Effects of management practices on the carbon balance of Waikato dairy farms

Susanna Rutledge
Aaron Wall
Dave Campbell
Louis Schipper
Outline

• Why carbon balances of dairy farms?
• Scott Farm (2008-2012) – effects of cultivation
• Troughton Farm (2011 – now) – effect of re-grassing to mixed sward
  • Experimental design
  • Results so far

• Methodological challenges
Soil C changes under pastoral agriculture

- resampling study -

C losses of \( \approx 1 \text{ t ha}^{-1} \) after 30 years for dairy, but no change (or gains) for non-dairy

(Schipper et al. (2010) Agriculture, Ecosystems & Environment, 139: 611-617)

→ Potential opportunity to increase storage in dairy soils
Goal

To identify management practices that can increase soil C gains or decrease losses

C input
(mostly through roots)

soil C store

C output
(mostly through microbial decomposition)
Annual carbon budget

soil C store

NEE = net ecosystem CO₂ exchange

Eddy covariance

respiration

photosynthesis

CH₄

C imports/exports

Farm records

Annual carbon budget

farm records

soil C store

Leaching

erosion
Field site: Scott Farm

- Scott farm
  (DairyNZ™ research farm)
- Dec 2007 – Feb 2012
Scott Farm 2008-2011

• Drought in summer
• Wet winter

Scott Farm 2008-2011

Scott Farm 2008-2011

Data for 2010 and 2011 are preliminary

- Drought in summer
- Wet winter

- “Normal” summer
- Cold winter

- Cultivation in March

C loss

~1700 kgC/ha

C gain
Scott Farm 2008-2011

Data for 2010 and 2011 are preliminary
Can a high diversity sward increase soil C?

- side-by-side experiment -

• Compare rye grass + clover with a high diversity (mixed) sward that has more and/or deeper roots

Hypothesis:
more roots → more C input
→ more C storage?
Preliminary data: flux comparison before regrassing

Both sites still in rye grass
Effect of grazing

![Graph showing CO₂ flux (μmol m⁻² s⁻¹) over time (in 2012)](image_url)

- **Grazed**
- **Not Grazed**

Time (in 2012)

17 Mar, 18 Mar, 19 Mar, 20 Mar
Challenges: lack of energy balance closure

\[ H + LE = -3.5 + 0.711 \times (R_n - G) \]

\[ R^2 = 0.908 \]
Challenges: underestimation of evaporation?
Challenges:
frequency response correction – CO₂ flux

Challenges:
frequency response correction – LE
Closed path vs. Open path - CO₂ flux

But different frequency response correction applied:
- Closed path: Ibrom
- Open path: Moncrieff
Closed path vs. Open path - LE

But different frequency response correction applied:

- Closed path: Ibrom
- Open path: Moncrieff
Conclusions

• Even after cultivation, Scott farm was a sink for CO$_2$ on an annual timescale

• Preliminary results suggest that regrassing to mixed sward may increase the CO$_2$ sink strength

• Triple-site comparison underway

• Low energy balance closure
  • Low installation height?
  • Closed path?
  • Storage fluxes?
  • Site-specific frequency response?
Acknowledgements

- Ben and Sarah Troughton
- Paul Mudge
- Dairy NZ staff
- David Whitehead
- Craig Hosking
- Dirk Wallace

Funding

- New Zealand Agricultural Greenhouse Gas Research Centre
- University of Waikato
- Dairy NZ
Modelling collaboration

• Miko Kirschbaum and student Isoude Kuijper using CenW
  • Disentangle weather drivers from management effects
  • Fate of C (which pools)

• Two way collaboration: feedback to interpret results
Higher root biomass of high diversity sward

- 25% more roots (0-30 cm) in mixed sward compared to traditional rye grass/clover
Experimental design

Control

Re-grass back to ryegrass

Re-grass to mixed sward