Sustainable Agro-ecosystems (SAE): An OLW aligned programme

Mike Beare
Paul Johnstone, Steve Thomas, Jo Sharp, Edmar Teixeira, Sarah Bromley, Roger Williams
New Zealand Institute of Plant & Food Research

OLW Symposium (April 2017)

Sustainable Agro-ecosystems Programme

- Knowledge & tools that enhance productivity & resilience of primary industries while reducing their environmental footprint to meet community and market defined limits.
  - Improve sustainable production
  - Improve water quality & availability
  - Reduce GHG, adapt to climate change
  - Inform policy and practice
  - Enable market access
  - Grow export earnings
- Diverse range of partners:
  - FAR, Zespri, DairyNZ, HortNZ, IrrigationNZ
  - MPI, NZAGRC,
  - OLW & Deep South NSC
- Current funding:
  - SSIF (Core) = $4.5 M
  - Industry/Policy aligned = $3.2 M

SAE Programme Leadership Team

Plant & Food RESEARCH
RANGAHAU AHUMĀRA KAI

SAE programme – Aligned to OLW NSC
(Focus on Soil, Arable, Horticultural & Environmental Science)

OLW Objective: *To enhance primary sector production and productivity while maintaining and improving our land and water quality for future generations*

Three Major Themes

- **Land use capability to suitability:** Knowledge & tools to better match land use & mgnt with productive potential & environmental constraints of land.
- **Productive plants for the environment:** Crops & mgt practices that deliver greater value to industries from better environmental performance of farm systems.
- **Future Farming Systems:** New production systems and technologies that enhance the productivity, profitability and environmental performance.

Outcomes

- Improved understanding of impacts, risks & trade-offs of land use & mgt decisions
- Position primary industries to respond to changes in community define limits, climate, resource allocation (e.g. water) and market values.

Plant & Food RESEARCH
RANGAHAU AHUMĀRA KAI

Land use capability to suitability

Outcome objectives:

- Knowledge and tools to better match land use and management with the productive potential and environmental constraints of the land.

Research focus:

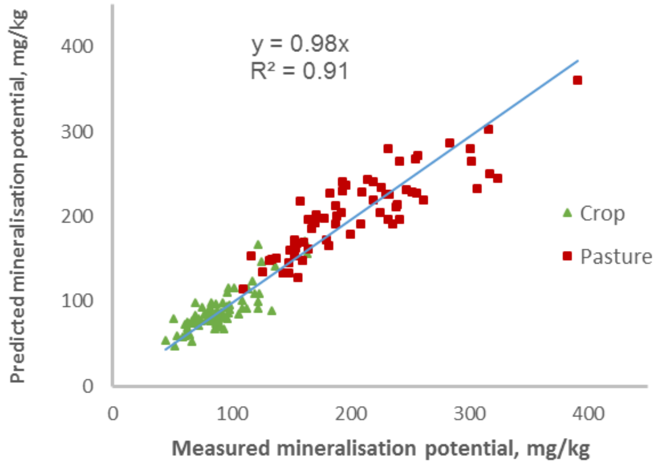
- Soil/Land attributes/constraints (with LCR)
  - Sustainable production of different land uses (resistance / resilience)
  - Risks of adverse environmental impacts (N, P, sediment, fecal bugs)
  - Addresses gap in the OLW LUS programme (beyond LU capability)
- Understanding and managing
  - Soil organic matter stock & services (Aligned to OLW Suitability)
  - Soil physical properties & biophysical processes (Aligned to OLW Suitability)
  - Water & solute transport, storage and attenuation (Aligned to OLW Sources & Flows)

Understanding and Managing Soil Organic Matter

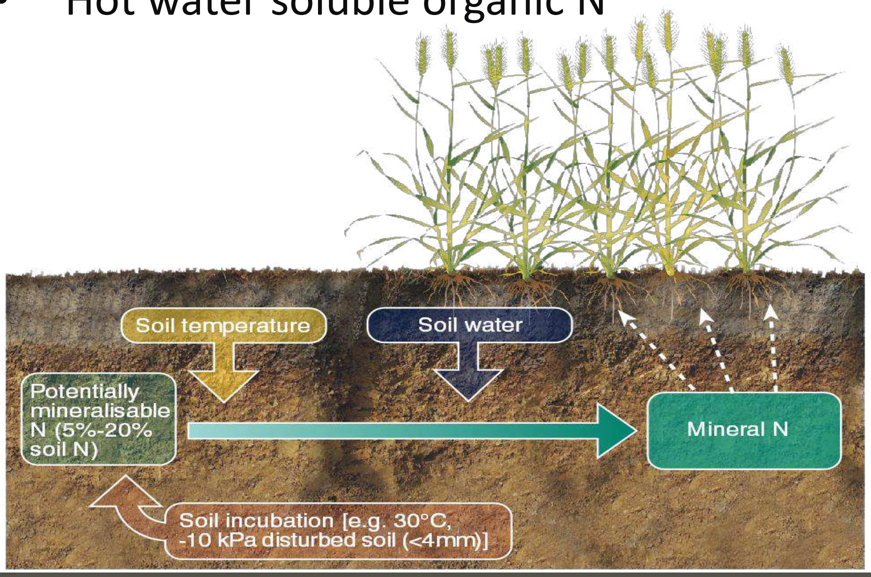
Improving predictions of N mineralisation

- N mineralised from SOM: important N source; difficult to predict
- Existing methods are poor predictors N mineralisation
- Better prediction → improved fertiliser forecasting
- Improved NUE and reduced risk of N losses

- Can we identify practical, dependable methods?
- N mineralisation – soil potential, in field actual
- What are the key soil fractions or sources?
- Hot water soluble organic N



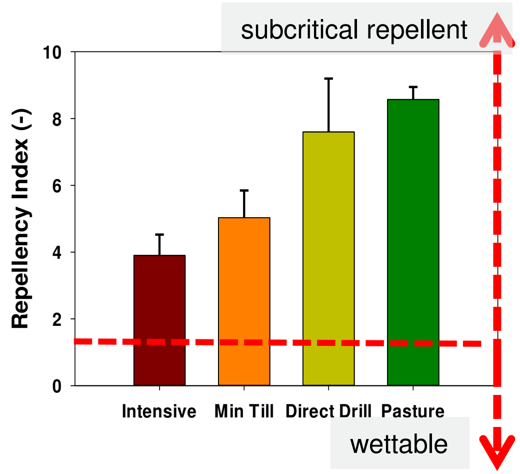
Curtin, Beare et al 2017 SSSAJ

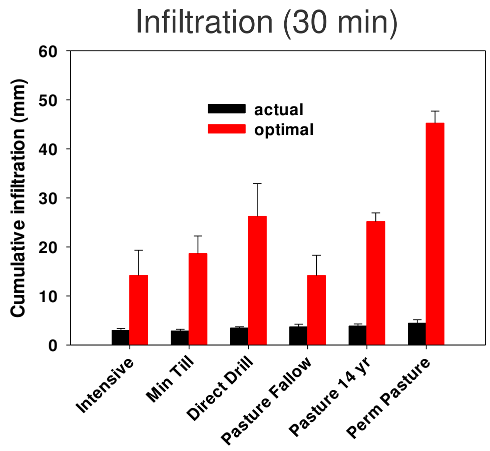


	Net N Mineralised (kg/ha)	
Method	Dryland	Irrigated
Measured	45 ± 7	71 ± 15
Predicted	41 ± 6	70 ± 14

Irrigation, soil organic matter & ecosystem services

- Agricultural intensification
  - Irrigation expansion on soils of low natural capital (shallow, stony, sloping)
- How does irrigation affect SOC storage & turnover?
  - Enhanced SOC storage assumed, but true?
  - What are the consequences for ecosystem services?
- Soil water repellency and irrigation (with MVI)
  - Most soils are sub-critically repellent
  - Even at low irrigation rates water will bypass much of matrix
  - Managing SC repellency could increase irrigation efficiency





Mueller, Thomas Carrick

Plant & Food RESEARCH
RANGAHAU AHUMĀRA KAI

Soil physical constraints to crop/pasture productivity

Different forms of constraints (Inherent vs dynamic):

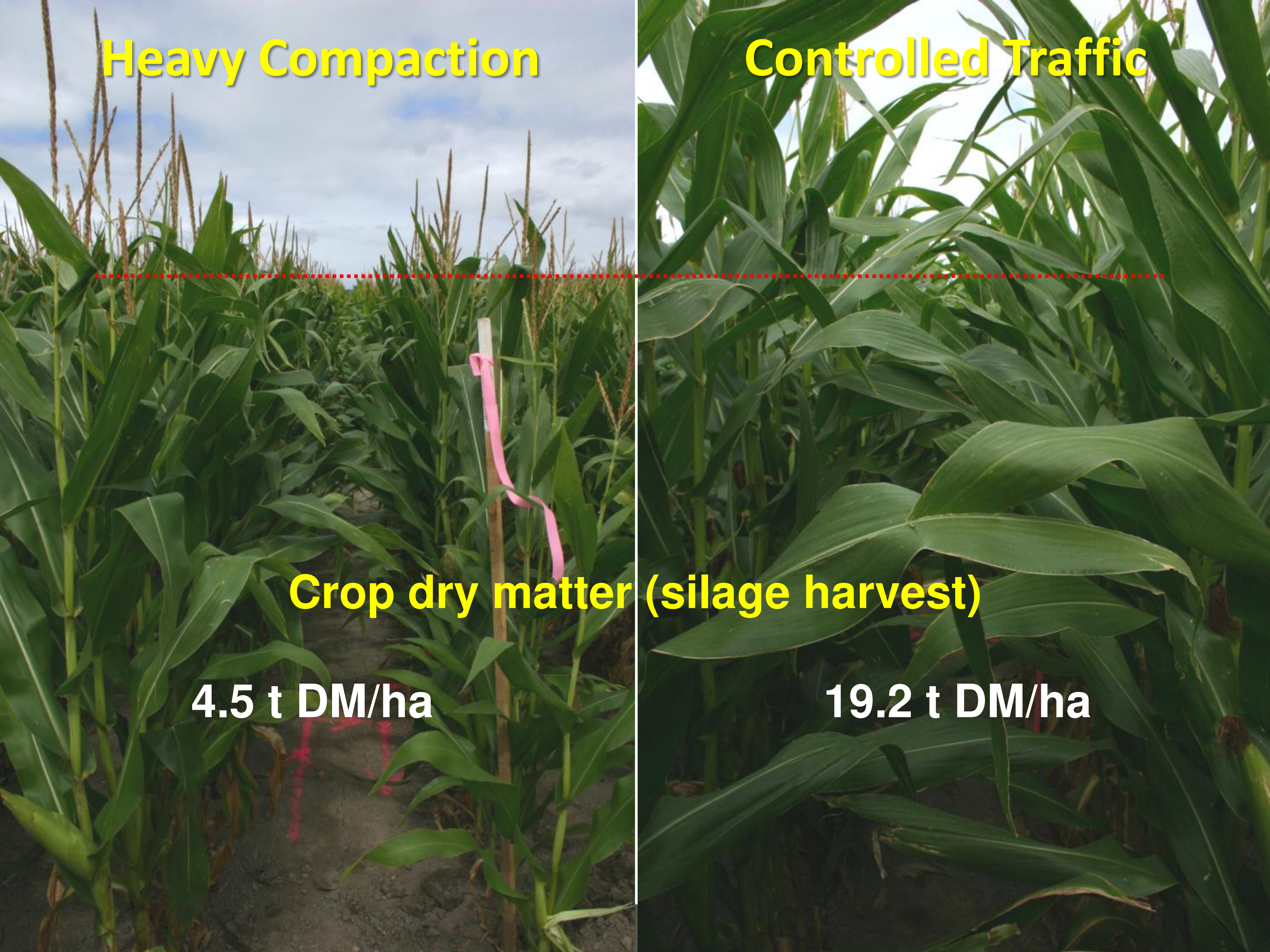
- Shallow top soils (subsoils affect water storage/drainage)
- Structural breakdown and consolidation from loss of SOM
- Soil compaction (wheel trafficking, livestock treading)

Soil compaction

- How prevalent is soil compaction? (soils, systems)
- How does it affect soil function? (water, nutrients)
- What are the costs? (loss of production, input costs etc)
- How can we represent the effects in crop system models?

% of paddocks with PR greater than 2.5 Mpa (PR normalised to 35% v/v)

	Land use	0-15 cm	15-25 cm
Pastoral	Sheep/beef	26	19
	Dairy	36	30
Cropping	Mixed arable	13	21
	Intensive arable	12	29
	Intensive vegetable	41	38


Heavy Compaction
Controlled Traffic
Crop dry matter (silage harvest)
4.5 t DM/ha
19.2 t DM/ha

Plants for the Environment

Productive plants with enhanced environmental traits

Outcome objective:

- Crops & mgt practices that deliver greater productivity, profit, and/or policy compliance to primary industries from better environmental performance.
- Includes crops to address specific yield or quality gaps and environmental impacts and crop rotations to enhance resource use efficiency and farm system resilience.

Research focus:

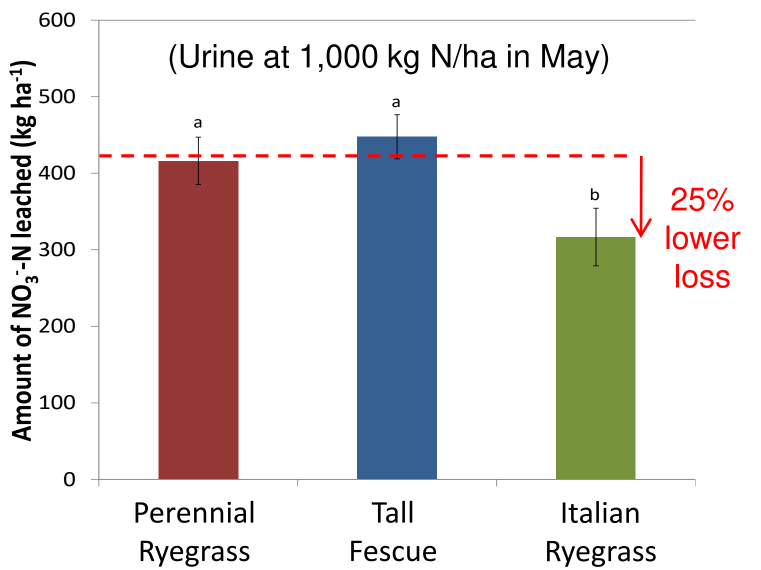
- Critical plant traits
- Optimising the mix and management of plant traits
- Advanced modelling tools to predict productive and environmental outcomes

Plants for the Environment

Productive plants with enhanced environmental traits

Beneficial attributes may include:

- Improved nutrient acquisition
  - Winter active & deep rooted plants to mop up excess N
  - Enhanced uptake of P (roots, adsorbed P)
- Root characteristics that:
  - improve soil structure formation
  - Enhance access to plant available water
  - Penetrate or reverse soil physical constraints
- Biological Nitrification Inhibition:
  - Focus has been on grasses
  - Some crops also have high BNI activity (species, cultivars)
  - What plants are most effective and under what conditions?
  - Can we manage the outcome?

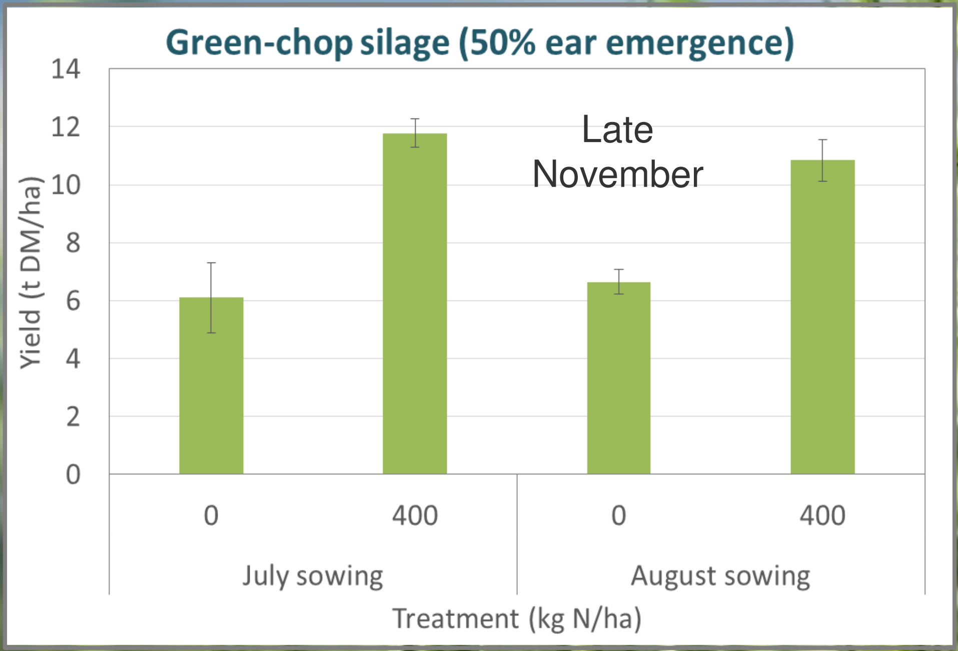


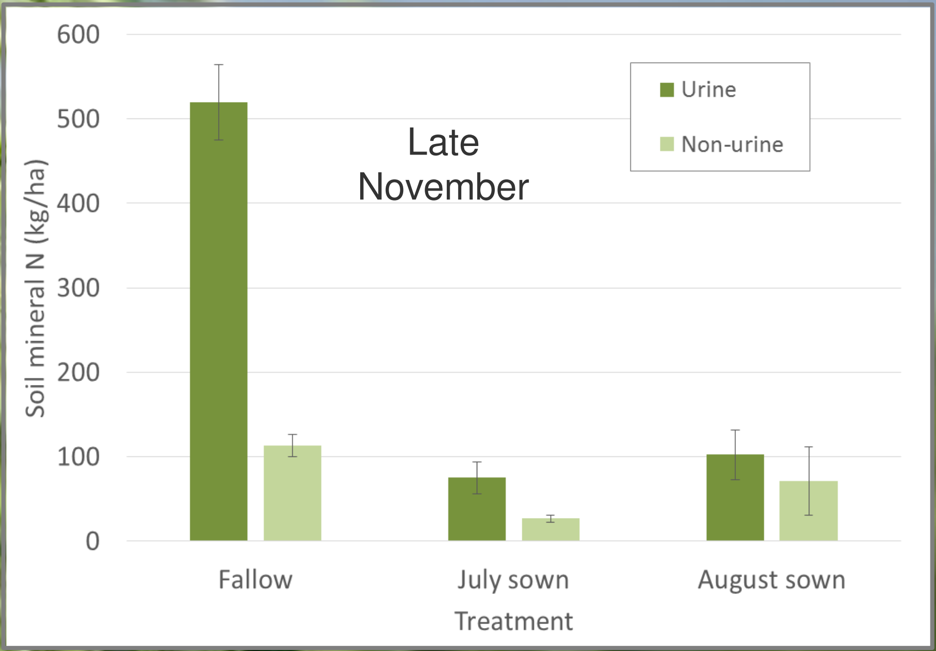
Malcolm *et al.* (2014)

Plant & Food RESEARCH
RANGAHAU AHUMĀRA KAI

Catch Crops to reduce NO_3 leaching ex grazing

Oats sown in winter yielded 6-12 t DM/ha and reduced soil N





Future Farming Systems

Outcome objective:

- New production systems and technologies that enhance the productivity, profitability and environmental performance of primary industries

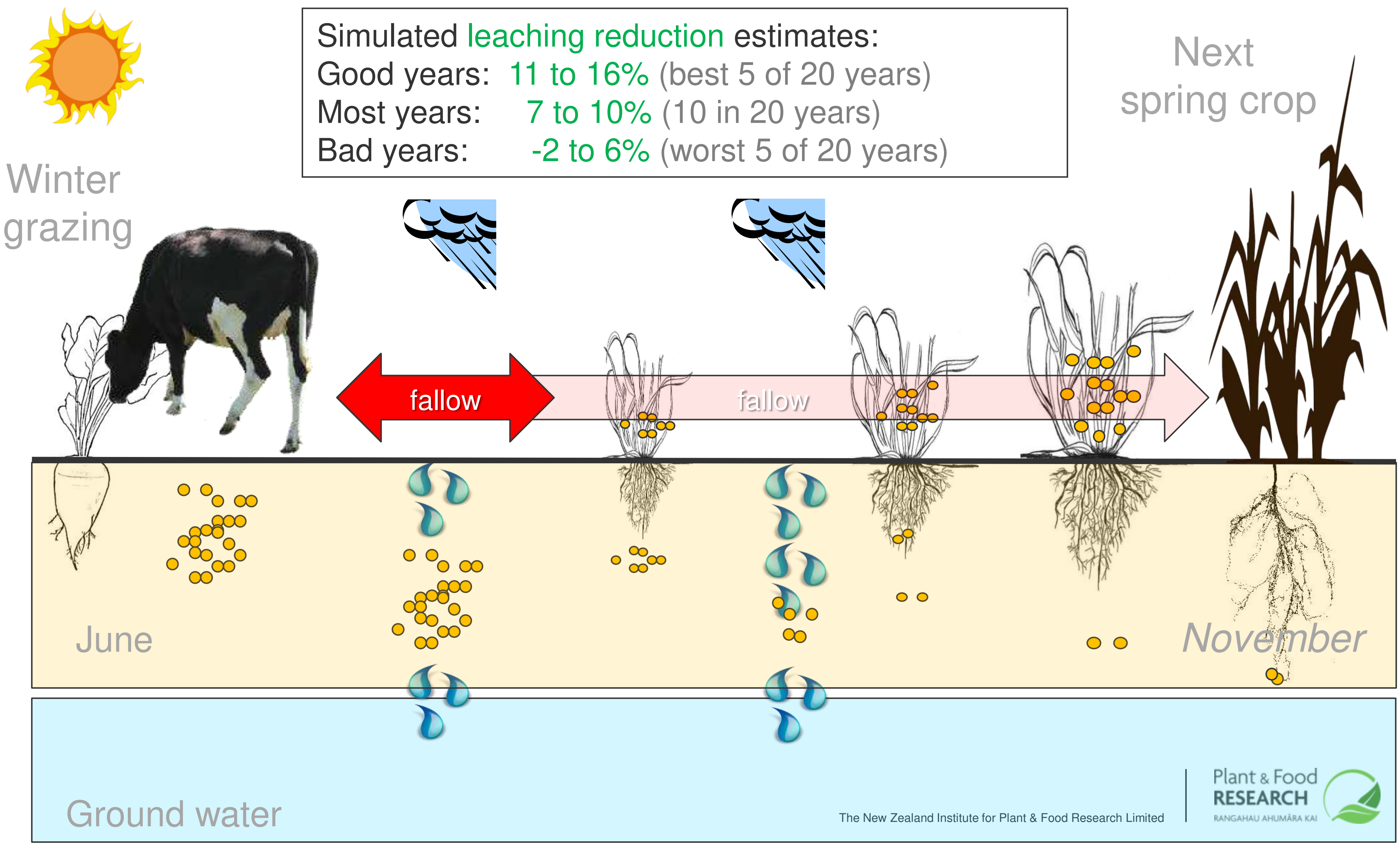
Research focus:

- Smarter irrigation and nutrient management systems
- Adaptive management for drought mitigation
- Precision (spatial & temporal) management
- Advanced modelling tools to predict productive and environmental outcomes

Multi-crop models to test variability in outcomes

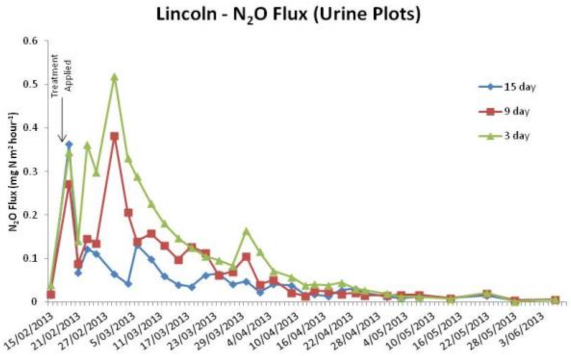
Example of variability for a June N load of 400 kg/ha with mid-July cover crop

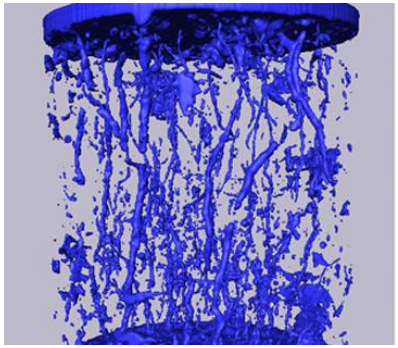
Simulated leaching reduction estimates:
Good years: 11 to 16% (best 5 of 20 years)
Most years: 7 to 10% (10 in 20 years)
Bad years: -2 to 6% (worst 5 of 20 years)



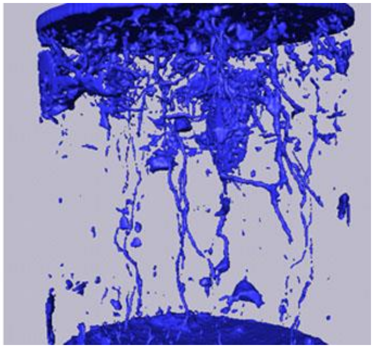
Irrigation, land use change & ecosystem services

- Managing Irrigation to mitigate N losses
  - Keeping soils wet = high N_2O emissions
  - Maintaining deficits (less frequent irrigation) reduces risk of large N_2O emissions and N leaching
- How do soil physical properties affect process?
  - PSD, pore connectivity and diffusivity
  - Effects of soil compaction & structural consolidation
- Are there trade-offs between N gaseous emission and N leaching?
- Can develop rules & tools to manage these interactions to enhance WUE and mitigate nutrient losses?





Uncompacted



Compacted

Plant & Food RESEARCH
RANGAHAU AHUMĀRA KAI


Thank You