Biological factors influence N mineralization from SOM and crop residues in Australian cropping systems

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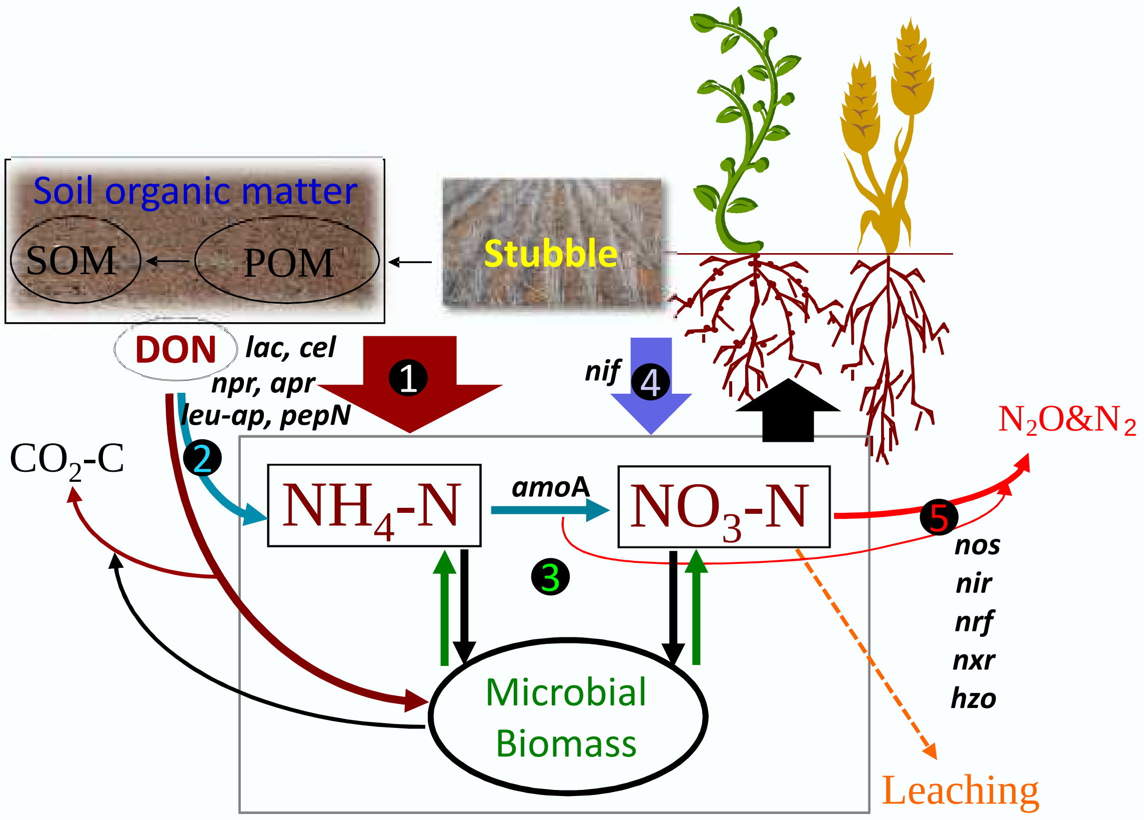
Processes, Factors and Prediction

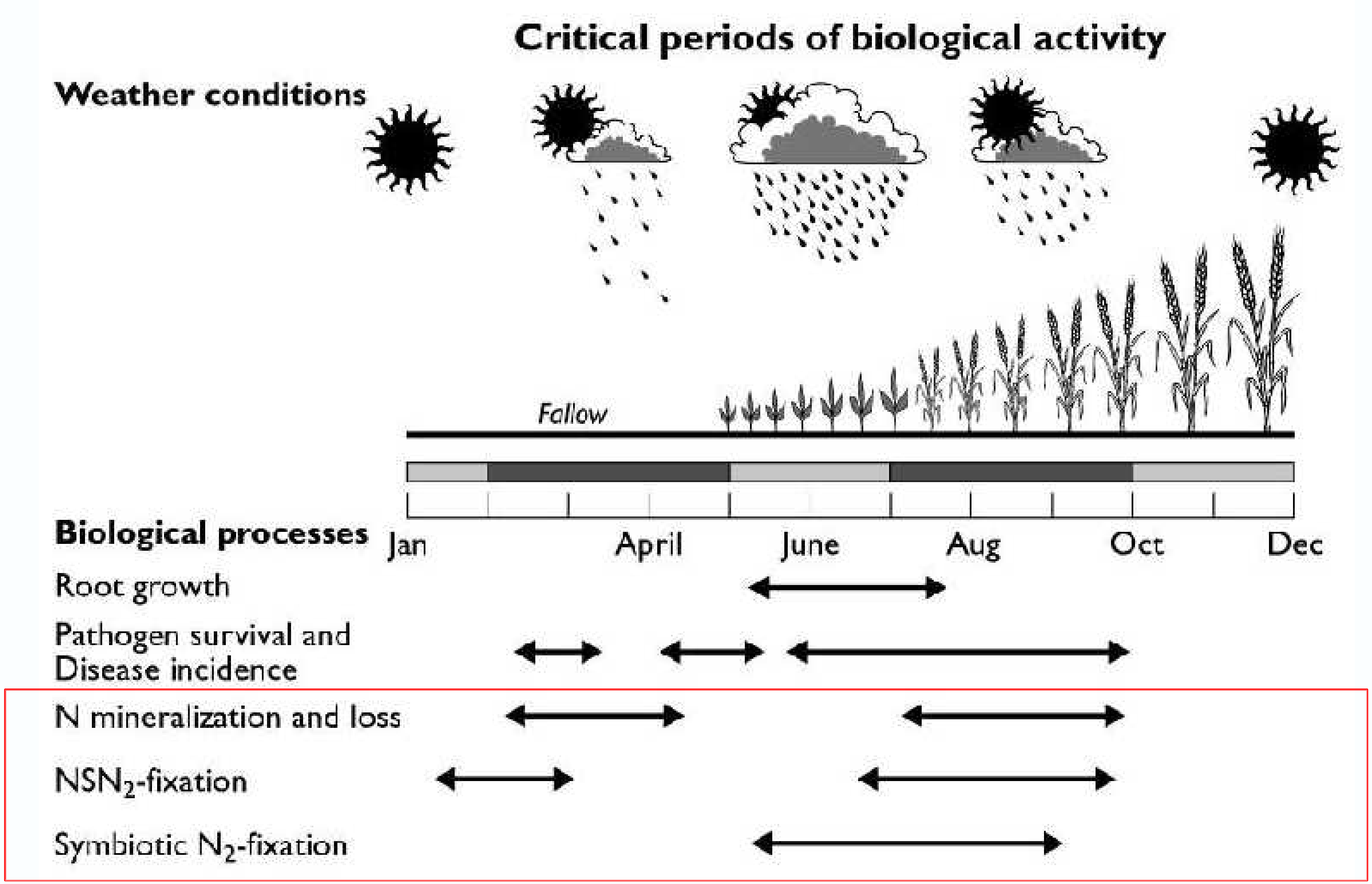


1. N_2 fixation
2. Decomposition & Depolymerization
3. Mineralization
   - ammonification
   - Nitrification
   - Immobilization
4. Microbial turnover
5. Denitrification & gaseous losses

- Soil type, management practices and crop type can influence diversity and abundance and along with environment affect biological processes

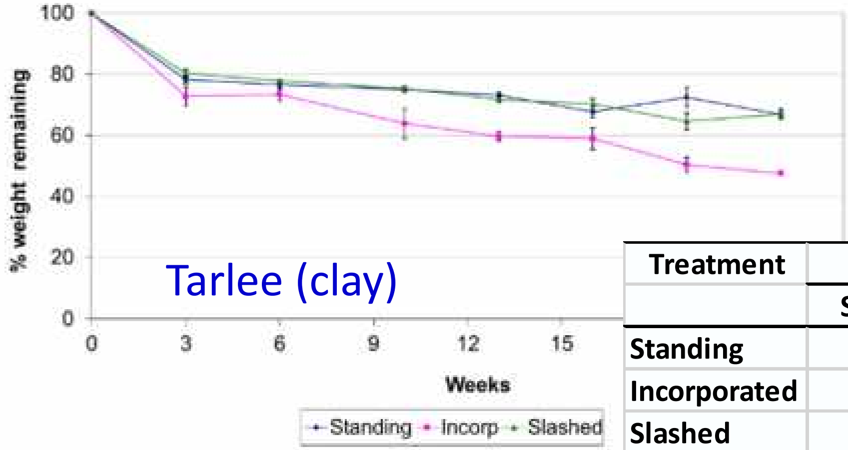
Temporal significance varies with different soil biological processes

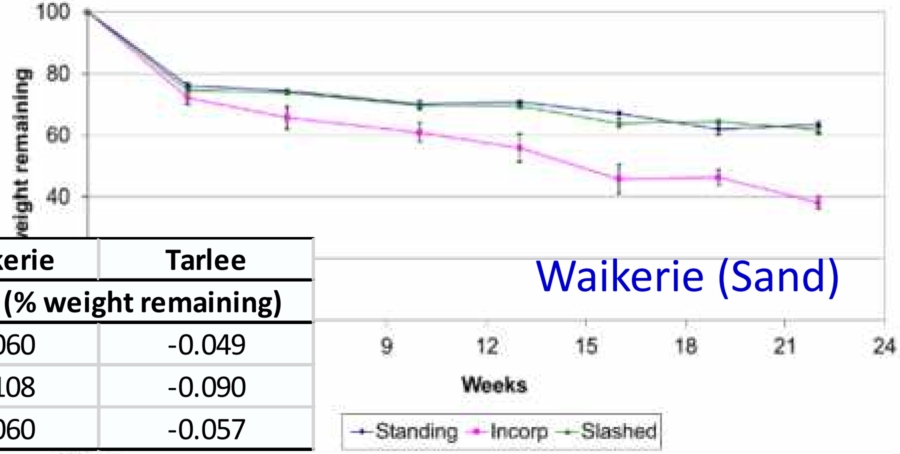
Gupta et al. (2011)



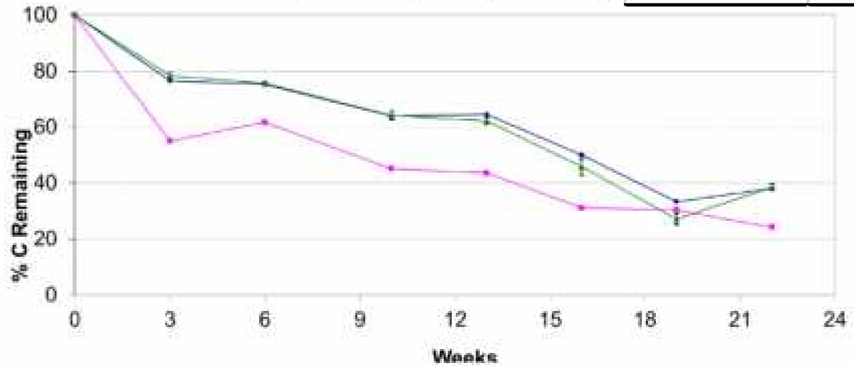
- Crop rotation
- Stubble retention
- Tillage

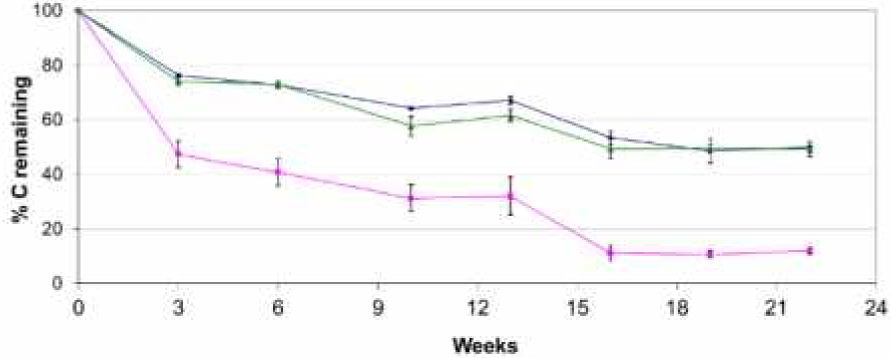
Decomposition of wheat residue

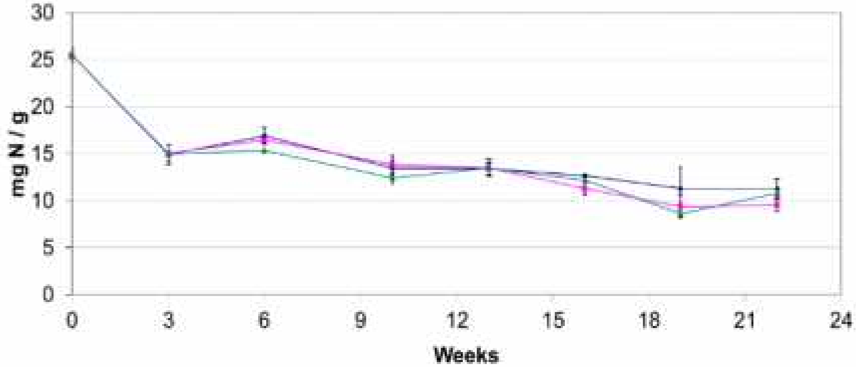


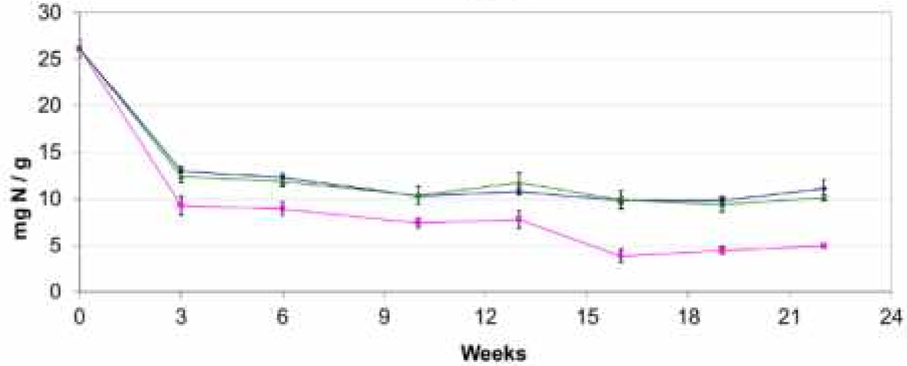


Treatment	Waikerie	Tarlee
	Slope (% weight remaining)	
Standing	-0.060	-0.049
Incorporated	-0.108	-0.090
Slashed	-0.060	-0.057









Gupta, Lardner, Kroker and Roget (2010)

Nitrogen dynamics in stubble retained systems

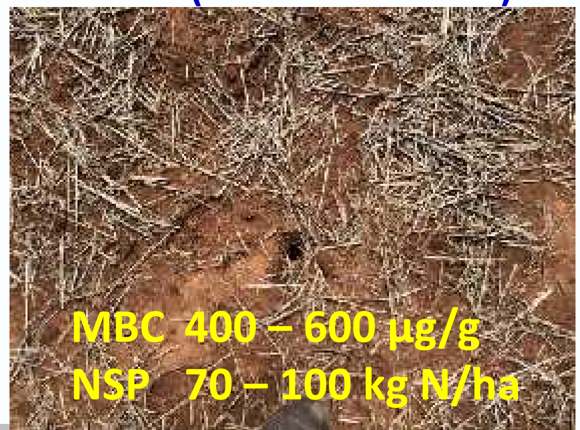
- N from legume residues to the next cereal crop: 25-35%
- N from cereal residues to the next cereal crop:

Location	Treatment	N in Stubble (kg N/ha)	N in next crop (% stubble N)
Karoonda	Surface	12	2.1
	Incorp		3.1
Temora	Surface	55	8.7
	Incorp		15.4
Horsham	Surface	32	4.4
	Incorp		5.0

Karoonda (Sand)

Horsham (Clay)

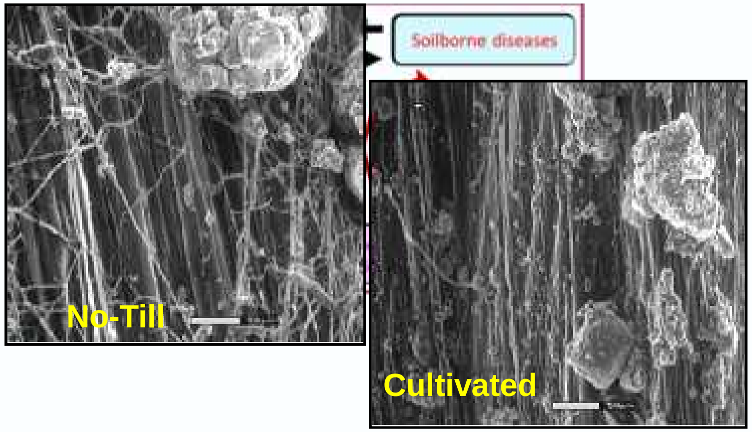
Temora (Reb brown earth)

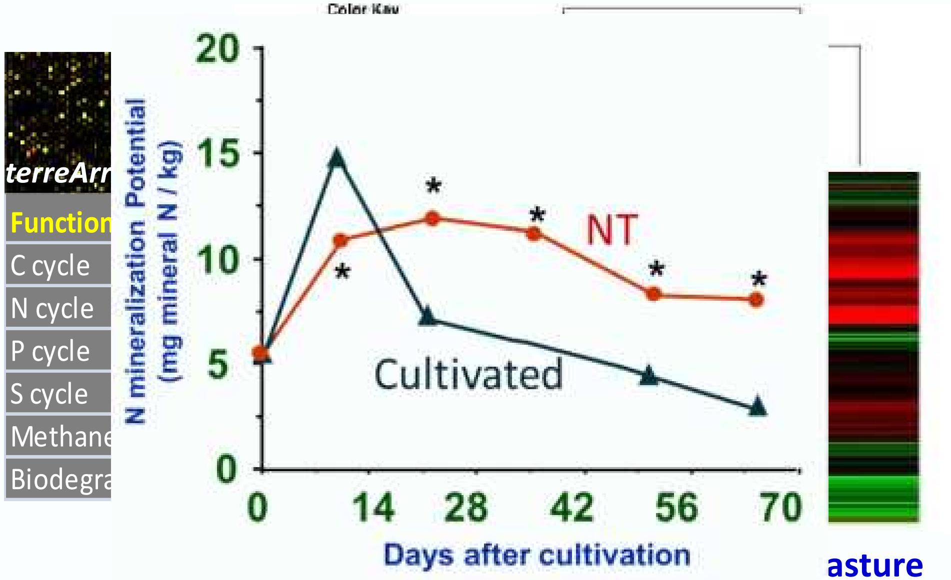


Gupta, McBeath, Richardson, Kirkegaard, Sanderman (CSIRO unpublished)

Soil microbial communities and C and nutrient turnover

- Stubble retention and No-till modifies microbial turnover: mineralization-immobilization rates
- Cultivation can disrupt the linkages between different processes involved in N mineralization and loss – influence rate of release and N use efficiency (better synchronization)
- Plant type based enrichment / alteration of specific members of bacteria and fungi involved in C and nutrient cycling – functional gene diversity

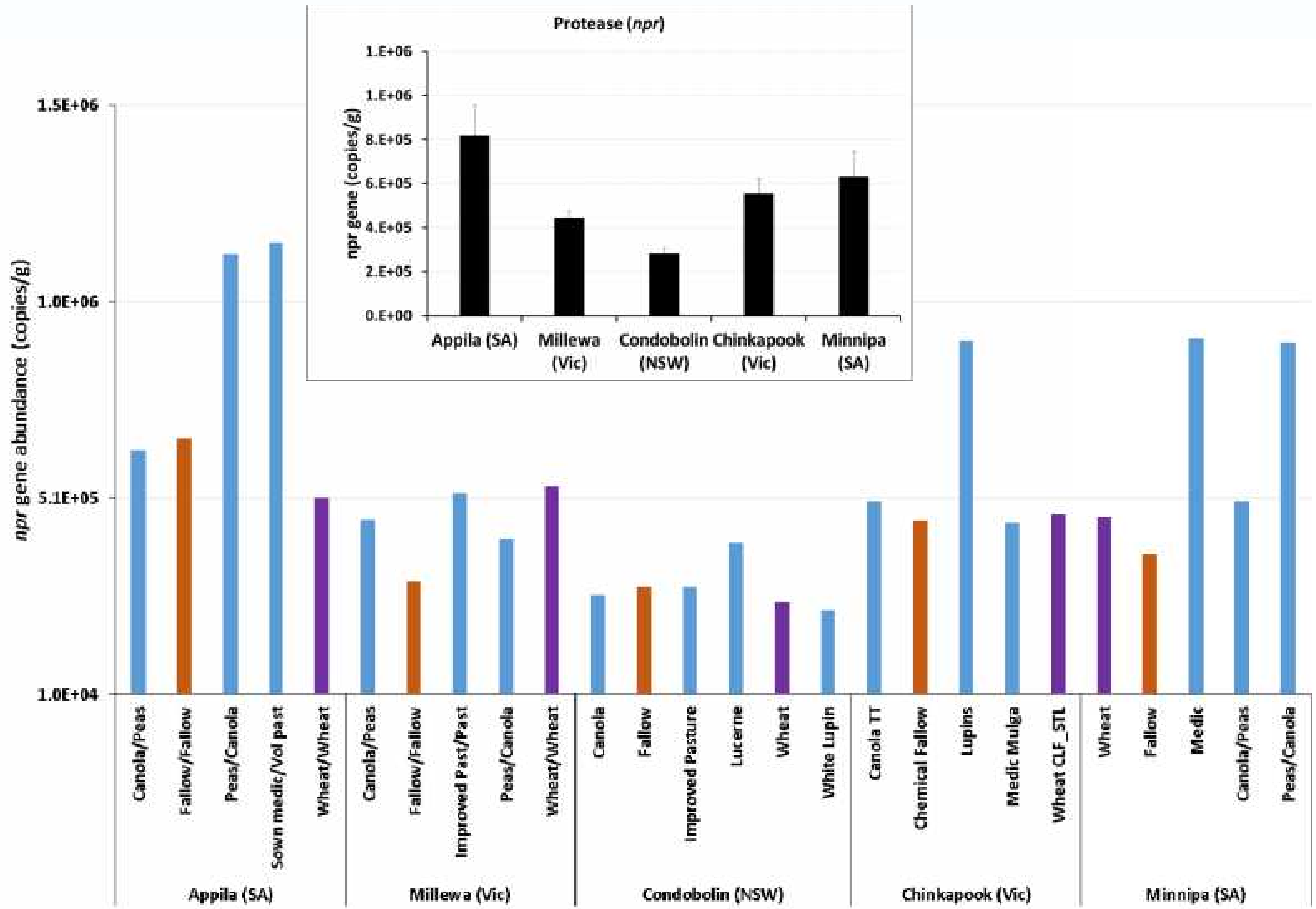




Significant probes	135		477	318
N mineralization (kg N/ha/day)	0.90	0.64	1.01	1.34

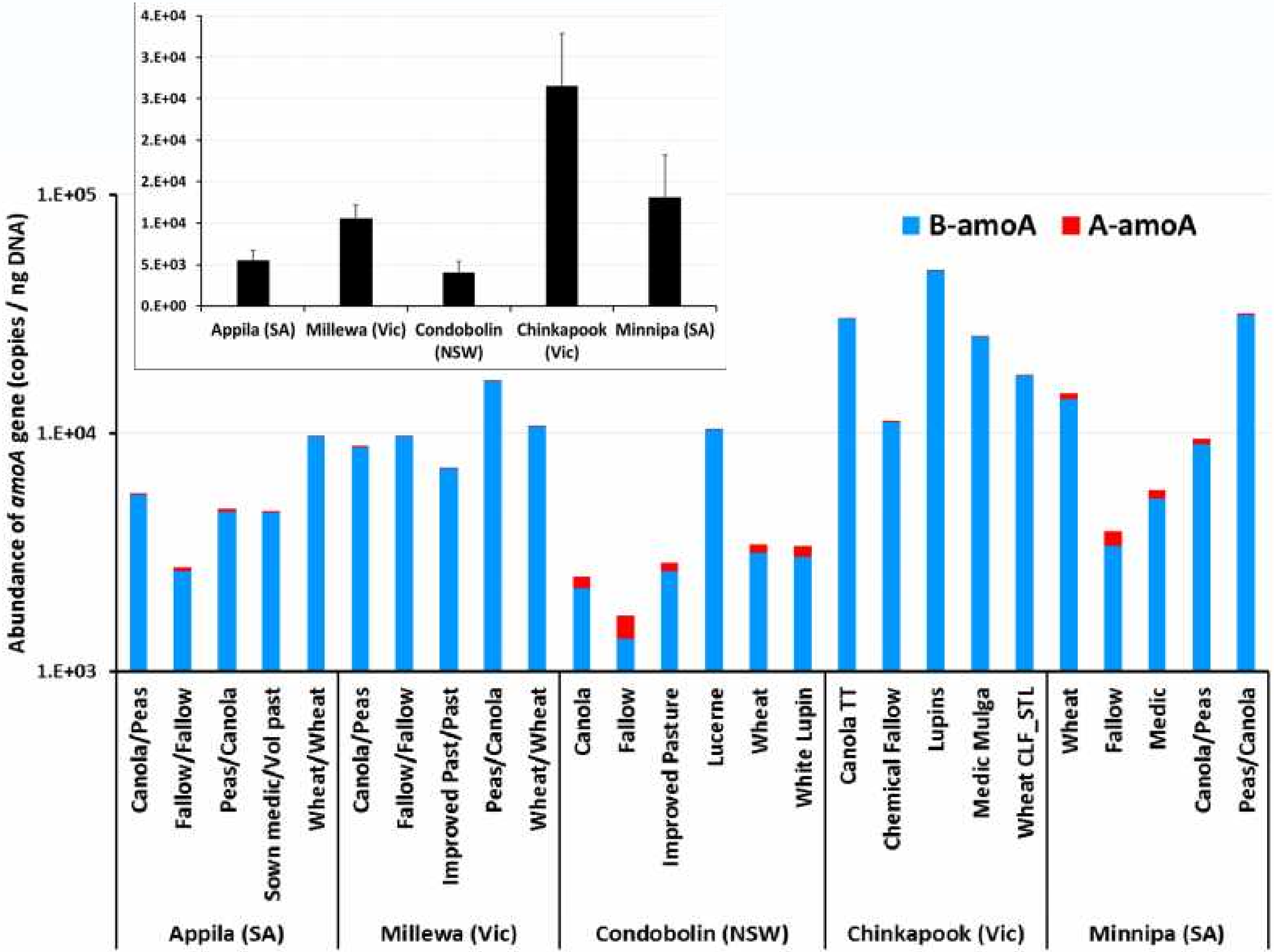
Gupta et al. 2010, 2011

Proteolytic community – *npr* gene abundance



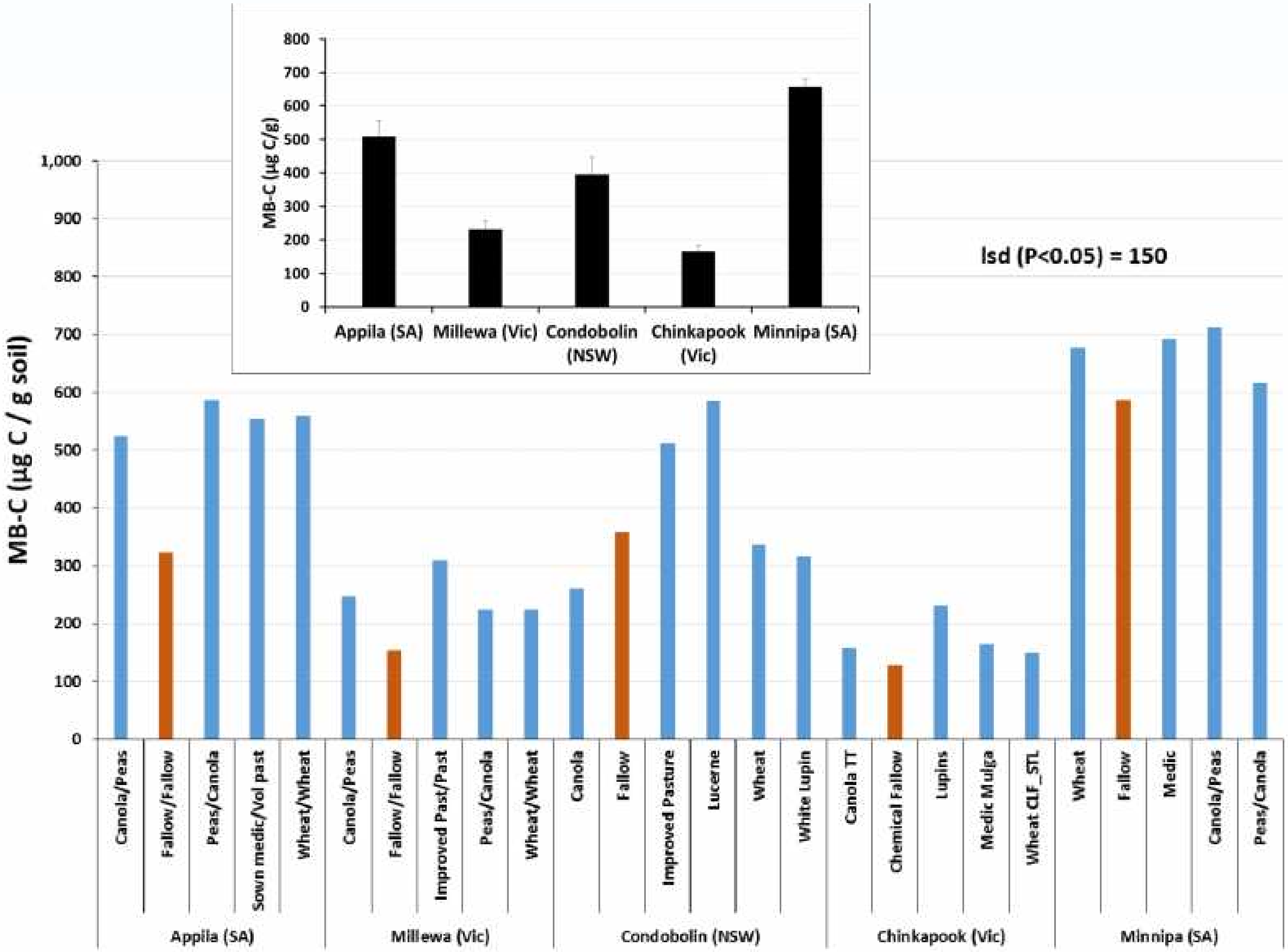
Gupta, Wilhelm, Kroker and Moodie (CSIRO unpublished)

Nitrifying bacteria – *amoA* gene abundance



Gupta, Wilhelm, Kroker and Moodie (CSIRO unpublished)

Microbial biomass carbon



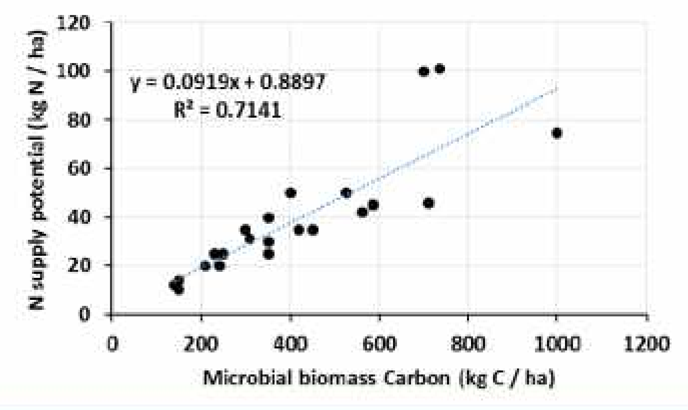
Gupta, Wilhelm, Kroker and Moodie (CSIRO unpublished)

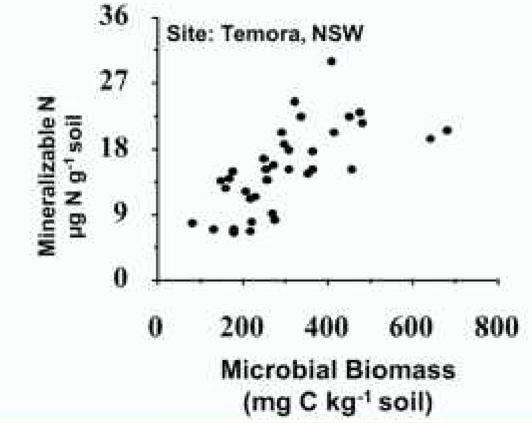
Microbial biomass and N supply potential

Table 1. Amount of microbial biomass and N supply and immobilization potentials (for the crop growth period) in agricultural soils.

Location	Soil type	MB-C	N immobilization potential[&]	N supply potential[$]
		kg C / ha	kg N / ha	
Waikerie/Karoonda, SA	Sand and sandy loam	150 - 300	12 - 22	10 - 35
Streaky Bay, SA	Calcarosol	210 - 400	15 - 30	20 - 50
Wongan Hills, WA	Loamy sand	250 - 350	18 - 25	25 - 40
Kerrabee, NSW	Loam	420 - 525	30 - 40	35 - 50
Temora, NSW	Red earth	500 - 735	35 - 55	50 - 100
Rutherglen, Vic	Red brown earth	350 - 700	25 - 50	30 - 100
Leeton/Warialda, NSW	Clay	350 - 1000	25 - 70	25 - 75

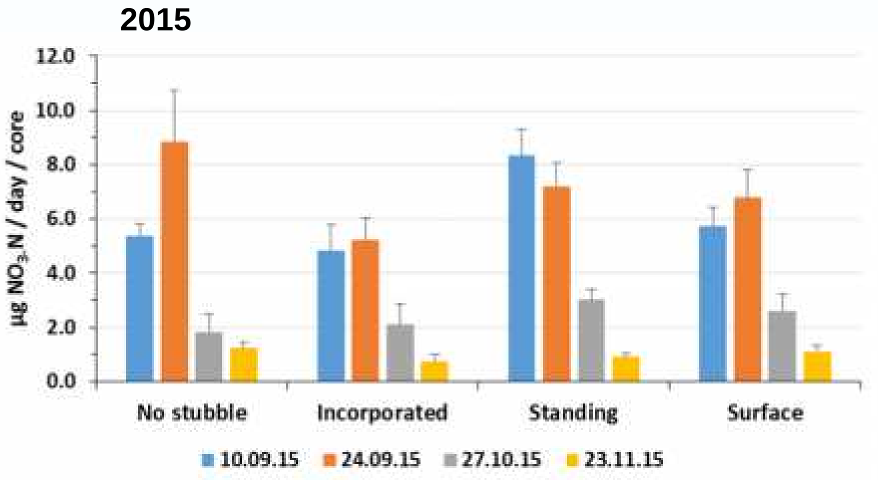
[&] N immobilization potential is estimated assuming an average 50% increase of *in-crop* microbial biomass.
[$] N supply potential is calculated from N in MB plus N mineralization measured in a lab-incubation assay.

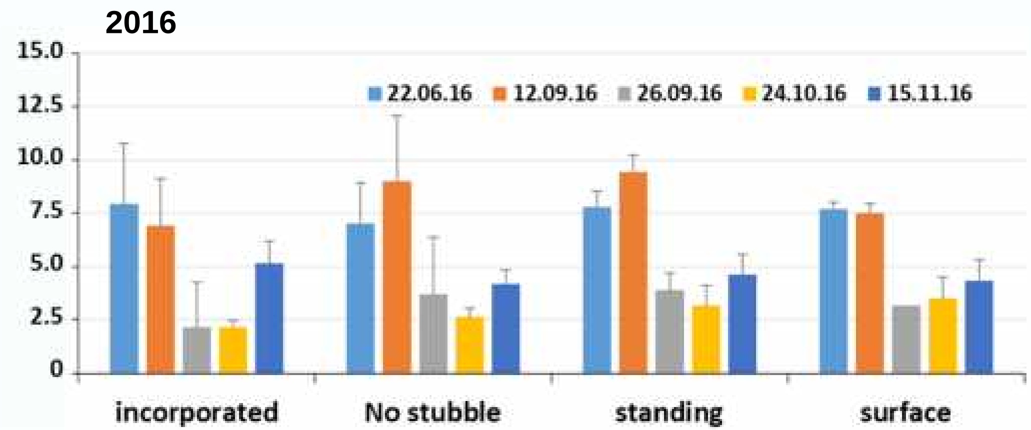




In-situ N mineralization during crop season (Karoonda 2015 & 16) (Wheat after Wheat)

Resin strip in Raison tubes





- Seasonal conditions effects on microbial turnover major factor

Gupta V.V.S.R. et al. CSIRO Unpublished

Conclusions

- Nitrogen mineralized from SOM and crop residues makes a substantial contribution to crop N uptake.
- Management strategies and crop and variety selection can help manipulate microbial communities involved in N mineralization
  - Abundance of proteolytic bacteria (*npr* genes) vary with soil type and legumes
  - The abundance and the type of nitrifiers (bacteria vs. archaea) present varies with soil type and depth; AOB most responsive
  - MB - size and rate of turnover influences $N_{mineralization}$ and $N_{immobilization}$ and also influence fertilizer N use efficiency.
- N supply potential estimates need to reflect soil's biological capacity and microbial turnover as influenced by seasonal conditions!

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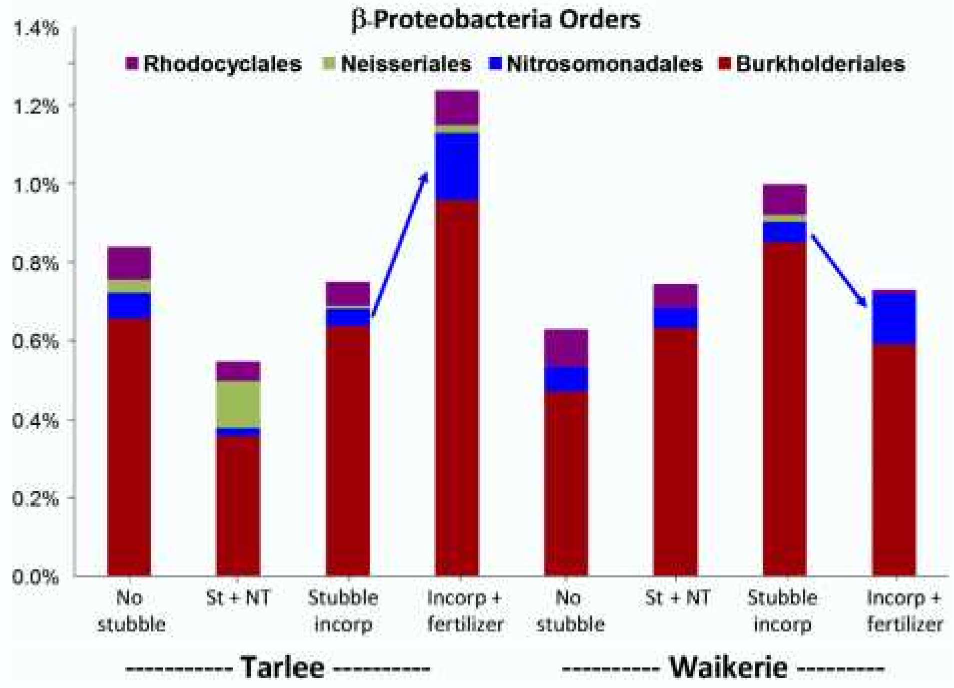
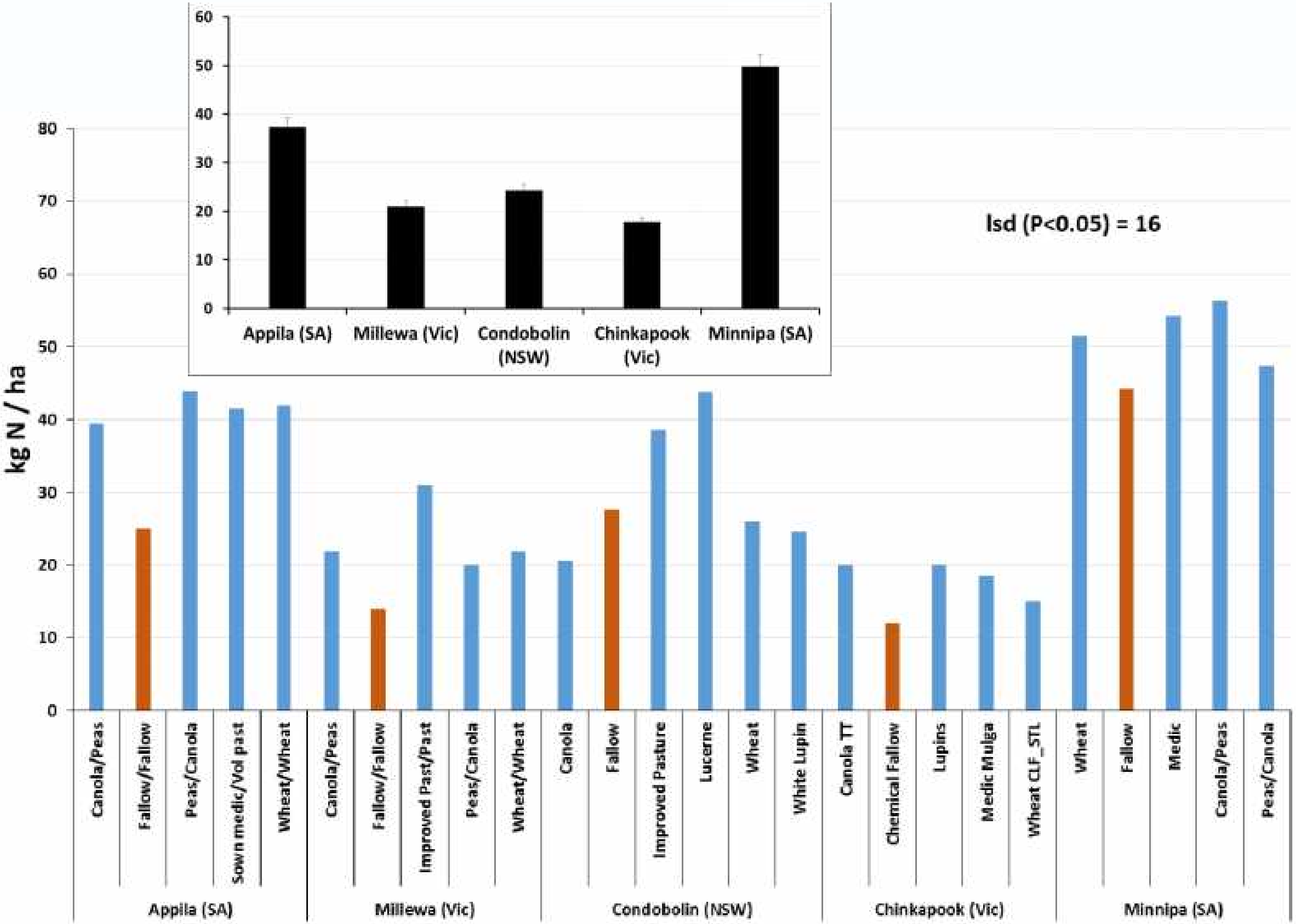
Nitrification: factors and management effects

- Nitrifiers which are mostly abundant in the surface soils and their activity can be influenced by management practices.
- The abundance and the type of nitrifiers (bacteria vs. archaea) present varies with soil type and depth.
- Banding fertilizers can influence the activity of these microbes and the accumulation of nitrate N (Angus, Gupta et al. 2014).
- Fertilizer N use efficiency could be manipulated by targeting fertilizer placement or the use of nitrification inhibitors



Gupta et al. (2010)

Nitrogen supply potential



Gupta, Wilhelm, Kroker and Moodie (CSIRO unpublished)

Biological factors influence N mineralization from soil organic matter and crop residues in Australian cropping systems

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Abstract

Nitrogen mineralized from the soil organic matter (SOM) and crop residues makes a substantial contribution to crop N uptake. Soil N supply comes from soil organic matter and recent crop residues and the rate of supply is influenced by the soil biological capacity, i.e. microbial biomass (MB) and microbial turnover, and modulated by management and environmental factors. Soil type, crop rotation and management practices associated with tillage, stubble retention and fertilizer application can influence the diversity of microbial populations and the size of MB, and along with the environment they affect biological processes involved in N_2 fixation, mineralization and availability and losses. The rate and timing of the availability of N from stubble to the following crops is determined by the rate of decomposition and immobilization by soil microorganisms (N in MB). The amount of MB-C & N vary with soil type, crop rotation, tillage and other management practices that can influence microbial populations. In southern Australian cropping regions, the effect of loss of N from stubble removal may not be greater than its temporary tie-up during decomposition.

Key Words

Nitrogen, mineralization, immobilization, microbial biomass, microbial diversity, *amo*A, *nif*H