Nitrogen mineralisation and impacts on fertiliser efficiency in pastures

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More Profit from Nitrogen

Australian Government
Department of Agriculture and Water Resources

Dairy Australia

IPL Agronomy Forum, 20th July, 2018

Motivation for Research Program

High Inputs of Nitrogen into dairy pastures

- SW Vic, average 40 kg N/ ha/ application = 200 - 480 kg N/year depending on dryland / irrigated
- or 1-2 kg N/ha/day
- + 1000 kg N/ha as urine (20% coverage)
- + manure (3% N)

Q: Is there too much N going into dairy pasture, how much is stored, and can we reduce the fertiliser inputs by using soil stored N?

Motivation for Research Program

Low nitrogen use efficiency from urea

Example: Research at Murroon, SW Vic

	Autumn	Spring
Agronomic N efficiency (kg pasture increase per kg N applied)	8	18
Apparent recovery efficiency (%) (net kg of N taken up per kg N applied)	34	76

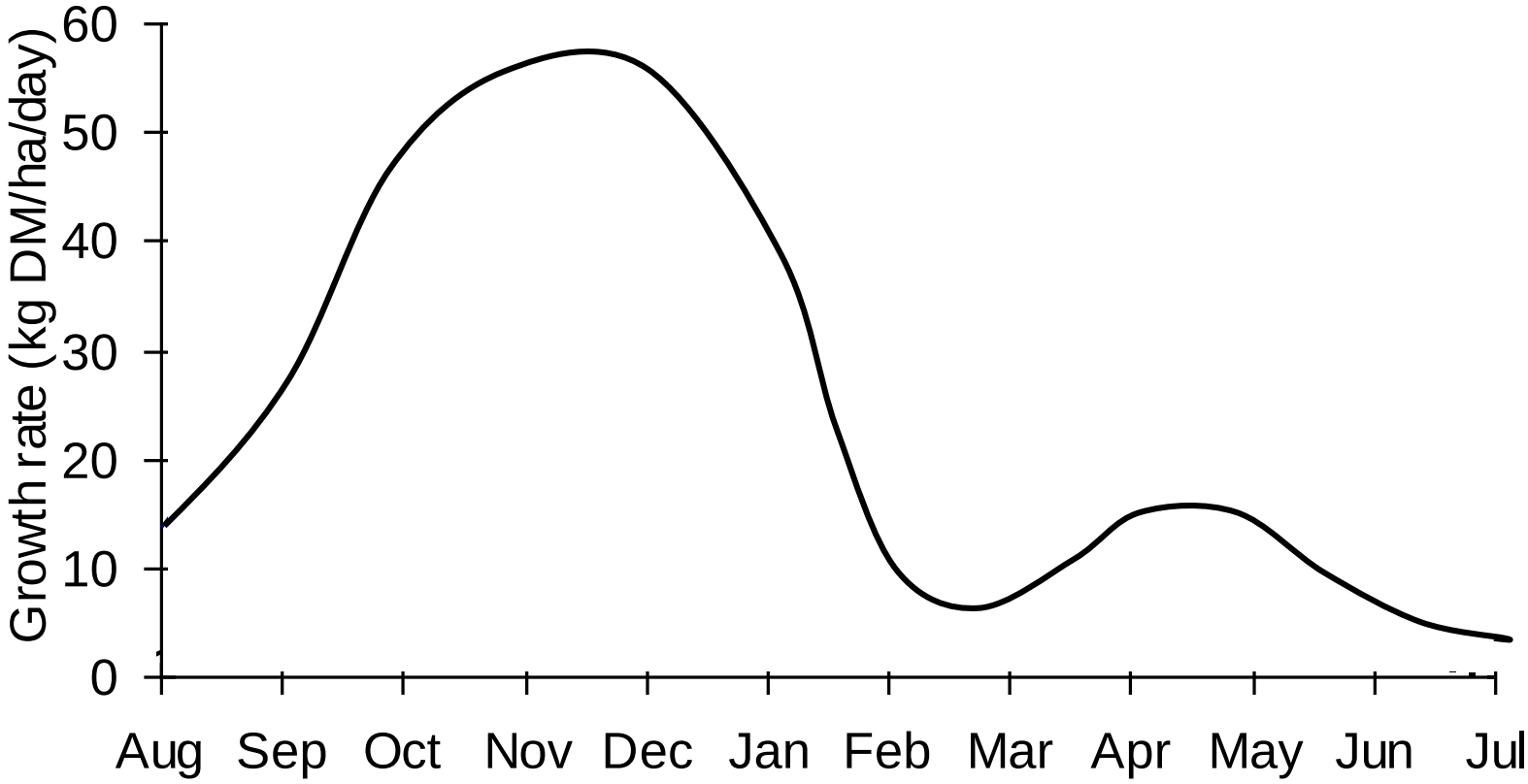
Ammonia volatilisation – up to 30%

Q: Can we reduce N inputs and improve NUE without affecting productivity?

Suter et al. (2013) Nutrient Cycling in Agroecosystems

Motivation for Research Program

Variable seasonal pasture growth

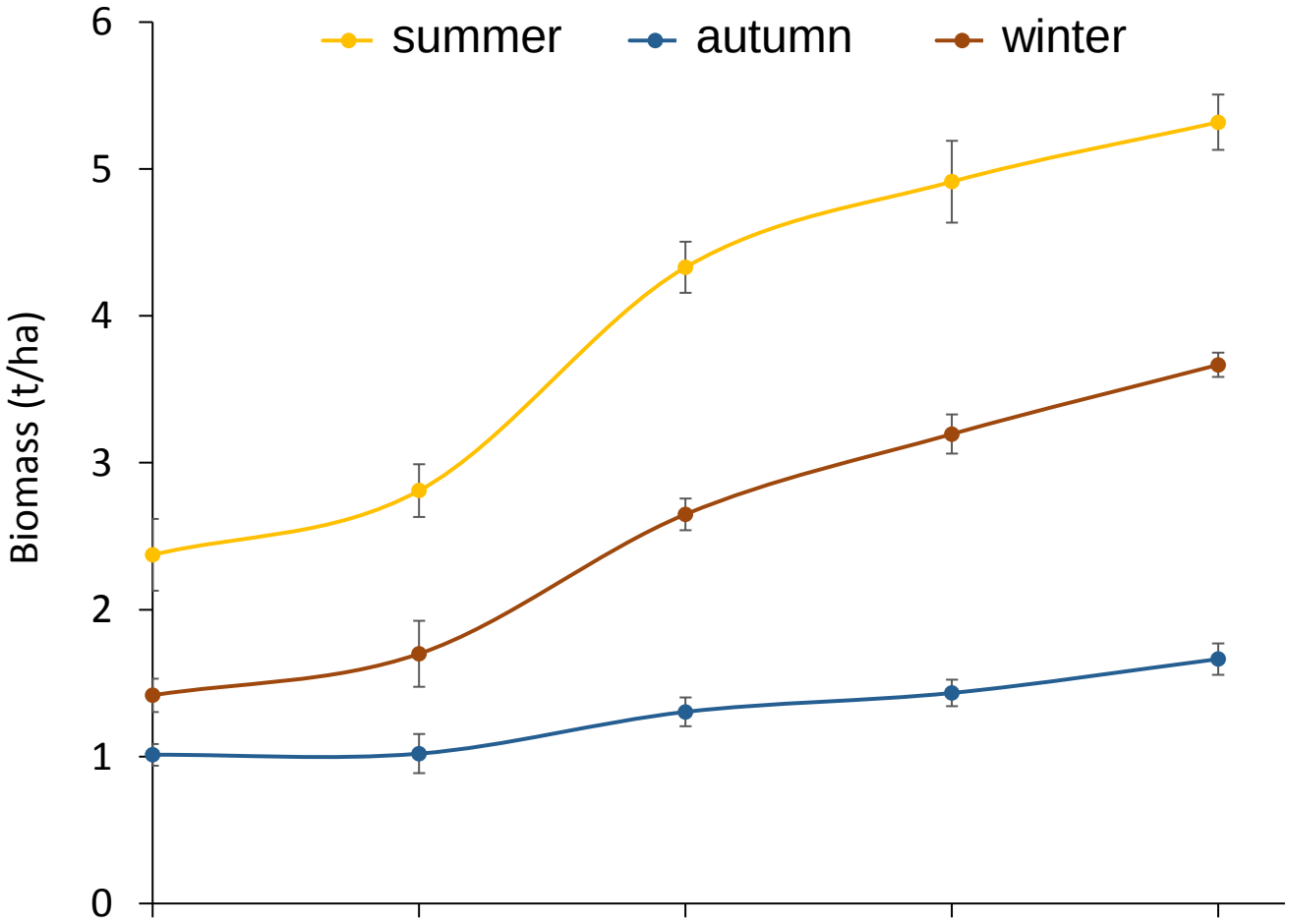


Q: Can we modify N fertilisers in line with the plant growth requirements and use soil N in its place at key times?

Eckard (1998) A critical review of research on the nitrogen nutrition of dairy pastures in Victoria

Motivation for Research Program

Variable seasonal nitrogen response curves

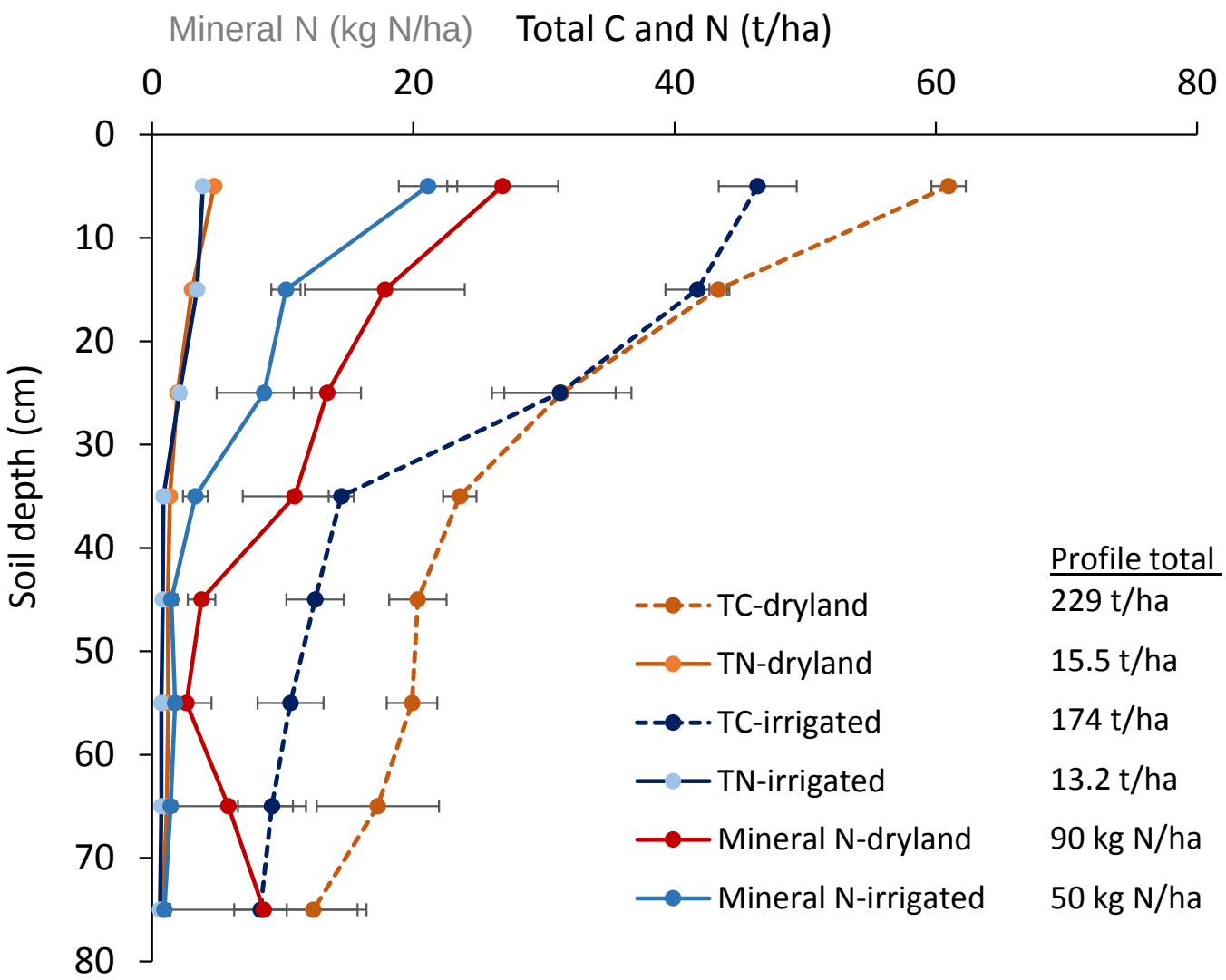


Q: Could the reason for a flat autumn N response be mineralisation with autumn rains?

Motivation for Research Program

High organic matter content

Example: SW Vic - Autumn soil nitrogen supply in the profile



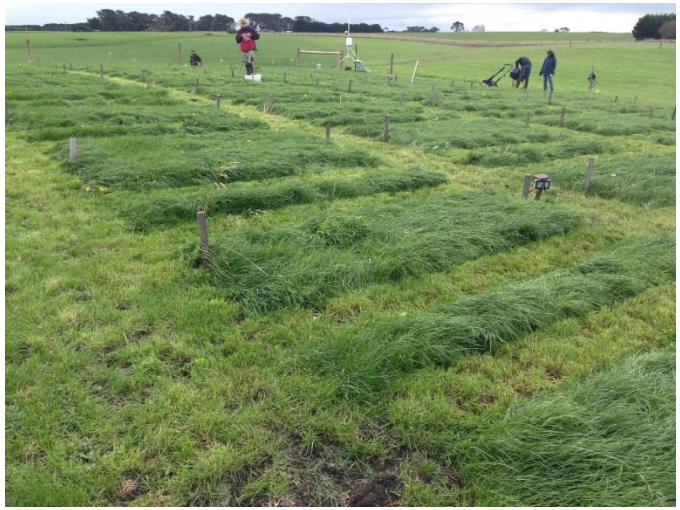
	Profile total	C:N
TC-dryland	229 t/ha	
TN-dryland	15.5 t/ha	15:1
TC-irrigated	174 t/ha	
TN-irrigated	13.2 t/ha	13:1
Mineral N-dryland	90 kg N/ha	⇨ 0.6% of TN
Mineral N-irrigated	50 kg N/ha	⇨ 0.4% of TN

Investigation of Mineralisation

- Q: Can the soil organic matter pool be effectively utilised for N nutrition?
- Q: Is it possible to drop N rates at particular times of the year without impacting biomass response at the time and into the future?
- Q: Can we estimate the amount of N that is likely to be provided from soil mineralisation at these times?

Research Program

- Two small plot trials operating at 1 farm
  - Dryland and Irrigated
- Site: Mepunga West, SW Victoria
- Perennial ryegrass dominant pastures
- N response trials (urea: 0, 20, 40, 60, 80 kg N/ha) + urine



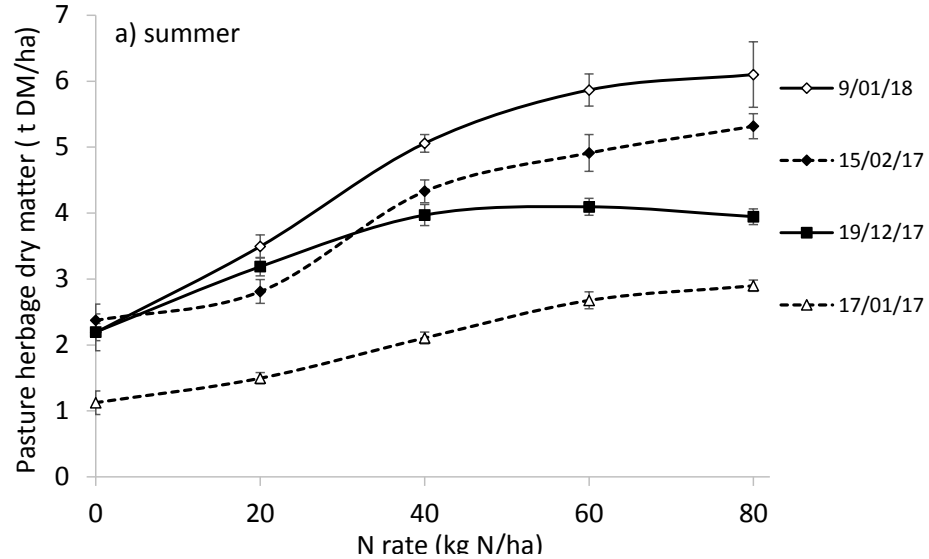
Research Program

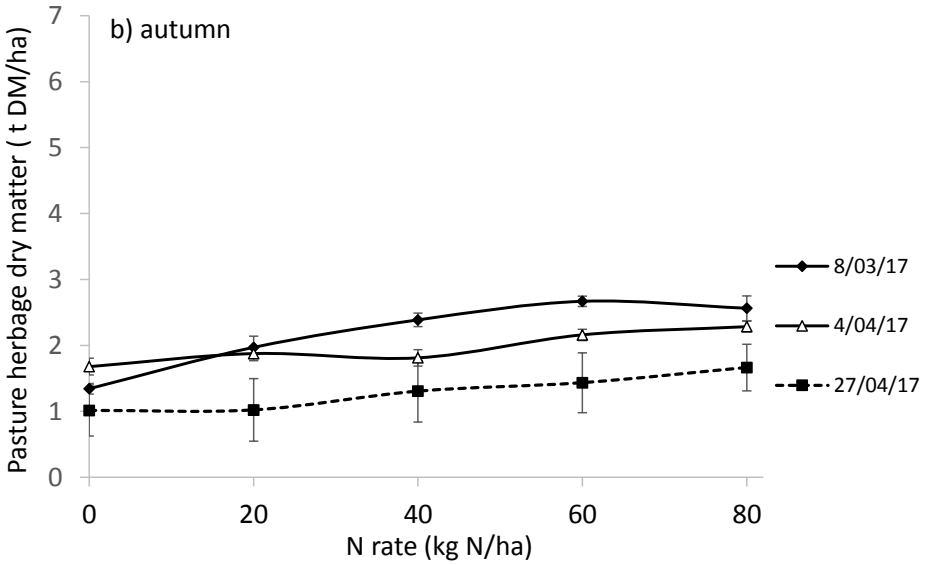
- 1.5 years
- Pasture biomass and N
- Stock exclusion, full removal
- Soil total C and N, mineral N
- Soil and ambient moisture, temperature

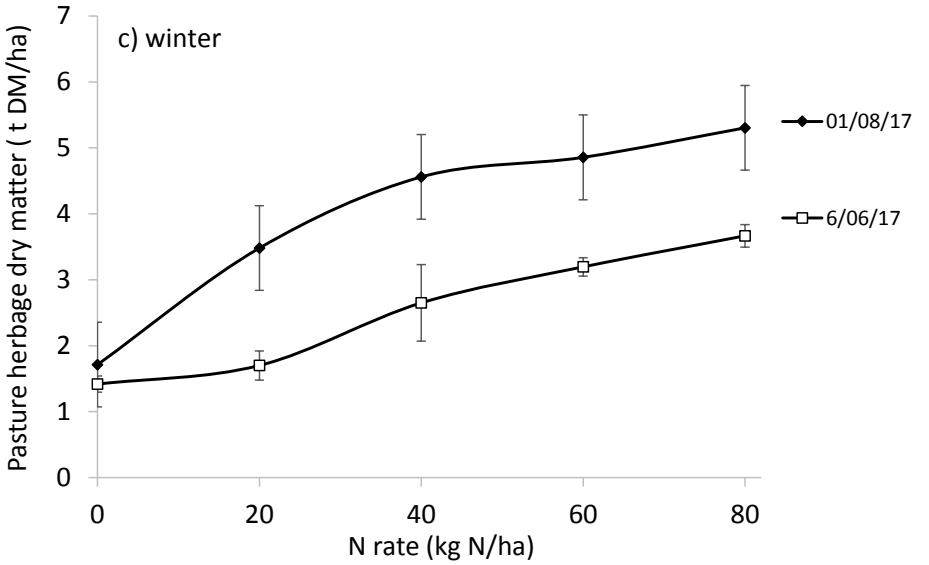
Research Program: NUE assessment

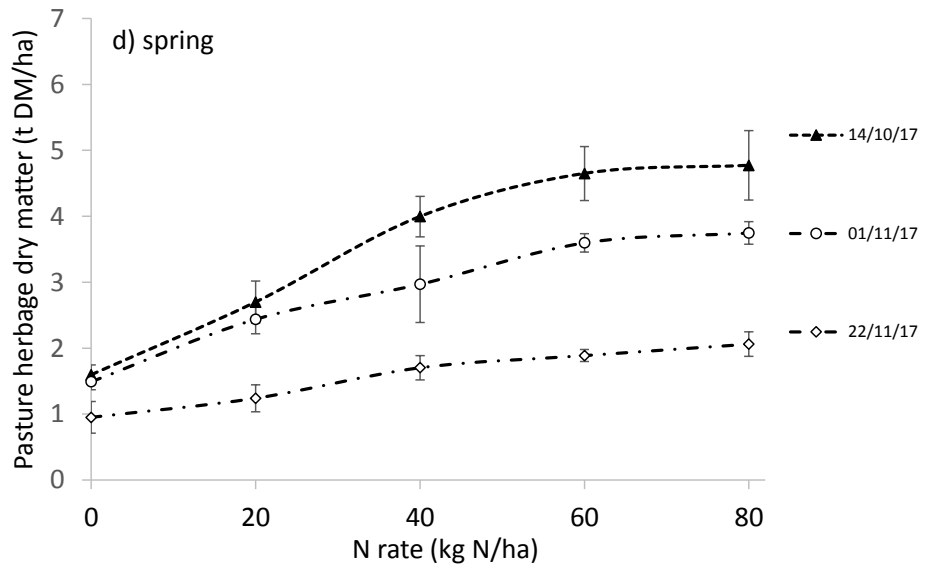
- ^{15}N techniques
- Modelling
- Potentially mineralisable N

Nitrogen Response : Irrigated









Nitrogen Use Efficiency: Urea – annual (20-80 kg N/ha)

	Dryland			Irrigated		
	Av.	Min.	Max.	Av.	Min.	Max.
Total N applied (kg/ha)	-	140	560	-	240	960
Annual Biomass Control (t DM /ha)	17	-	-	21	-	-
Annual Biomass Fertiliser (t DM/ha)	24	21	27	40	29	47
Annual N removed in Control (kg N/ha)	562	-	-	656	-	-
Annual Nitrogen Use Efficiency (Net-nitrogen removed /N input)	0.83	0.75	0.95	0.90	0.74	1.02
Annual Agronomic Nitrogen Use Efficiency (kg DM / kg N)	21	15	26	27	22	32

Soil supply of N : ^{15}N results Autumn break (late-April)

Soil supply of N : ^{15}N results Autumn break (late-April)

N rate (kg N/ha)	Dry matter (t/ha)	N removed by pasture (kg/ha)	^{15}N recovery (%)	Ndff (%)	Ndfs (%)
Dryland					
10	1.2	44	23	18.3	81.7
20	1.1	40	23	38.2	61.8
40	-	-	-	-	-
Irrigated					
10	0.7	27	18	5.9[c]	94.1[a]
20	1.0	39	24	11.0[b]	89.0[b]
40	1.1	45	25	20.5[a]	79.5[c]

Ndff : Nitrogen derived from fertiliser

Ndfs: Nitrogen derived from soil

Potentially mineralisable N (PMN)

Date	Location	TC	TN	PMN (0-10 cm)	
		(%)	(%)	(mg/ kg soil)	(kg /ha)
April-2017	Dryland	4.09	0.31	113.1	147.0
	Irrigated	3.37	0.27	95.5	114.6
Nov-2017	Dryland	3.37	0.25	44.9	58.4
	Irrigated	3.46	0.27	79.7	95.6

Acknowledgement: Phil Moody, Qld Department of Environment and Science

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	Irrigated	3.46	0.27	79.7	95.6	2.9

*BD 1.3 g/cm^3 and 1.2 g/cm^3 for dryland and irrigated systems respectively

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Potentially mineralisable N (PMN)

Date	Location	PMN (0-10 cm)	TN removed (^{15}N studies)		Ndfs (^{15}N studies)	
		(kg /ha)	@ 20 kg N/ha (kg/ha)	@ 40 kg N/ha (kg/ha)	@ 20 kg N/ha (kg/ha)	@ 40 kg N/ha (kg/ha)
April-2017	Dryland	147.0	40	-	25	-
	Irrigated	114.6	39	45	35	36

17 - 31% of the PMN taken up by the plant over 23 days of growth

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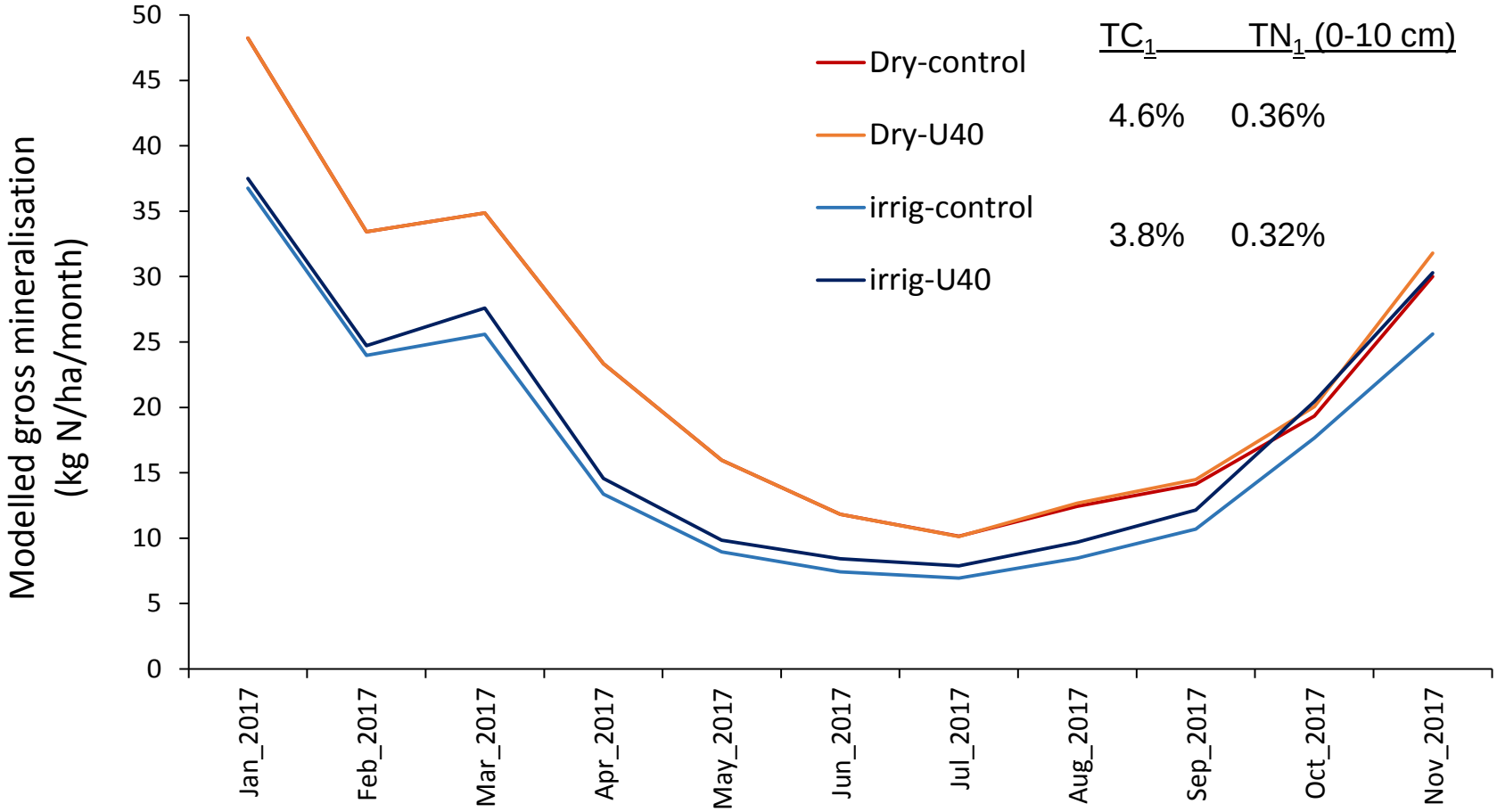
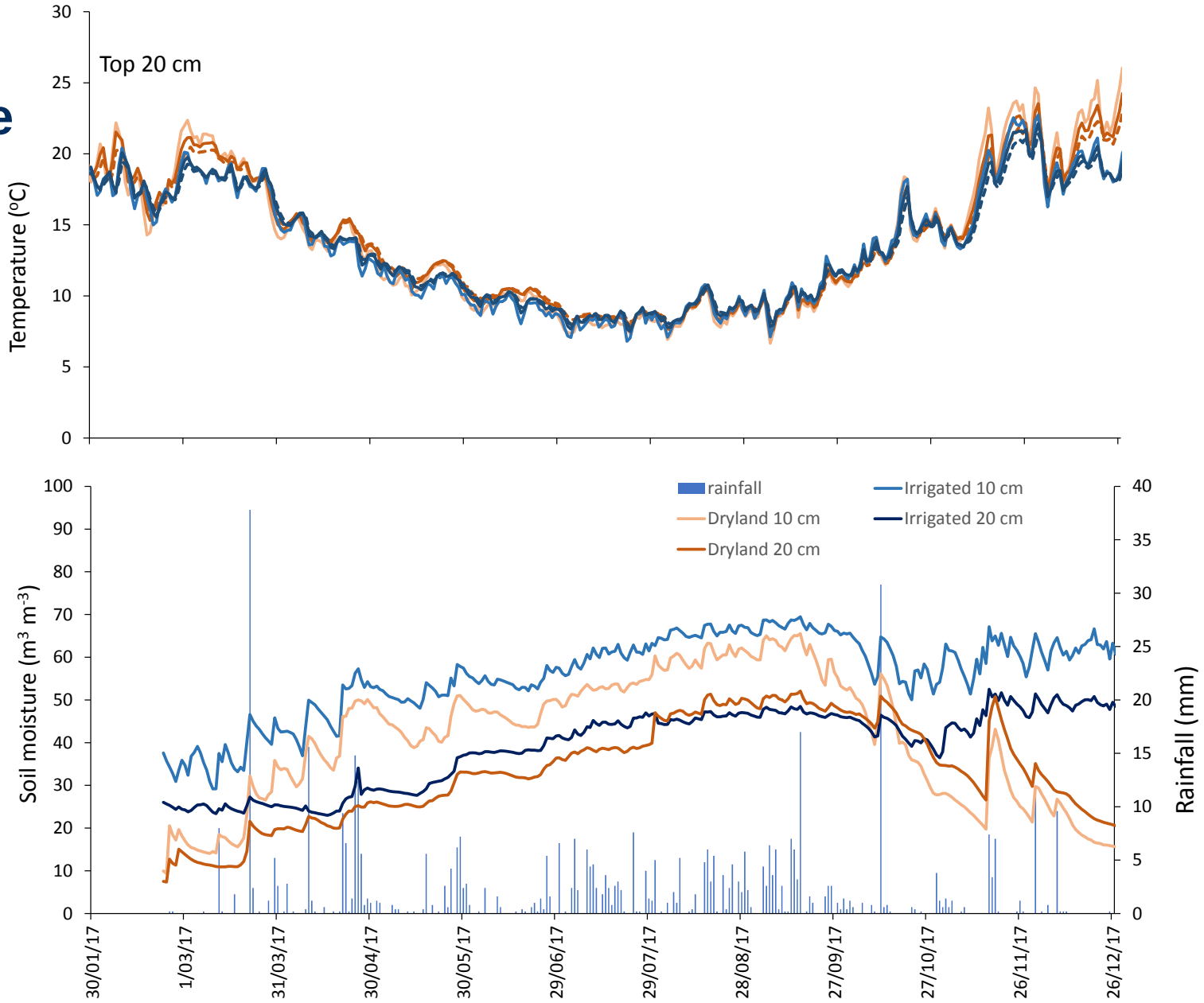
Climate influences : Estimation of mineralisation

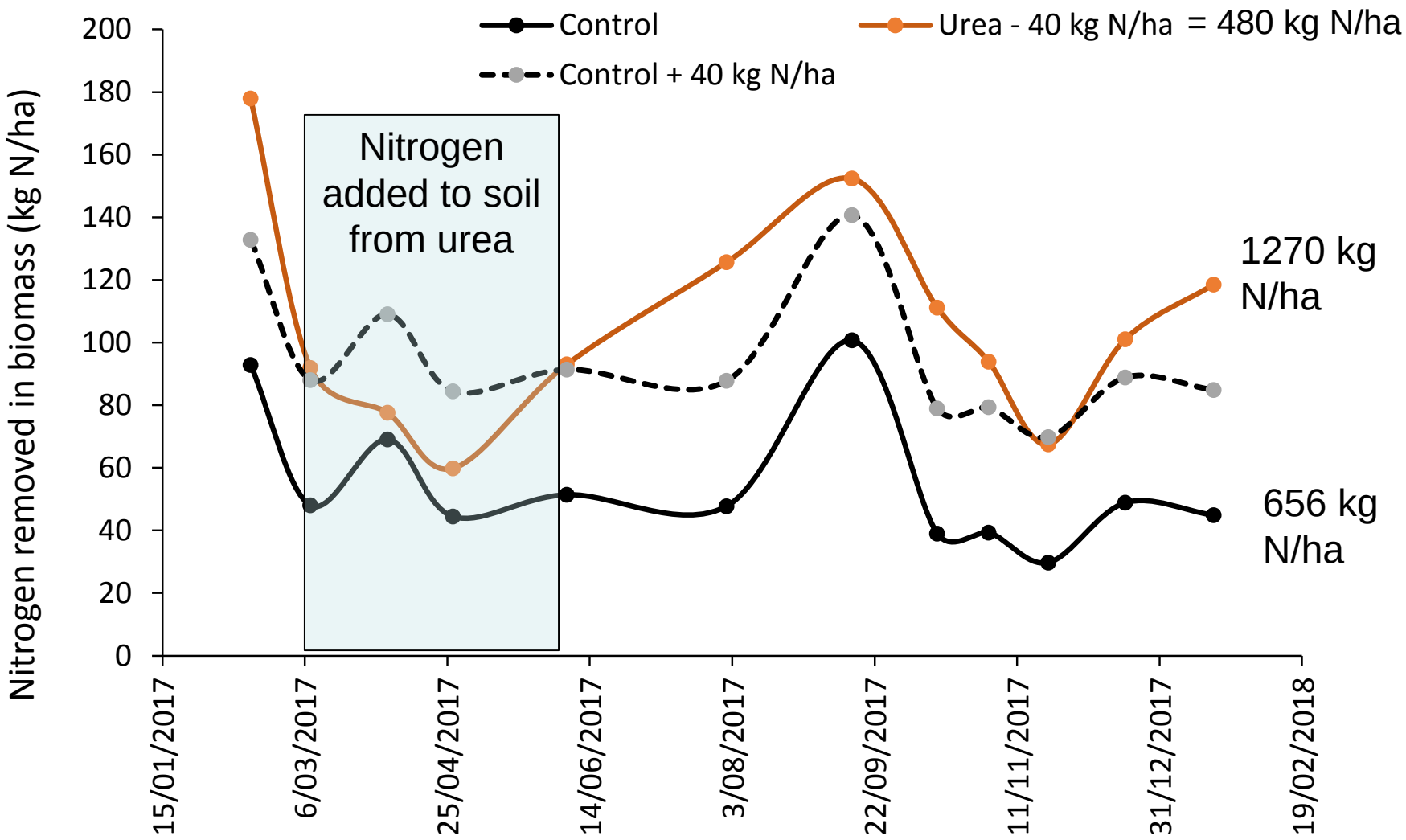
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
Ambient °C	23	23	25	19	16	14	13	13	15	18	23
Rain (mm)	53	55	60	75	37	24	65	56	72	43	24
Rain + irrig (mm)	164	157	137	105	54	35	99	100	170	100	217



Soil temperature & moisture



Annual N removal from irrigated pasture



Conclusions

- Q: Can the soil organic matter pool be effectively utilised for N nutrition?

Modelled estimates are <1% of total N is mineralised annually

<u>Autumn</u>

- PMN supply 115-147 kg N/ha

- > 60% of the N taken up by plants over 23 days comes from soil

= 25-36 kg N/ha

YES: The soil organic pool can supply N to pastures

Conclusions

- Q: Is it possible to drop N rates at particular times of the year without impacting biomass response at the time and into the future?

- YES: In autumn flat responses indicate that N fertiliser could be dropped without impact on biomass

+ Improvements in NUE

- However: Long term impacts are not known at this stage and additional N supply later may be required.
    - Small plot trial shows N mining from soil
    - No animal and pasture returns

Conclusions

- Q: Can we estimate the amount of N that is likely to be provided from soil mineralisation at these times?

- A WORK IN PROGRESS:

PMN values obtainable but climate and soil conditions will influence mineralisation

Good first estimates from model of mineralisation

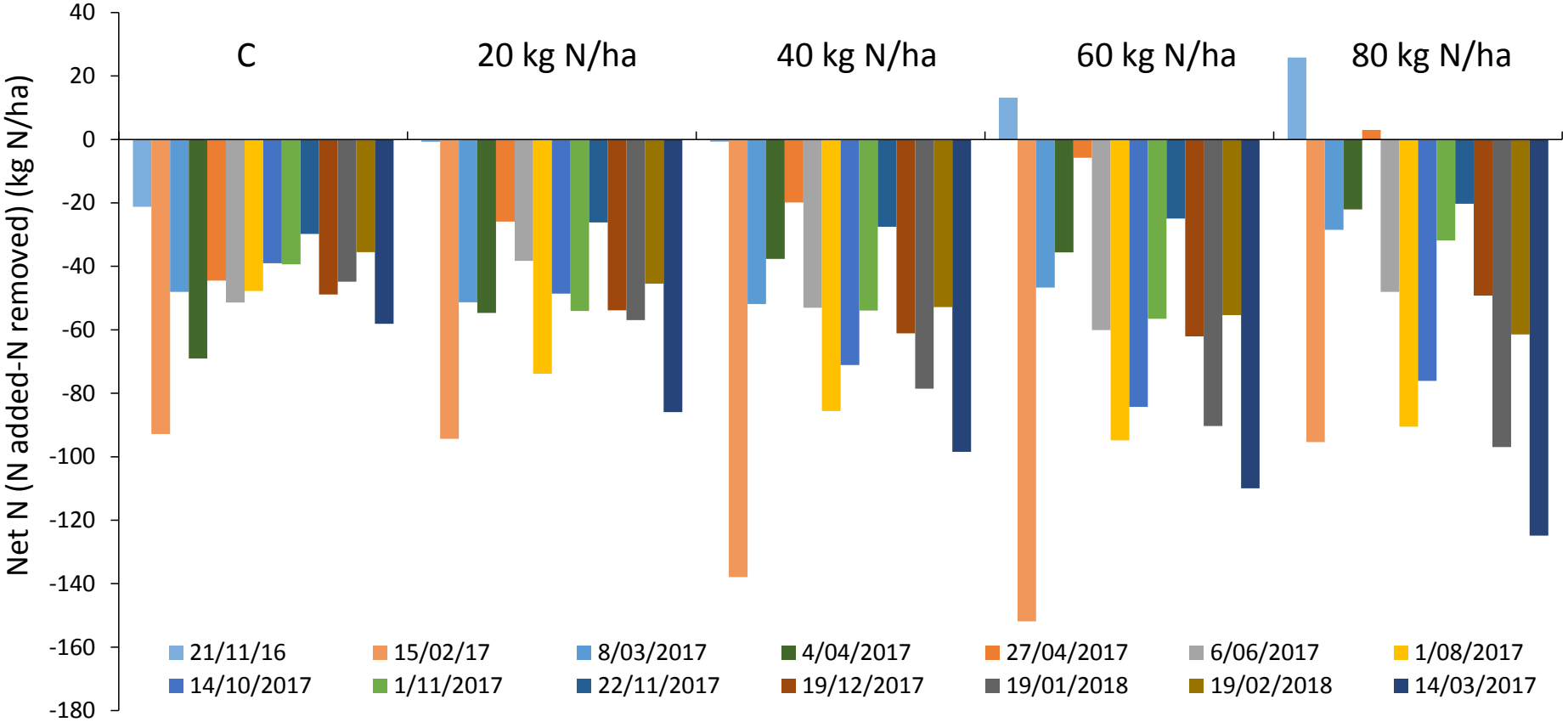
25-36 kg N/ha supplied in April -2017

N_2 fixation contribution unknown

Acknowledgments: Deli Chen, Jim He

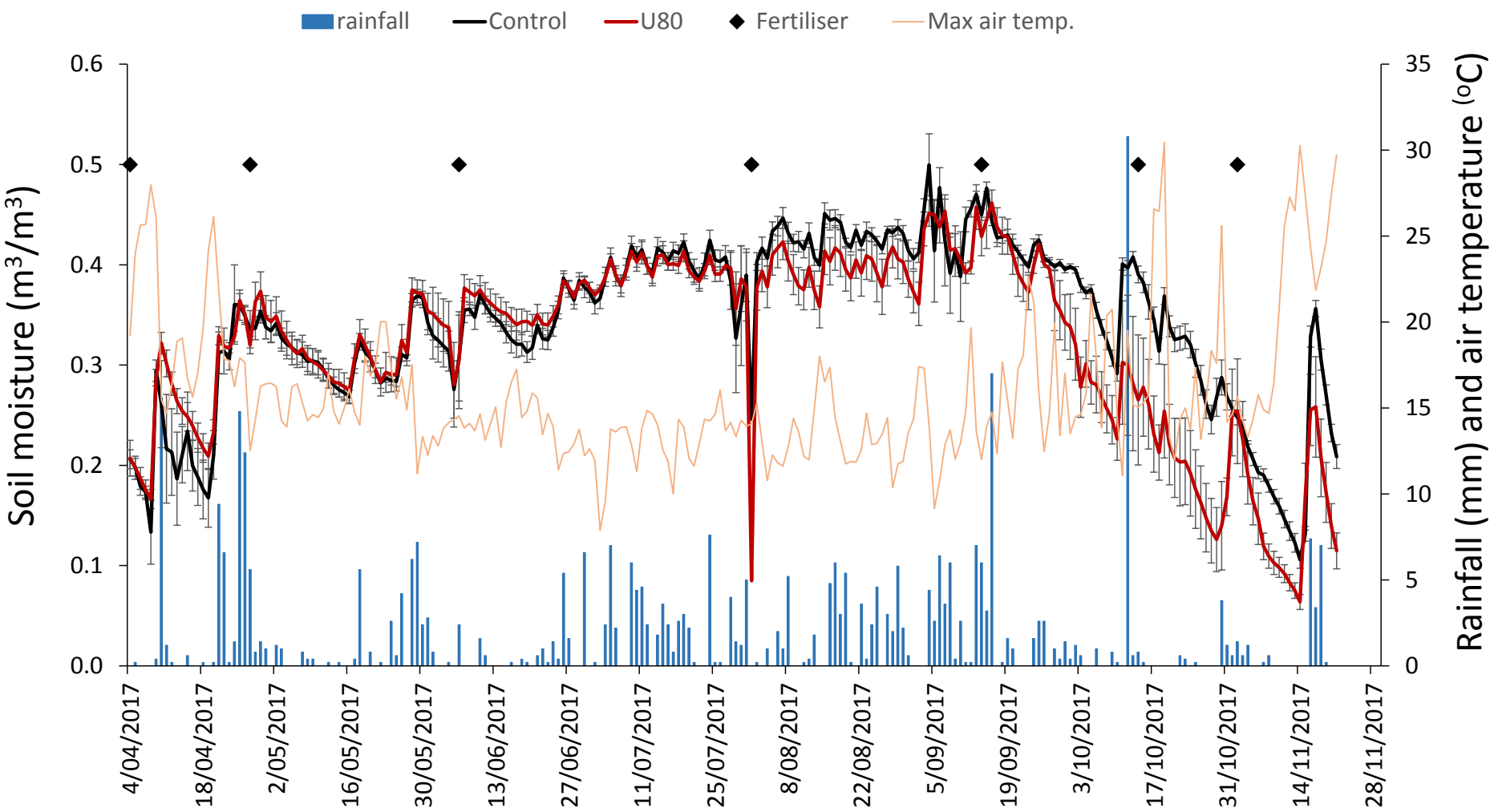
This project is supported by funding from the Australian Government Department of Agriculture and Water Resources as part of its Rural R&D for Profit program, The University of Melbourne and Dairy Australia

Nitrogen Balance : Irrigated



- Excess N being removed from soil
  - Seasonal effect
- Possible replenishment from
  - i) N_2 fixation = 550-650 kg N/ha/yr (dryland 350-550)
  - ii) Animal inputs (outside of plots) = 400 kg N/ha/event (localised)

Soil moisture and treatment : Dryland site topsoil (0-6 cm)



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