<tr>
<td>Phase 1 2011</td>
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<td>Phase 1 2015</td>
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<td>145</td>
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<tr>
<td>Phase 2 2012</td>
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<td>Phase 2 2013</td>
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<tr>
<td>Phase 2 2015</td>
<td>145</td>
<td>170</td>
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</tbody>
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P-value 0.018
LSD (P=0.05) 26
Wheat grain N uptake (kg/ha)
(main effect 85 to 92 kg/ha N)

<table>
<thead>
<tr>
<th>Phase year</th>
<th>Graze treatment</th>
<th>Stubble management</th>
<th>Stubble burn</th>
<th>Stubble retain</th>
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<tr>
<td>Phase 1 2011</td>
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<td>Stubble</td>
<td>107</td>
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P-value < 0.001
LSD (p=0.05) 8
Cumulative grain N uptake in Stubble Retain treatments
What happens to C in stubble when sheep eat it (assuming no weight gain)?

- **Stubble**
  - 40% C
  - 0.5% N
  - C:N ~80

- 4% methane
- 58% respired as CO₂
- 1% wool
- 37% faeces (C:N ratio ~24)
What happens to N in stubble when sheep eat it (assuming no weight gain)?

Stubble
40% C
0.5% N
C:N ~80

36% faeces
(C:N ratio ~24)

59% urine (urea)
<25% lost as ammonia

5% wool
C & N dynamics when stubble grazed

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<thead>
<tr>
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<th>Stubble retained</th>
<th>Stubble grazed</th>
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</thead>
<tbody>
<tr>
<td>Post harvest stubble mass</td>
<td>7 t/ha</td>
<td>7 t/ha</td>
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<tr>
<td>Amount of stubble consumed</td>
<td>-</td>
<td>3 t/ha</td>
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<tr>
<td>Amount of stubble remaining</td>
<td>7 t/ha</td>
<td>4 t/ha</td>
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<tr>
<td>N mass in stubble remaining</td>
<td>35 kg/ha</td>
<td>20 kg/ha</td>
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<tr>
<td>N mass in urine</td>
<td>0 kg/ha</td>
<td>9 kg/ha</td>
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<tr>
<td>N mass in faeces</td>
<td>-</td>
<td>5 kg/ha</td>
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<tr>
<td>C mass in stubble remaining</td>
<td>2.8 t/ha</td>
<td>1.6 t/ha</td>
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<td>C mass in faeces</td>
<td>-</td>
<td>0.4 t/ha</td>
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<td>Immobilising power of C</td>
<td>112 kg/ha N</td>
<td>64 kg/ha</td>
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Conclusions

• Grazing stubble makes more N available to wheat crops
  • Soil mineral N prior to sowing
  • Grain N uptake
• Dominant mechanism is likely reduced immobilisation rather than faster cycling
• Stubble grazing increases rate of N mining...
• ...but mixed farming systems have pasture leys!
• Can we train termites to do the same thing in crop-only systems?
Thank you

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Benefits of mixed farms – N for crops from legume based pastures

Benefits of mixed farms – Financial Risk Mitigation