Soil N testing to improve N management of annual crops

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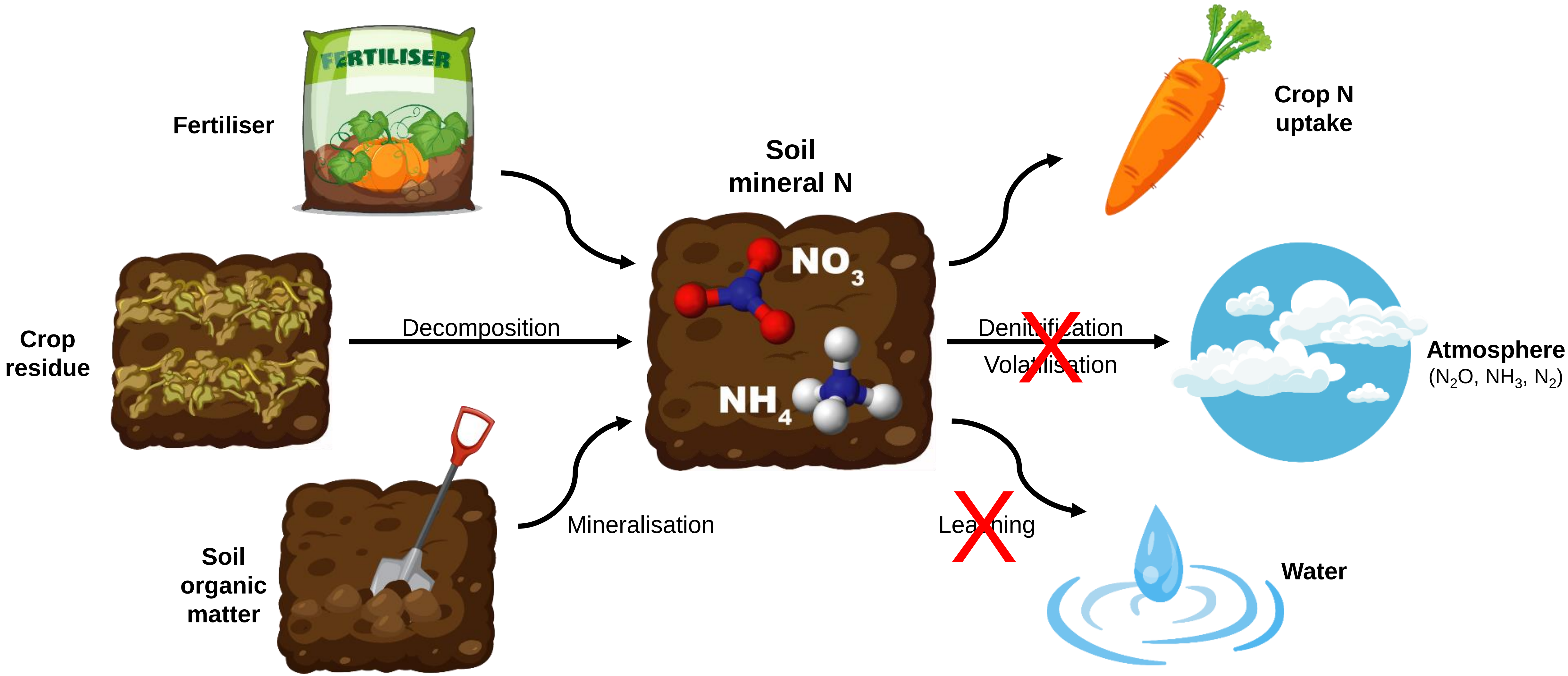
The New Zealand Institute for Plant and Food Research Limited

Background

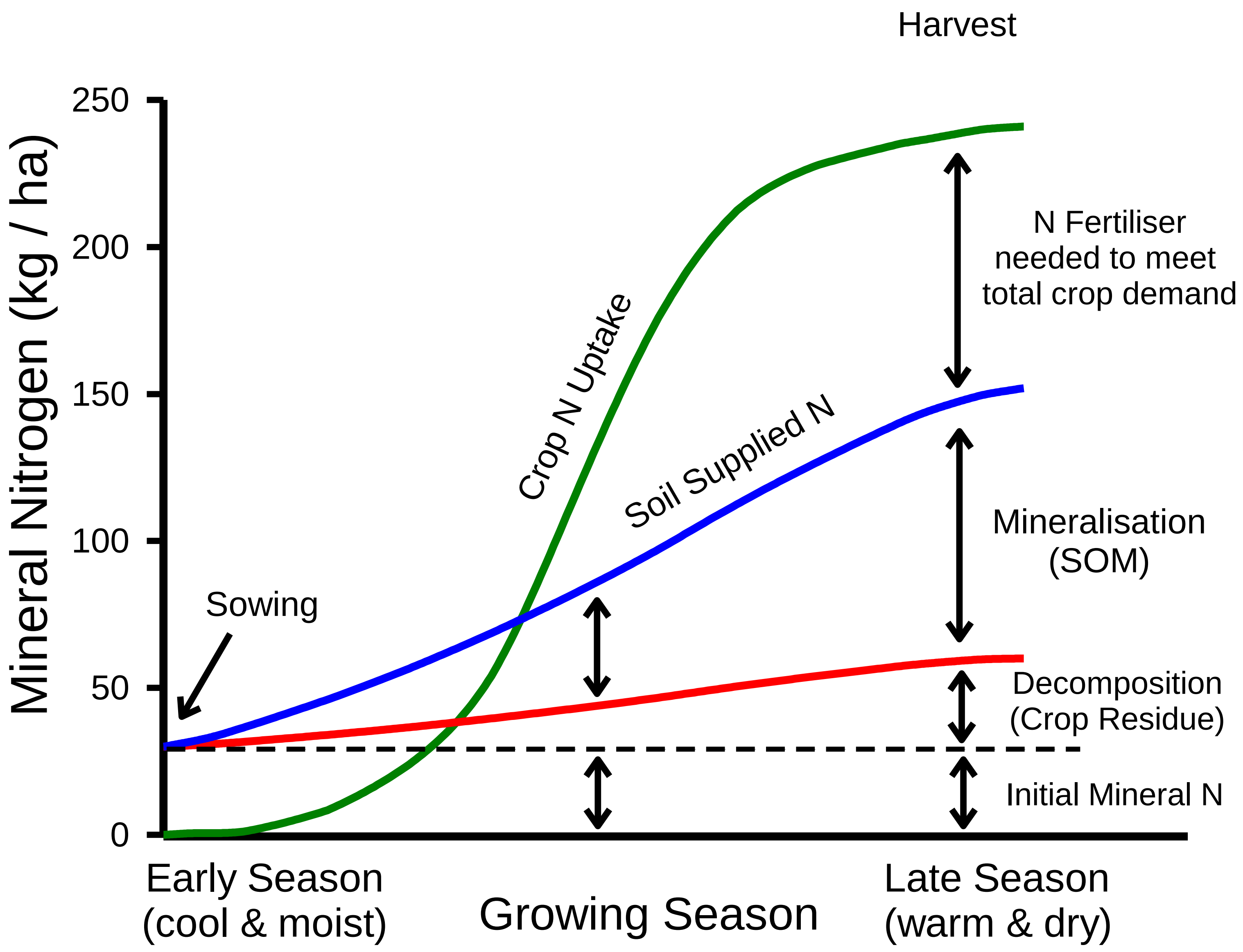
- Good N management is important
  - Ensuring N supply meets crop demand
  - Minimising N losses & complying with policy limits
  - Improving N use efficiency, reducing costs
- More precise N fertiliser forecasting is critical
  - Understand and match N supply with crop demand
  - Right amount, right time, right type & right place
- Predicting soil N supply still major challenge
  - Pre-existing test methods and model predictions poor
  - Major limitation to fertiliser N forecasting
  - Recent advances soil N testing - key to the challenge

Sources and sinks for nitrogen

SOM N + Crop residue N + Fertiliser N = Crop N uptake



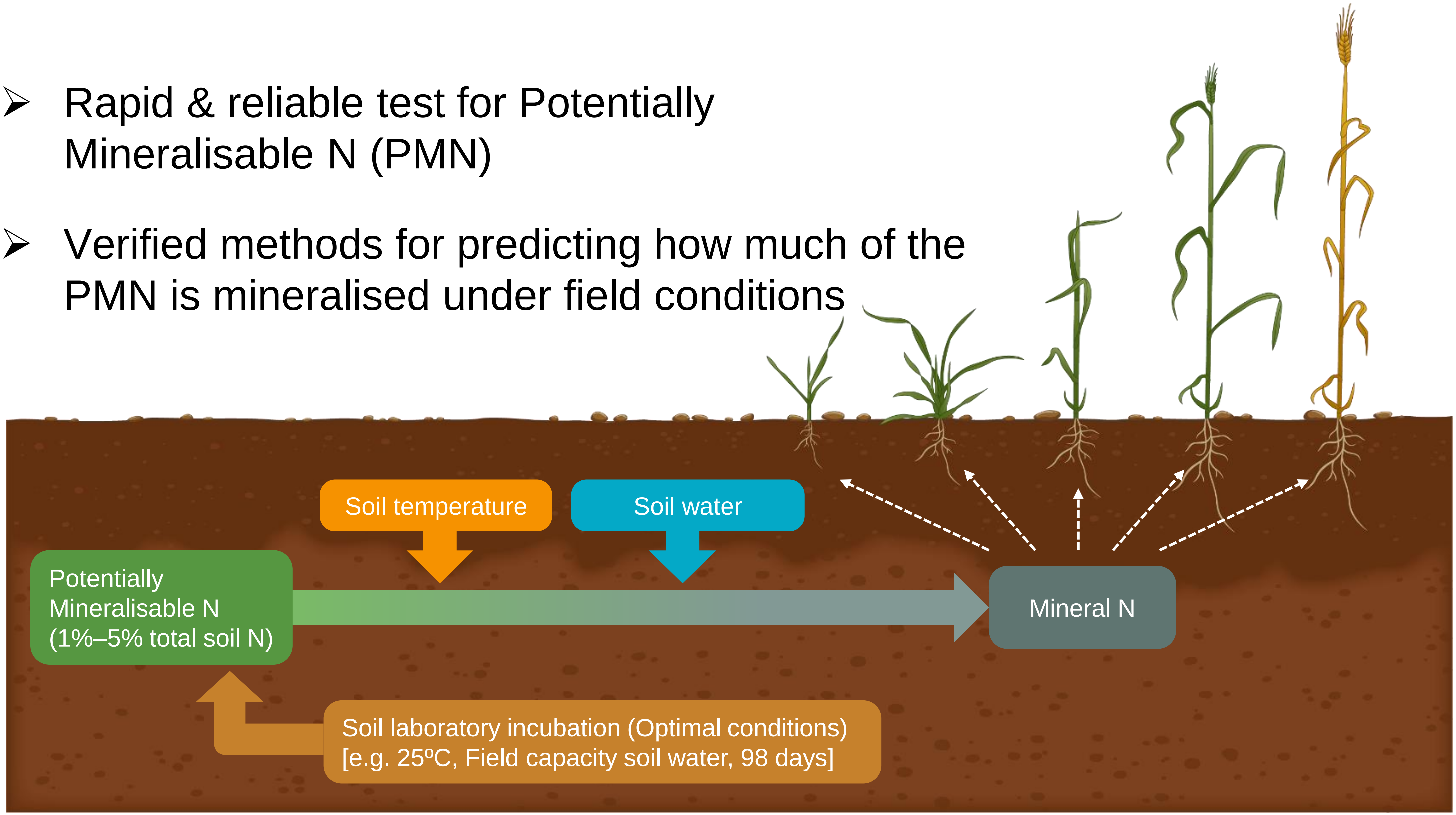
Sources and Supply of N for Crop Uptake



Forecasting N mineralisation: What is needed?

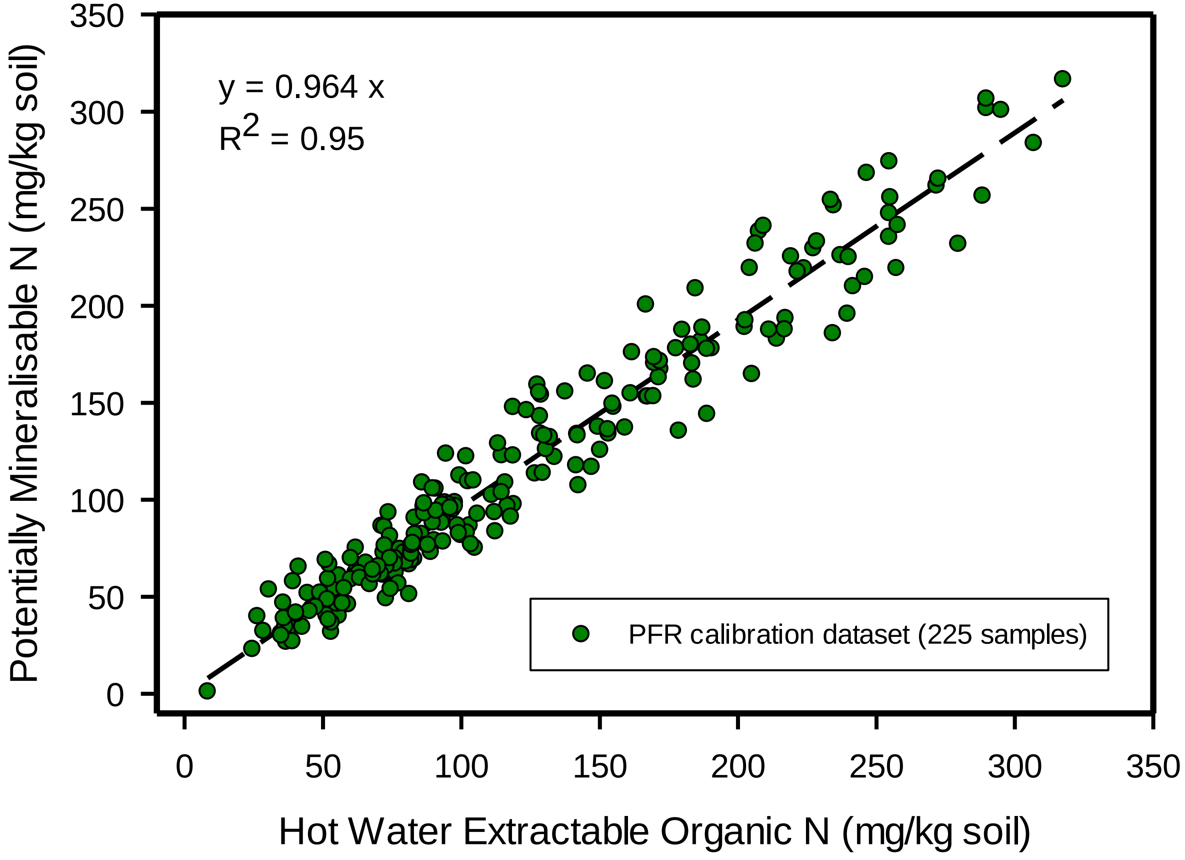
- Rapid & reliable test for Potentially Mineralisable N (PMN)

- Verified methods for predicting how much of the PMN is mineralised under field conditions



Measuring Potentially Mineralisable Nitrogen (PMN)

- “Gold Standard” method for PMN
  - Aerobic incubation (14 wks; 25ºC; 90% FC)
  - Not suitable for rapid, routine testing
- Testing for PMN
  - Pre-existing AMN test – not reliable
  - Hot Water Extractable Organic N good predictor
  - Rapid, reliable (high precision) & cost effective
  - Commercial test protocol developed (PMN_{Test})
- PMN_{Test} available to growers
  - Objective – build farmer confidence in testing
  - Commercial labs now offering the test



Curtin, Beare et al 2017. SSSAJ 81(4): 979-991

Potentially Mineralisable N in New Zealand Soils (0-15 cm)

PMN (kg N/ha) = PMN (mg/kg) x depth (cm) x bulk density (g/cm^3) x 0.1

PMN (kg N/ha) affected by:

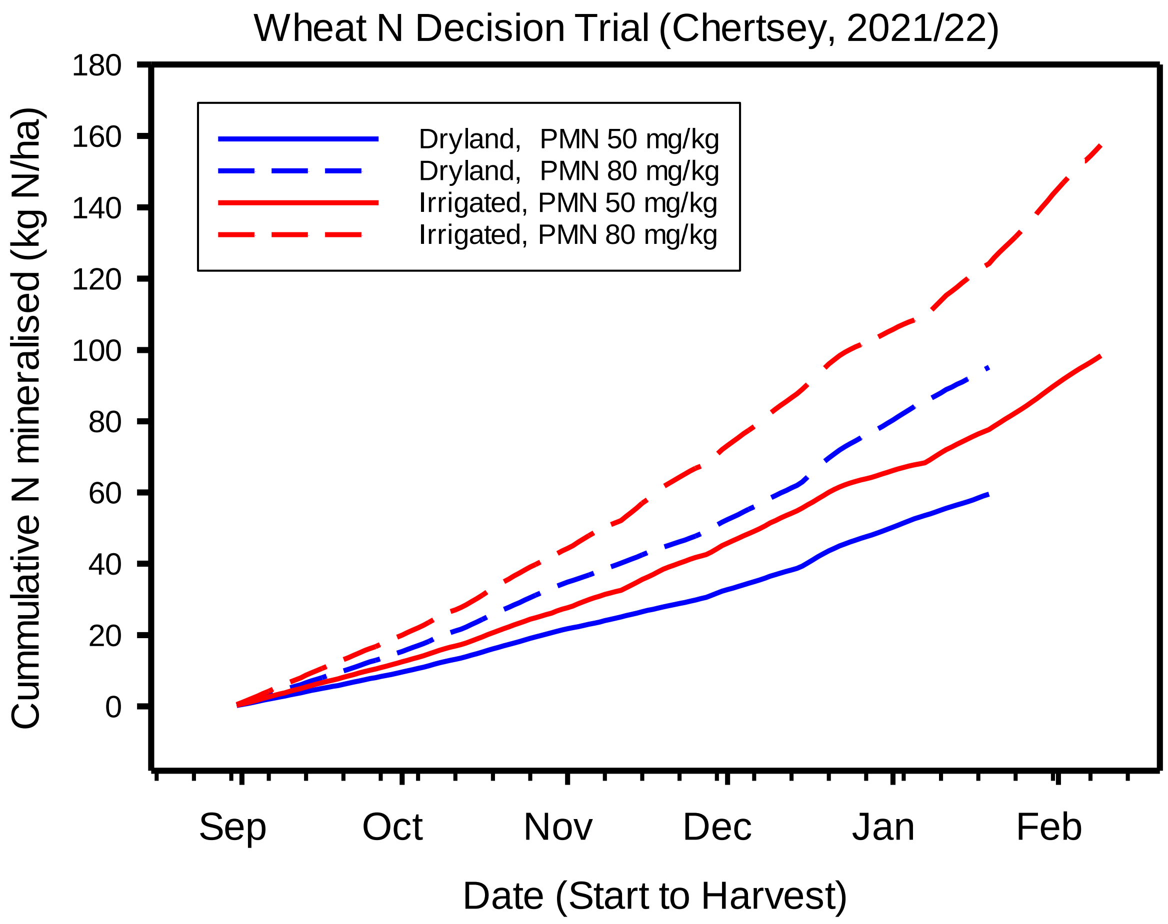
- Soil Order
- Land use & management history

Soil Order	Dairy	Drystock	Arable crop	Veg crop
Allophanic	216 ± 38	213 ± 48	ND	105 ± 33
Brown	189 ± 60	179 ± 52	91 ± 28	45 ± 19
Pallic	293 ± 70	227 ± 51	84 ± 24	69 ± 23
Gley	211 ± 51	158 ± 9	116 ± 39	76 ± 24
Recent	231 ± 47	171 ± 43	93 ± 32	81 ± 27

Adapted from: Curtin, Beare et al 2017. SSSAJ 81(4): 979-991

Predicting in-field N mineralisation from PMN

- N mineralised in the field is a function of soil temp & water content during growing season
- In-field $N_{min} = \sum_{1\text{-}n}(\text{PMN (kgN/ha/d)} \times T_f \times W_f)$
  - T_f : Lloyd-Taylor (1994), where N mineralisation is a function of mean daily soil temperature
  - W_f : Qiu et al (2022), where N mineralisation is a function of relative available soil water content (Adapted from Paul et al (2003))



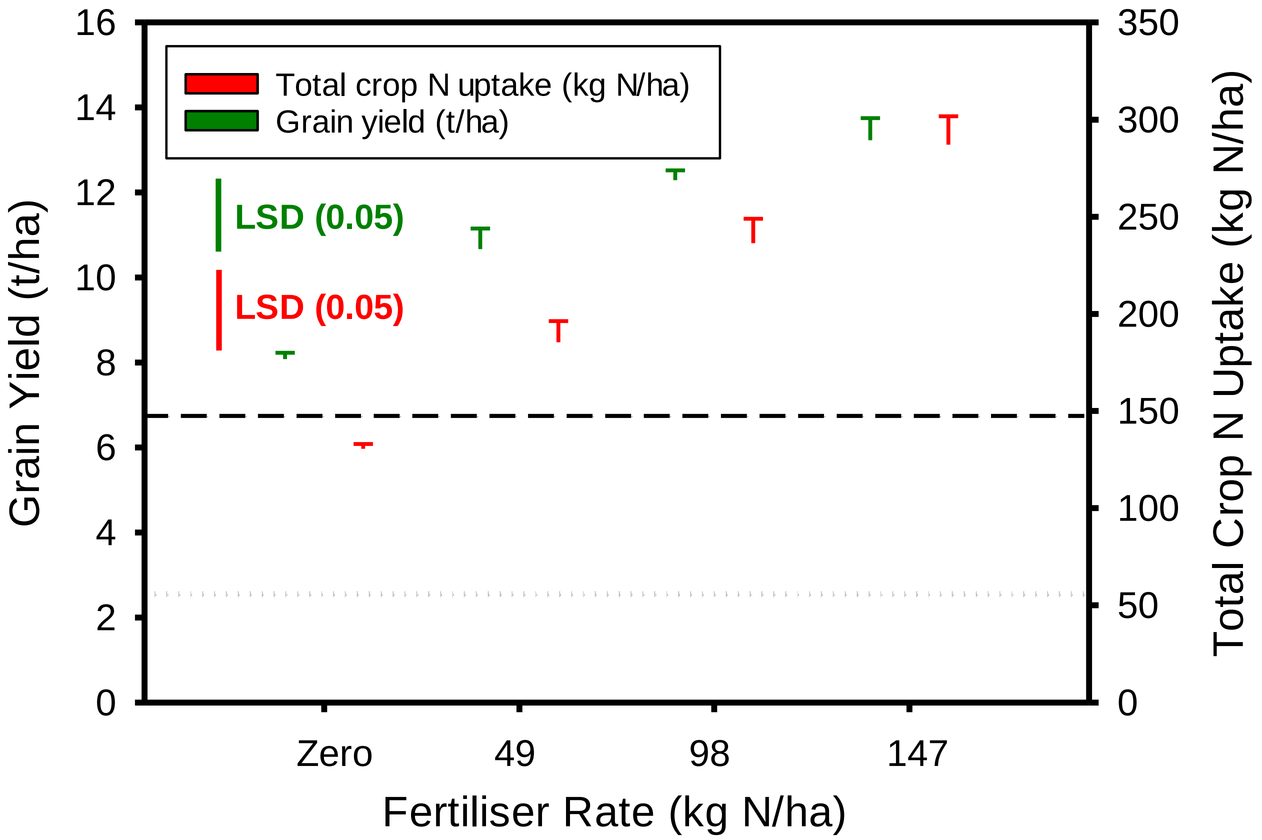
Qiu, Curtin & Beare (2022) Soil Research

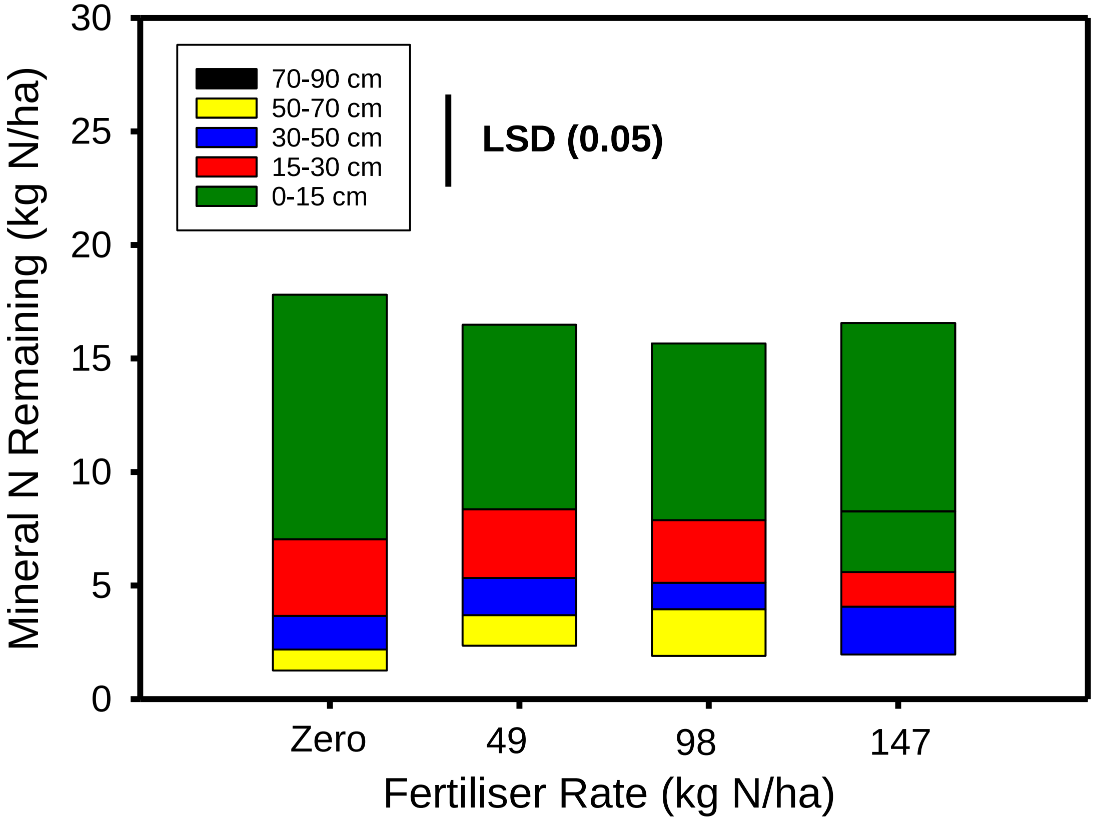
Validation Trials

Verifying predictions of in-field N mineralisation

- Field Trials
  - Different crops (wheat, barley, ryegrass seed, kale, carrot, broccoli, onion, potato, sweetcorn, etc)
  - Different soils and climates (Canterbury, Hawke's Bay & Waikato)
  - Zero, Low, medium (Good practice) and high rates N Fertiliser
- Measuring in-field N mineralisation (N balance)
  - PMN and mineral N in root zone at sowing
  - Yield and crop N uptake (above-ground & roots)
  - Mineral N in root zone at harvest
  - Soil temp; soil water content (0-15 cm; daily mean)
  - Nmin = Crop N + Final soil min-N – Initial soil min-N
- Predicted vs Measured N mineralisation

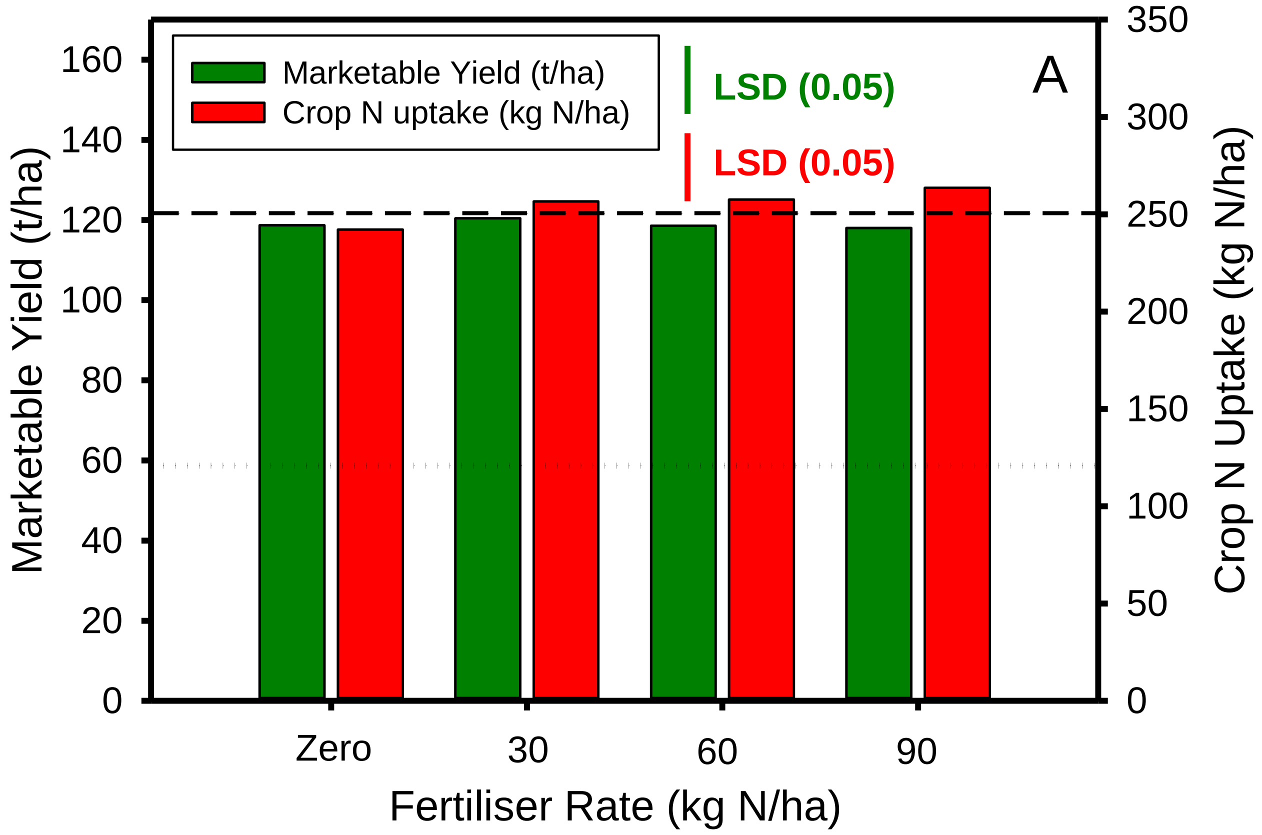
Grain yield, N uptake and Residual Mineral N Wheat (Southbridge)

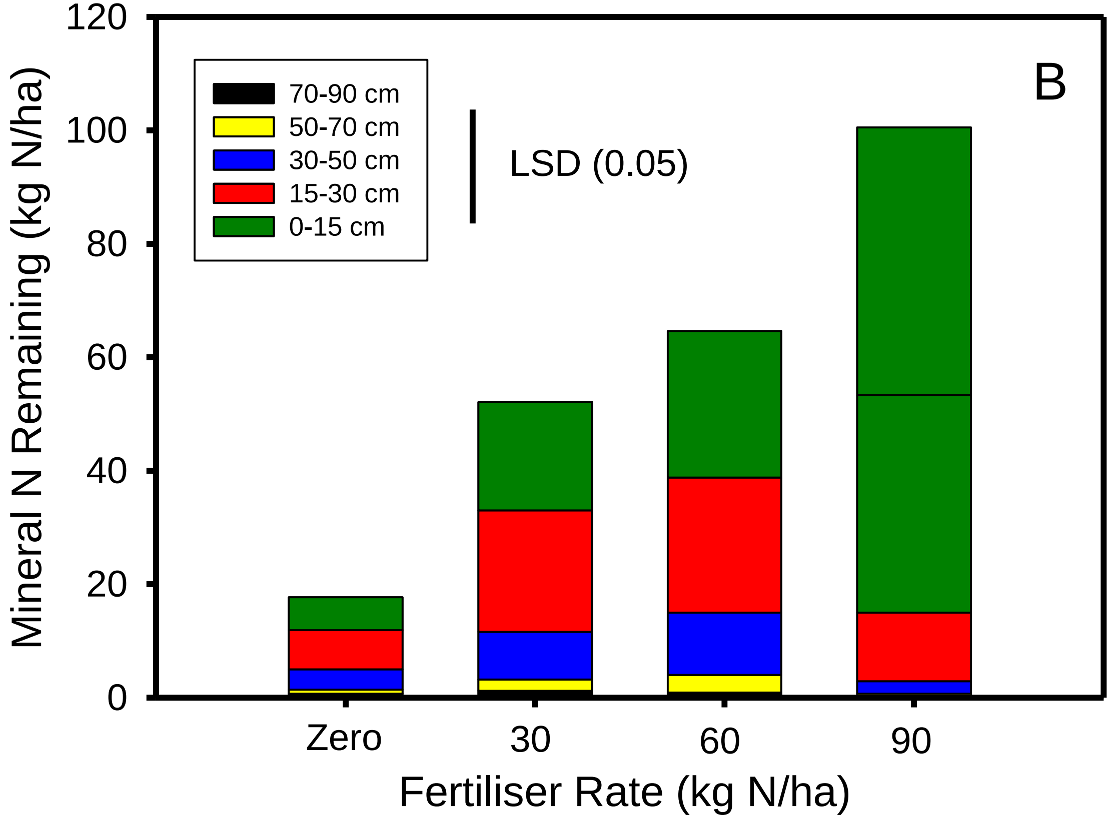




- Industry guideline N Fertiliser rate (excl N mineralisation) = 273 kg N/a

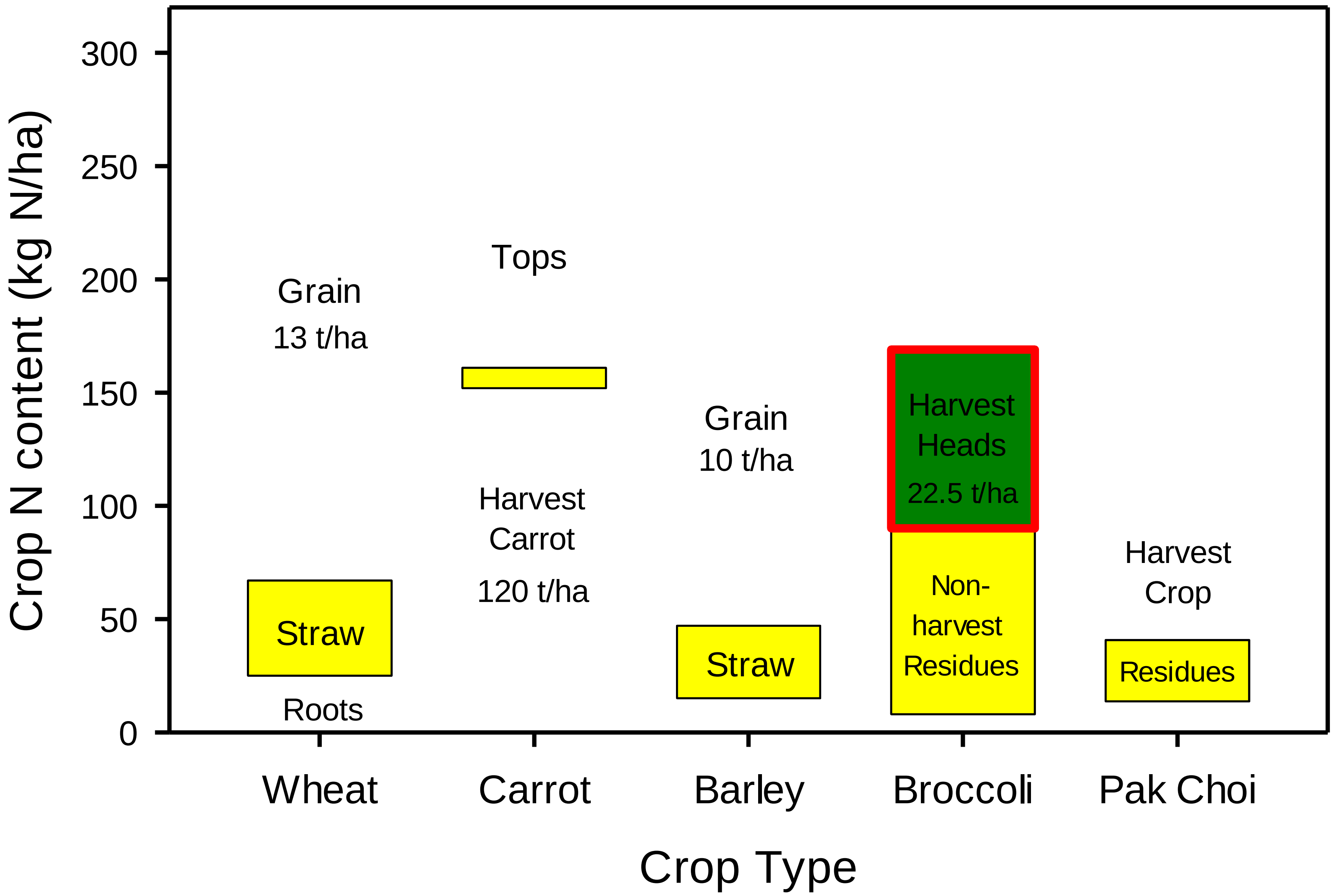
Crop yield, N uptake and Residual Mineral N
Carrots (Lincoln)



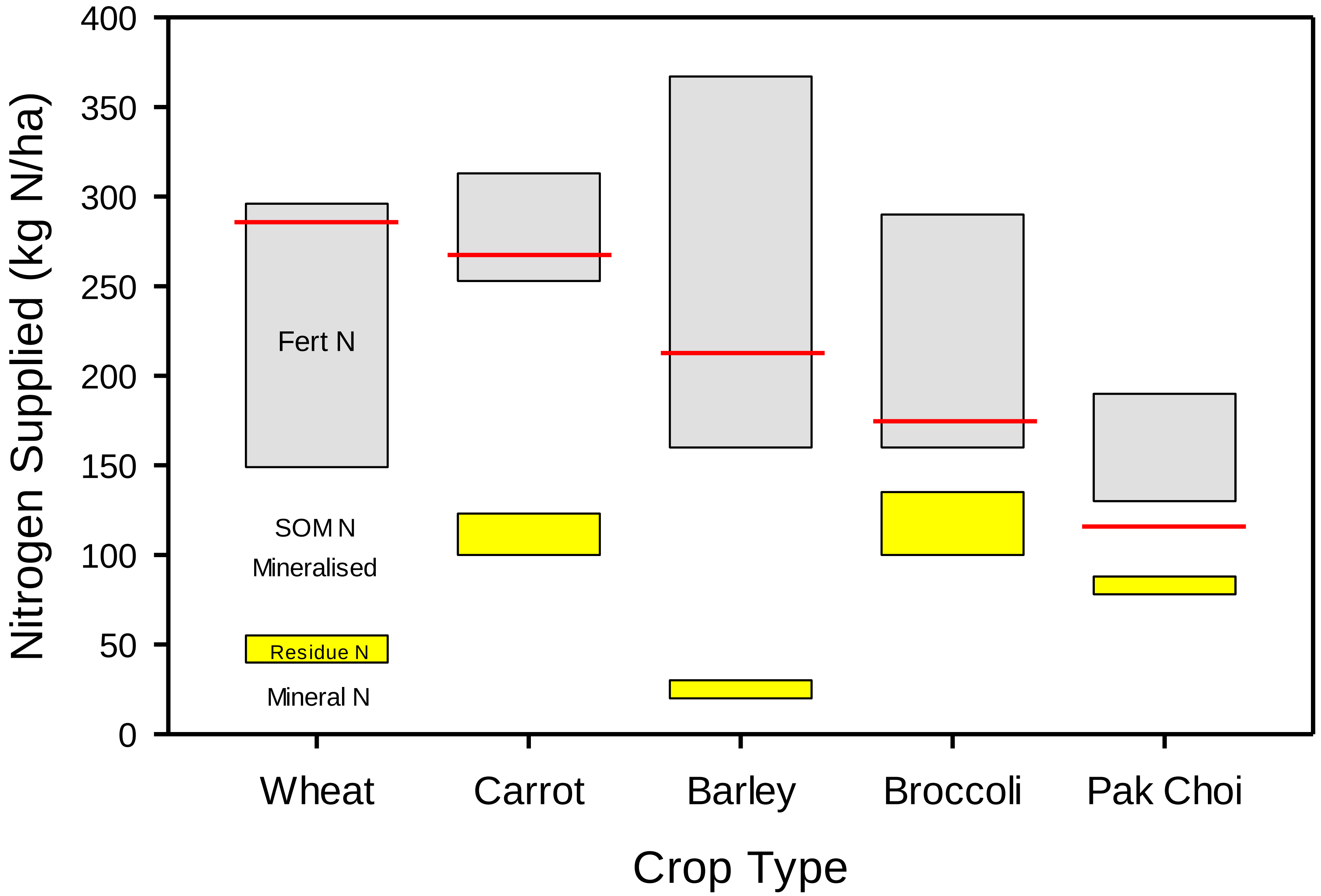


- Soil mineral N and PMN provided all of the N needed to meet crop demand
- High risk of N losses after crop harvest

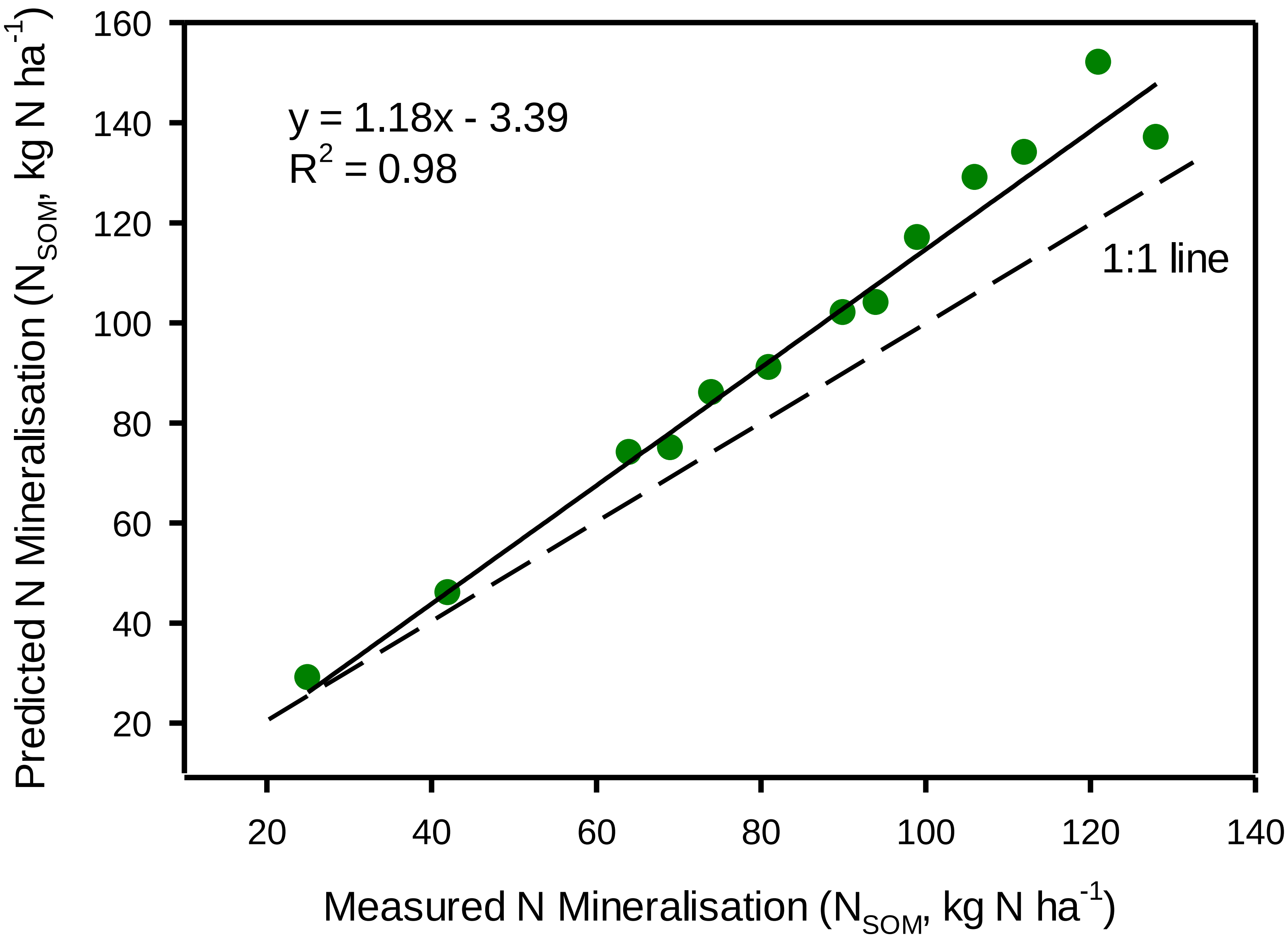
How is N partitioned in crops?



How much N was supplied from soil, residues & fertiliser?



N Mineralisation (Measured vs Predicted)



Wheat N Decision Trials (Chertsey)

Autumn sown feed Wheat
150 plants/m^2, 15 cm rows
Plots (8 m x 1.65 m)
No N applied prior to spring

Two water management trials
- Irrigated
- Dryland

Col 2 - IRRIGATED

Grass Laneway

Buffer

Block 4		Block 3		Block 2		Block 1	
401	4	301	3	201	5	101	2
402	2	302	4	202	3	102	1
403	1	303	5	203	4	103	3
404	3	304	2	204	1	104	5
405	5	305	1	205	2	105	4

Buffer

Col 1 - DRYLAND

Grass Laneway

Buffer

Block 1		Block 2		Block 3		Block 4	
101	4	201	2	301	5	401	3
102	5	202	5	302	4	402	2
103	1	203	4	303	3	403	1
104	2	204	3	304	1	404	4
105	3	205	1	305	2	405	5

Buffer

Nitrogen Management Treatments

Treatment 1: Full industry guideline N fertiliser rate (25 kg N/ha per t of target grain yield)

Treatment 2: Full N rate – initial mineral N (0-30 cm)

Treatment 3: Full N rate – initial mineral N and predicted N mineralisation (0-30 cm)

Treatment 4: Full N rate – initial mineral N (0-30 cm), adjusted using Quick N tool

Treatment 5: Zero (nil) N fertiliser applied

Fertiliser N applied to the N Decision Trials

Initial mineral N = 18 kg/ha

Mineralised N = 57 kg/ha

Irrigated Wheat		Fertiliser N applied (kg N/ha)			
Target grain yield = 12 t/ha	Trt No.	Early N	GS 32	GS39	Total N
Full N rate	1	40	174	86	300
Full N – mineral N	2	38	164	81	282
Full N – (min N + Mineralised N)	3	30	131	65	225
Full N – (min N + Quick N Tool)	4	38	37	80	155
Nil Fertiliser N	5	0	0	0	0

Initial mineral N = 29 kg/ha

Mineralised N = 47 kg/ha

Dryland Wheat		Fertiliser N applied (kg N/ha)			
Target grain yield = 8 t/ha	Trt No.	Early N	GS 32	GS39	Total N
Full N rate	1	40	107	53	200
Full N – mineral N	2	34	92	45	171
Full N – (min N + Mineralised N)	3	25	66	33	124
Full N – (min N + Quick N Tool)	4	34	23	38	95
Nil Fertiliser N	5	0	0	0	0

Performance Indicators

Irrigated Wheat (Target yield = 12 t/ha)

Treatment	N Fertiliser (kg/ha)	Grain Yield (t/ha)	Residual Min-N (kg/ha)	N Fert cost ($/ha)	Emissions (kg CO_2-e/ha)
Full N	300	12.1	65.5	842	1460
Full – min N	282	12.0	46.9	793	1373
Full – min N + N_{min}	225	12.0	30.9	632	1096
Full + Quick N	155	9.2	30.5	434	752
Zero N	0	5.6	28.2	0	0
LSD (0.05)		0.7	8.3		

N fertiliser price assumed = $1289/t (SustaiN)

Performance Indicators

Dryland Wheat (Target yield = 8 t/ha)

Treatment	N Fertiliser (kg/ha)	Grain Yield (t/ha)	Residual Min-N (kg/ha)	N Fert cost ($/ha)	Emissions (kg CO_2-e/ha)
Full N	200	10.2	12.3	561	973
Full – min N	171	9.6	9.7	482	835
Full – min N + N_{min}	124	9.0	13.9	348	603
Full + Quick N	95	7.9	15.2	268	464
Zero N	0	5.4	10.7	0	0
LSD (0.05)		0.4	NS		

N fertiliser price assumed = $1289/t (SustaiN)

Conclusions

- SOM can be important source plant available N
  - Pre-existing test methods and model predictions are poor
  - Major limitation to fertiliser N forecasting
- HWEON can be used to predict PMN
  - Site specific, varies with soil type and land use history
  - Commercial testing available, highly reproducible
  - PMN ≠ actual (in-field) N mineralisation
- In-field N mineralisation can be predicted
  - PMN test and local soil temperature and water content data
  - Field N balance data verify N mineralisation predictions
  - Soil test data can improve fertiliser forecasting with no yield penalty, other benefits.

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Rangahau Ahumāra Kai

Thank You

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