



*funded by the Department of Agriculture
and Water Resources

THE NATIONAL AGRICULTURAL NITROUS OXIDE RESEARCH PROGRAM (NANORP)*

PETER GRACE

27 APRIL 2016



Queensland University of Technology





THE NATIONAL AGRICULTURAL **'NITROGEN USE EFFICIENCY'** RESEARCH PROGRAM

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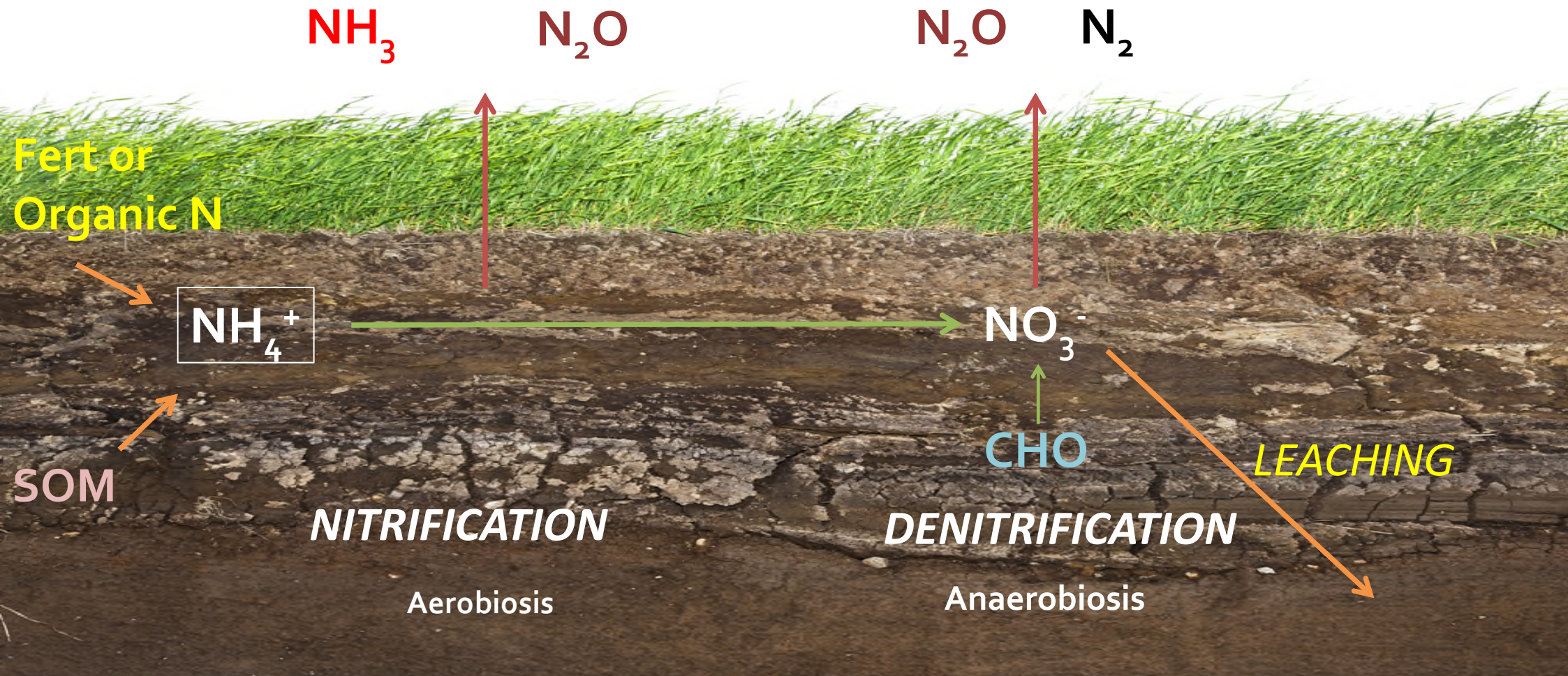
Soil GHGs and Sustainable Agriculture

- Measurable and reliable indicators of resource use
INEFFICIENCY & soil health
 - **Low** CO_2 (per unit SOC) = low microbial activity & C inputs
 - **High** N_2O = excess N and/or poor soil physical condition
 - **High** CH_4 = poor soil physical condition
- Any of these factors = **decreased production/profitability**

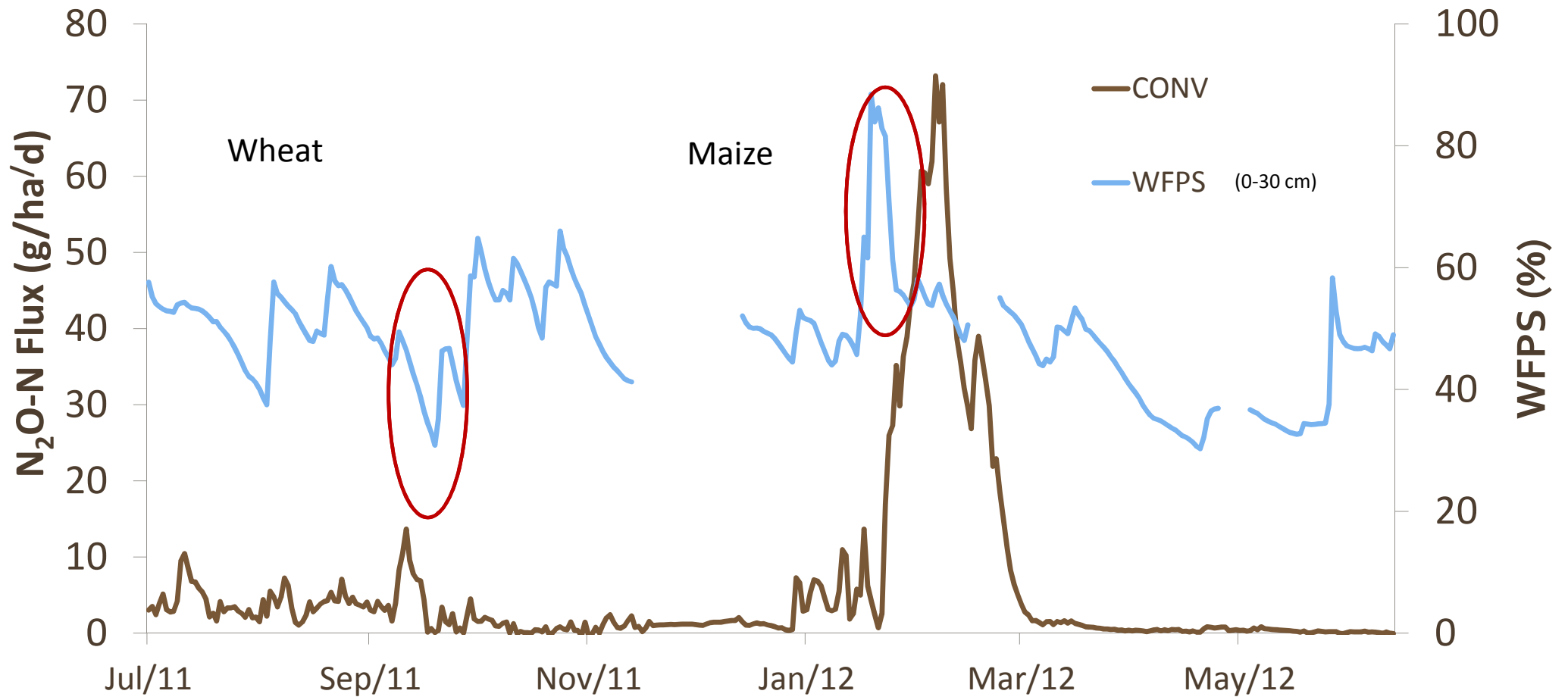
Nitrous Oxide...Quick Facts

- Potent greenhouse gas (GWP = 298 CO₂)
- 8% of global GHG emissions
- Agricultural soils contribute 50% of global N₂O emissions
- Approx 1% of applied N fertiliser globally
- N₂O reductions are permanent
- Measurable indicator of NUIE (e.g. N₂/N₂O ratio = 1 – 50+)

Sources of N emissions

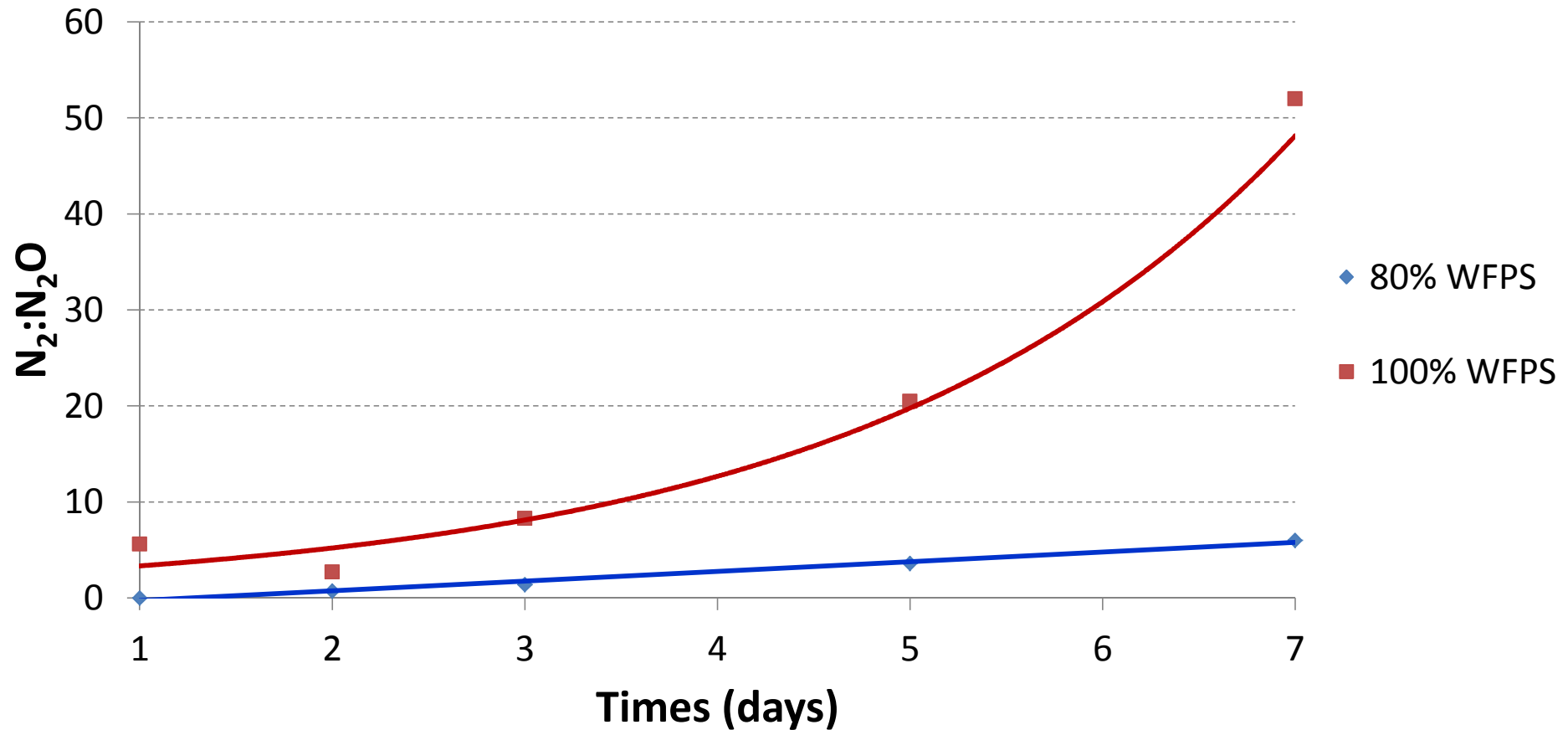


N₂O vs Soil Water Content (WFPS) – Kingaroy (Qld)



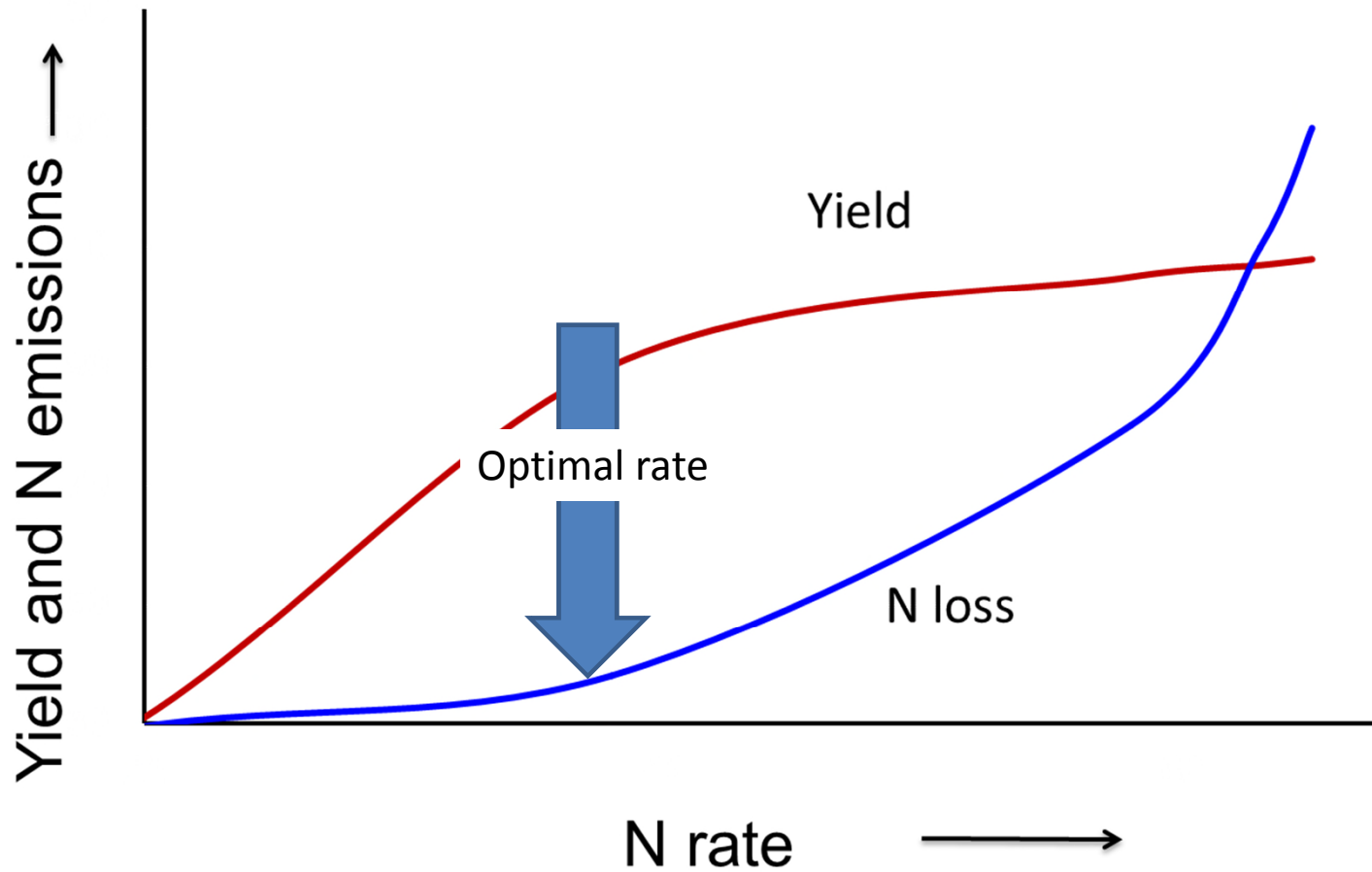
De Antoni Migliorati et al. (2014)

$N_2:N_2O$ vs Soil Water Content

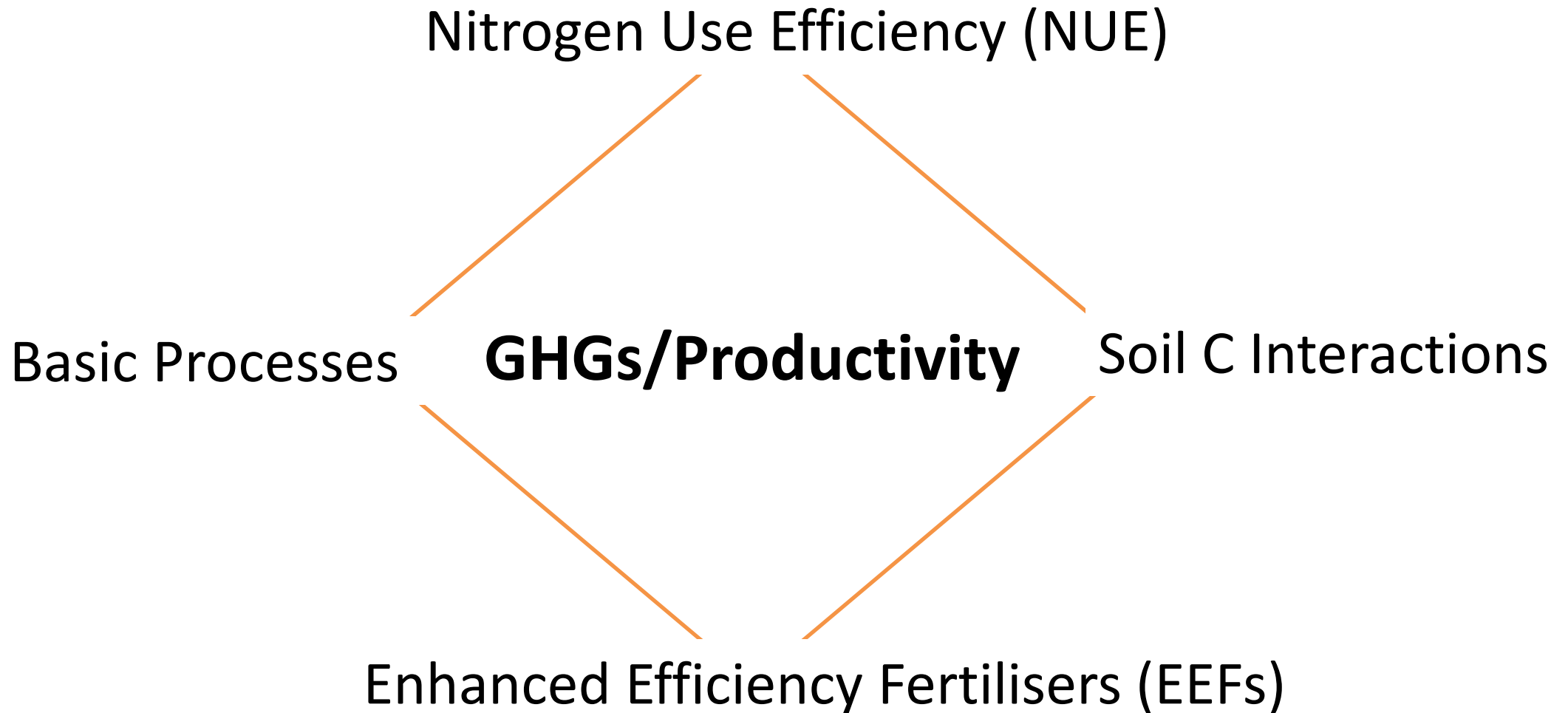


Friedl et al. (2016)

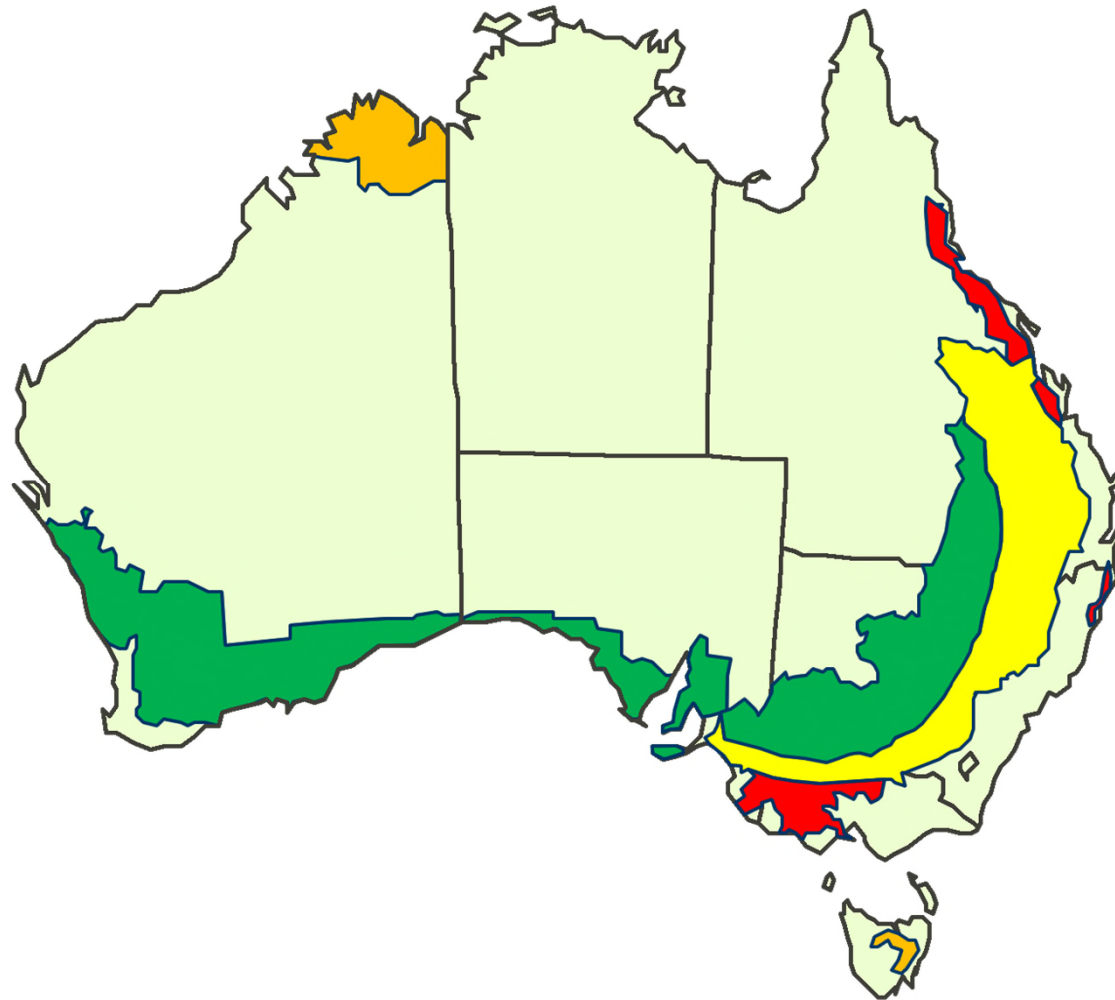
Improving Nitrogen Use Efficiency (NUE)



NANORP Research Themes

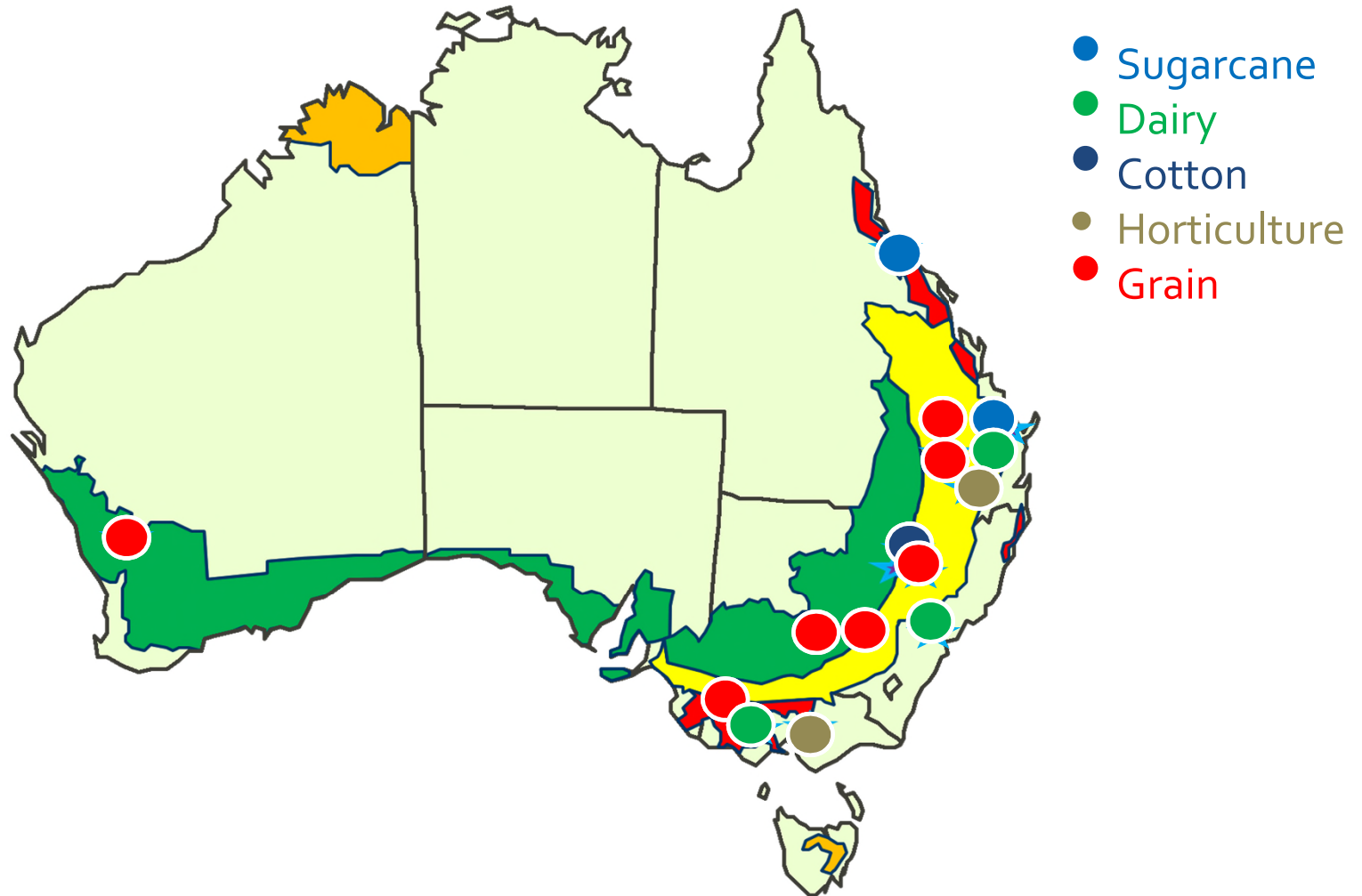


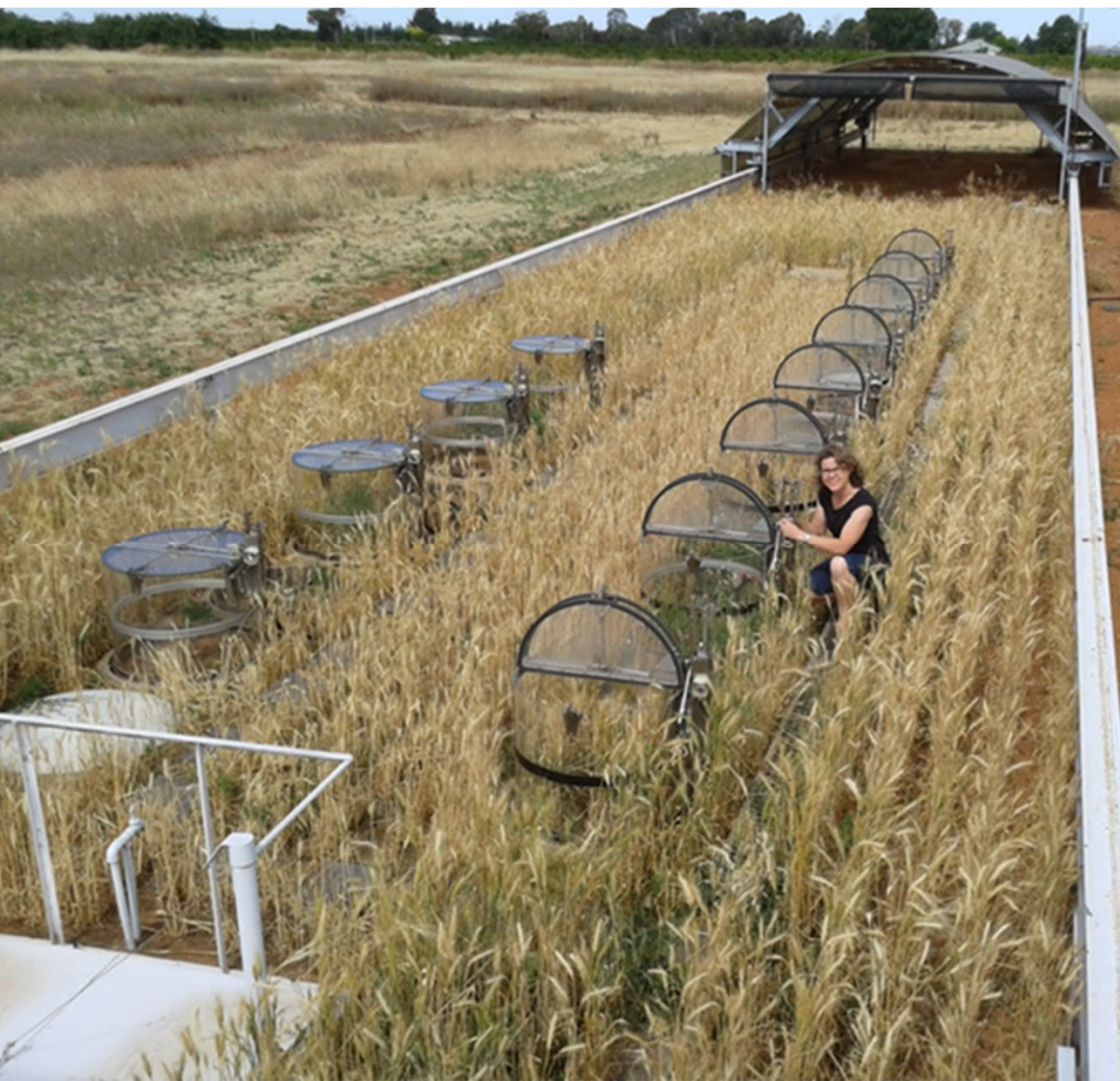
N₂O Emissions vs Agricultural Production Zones



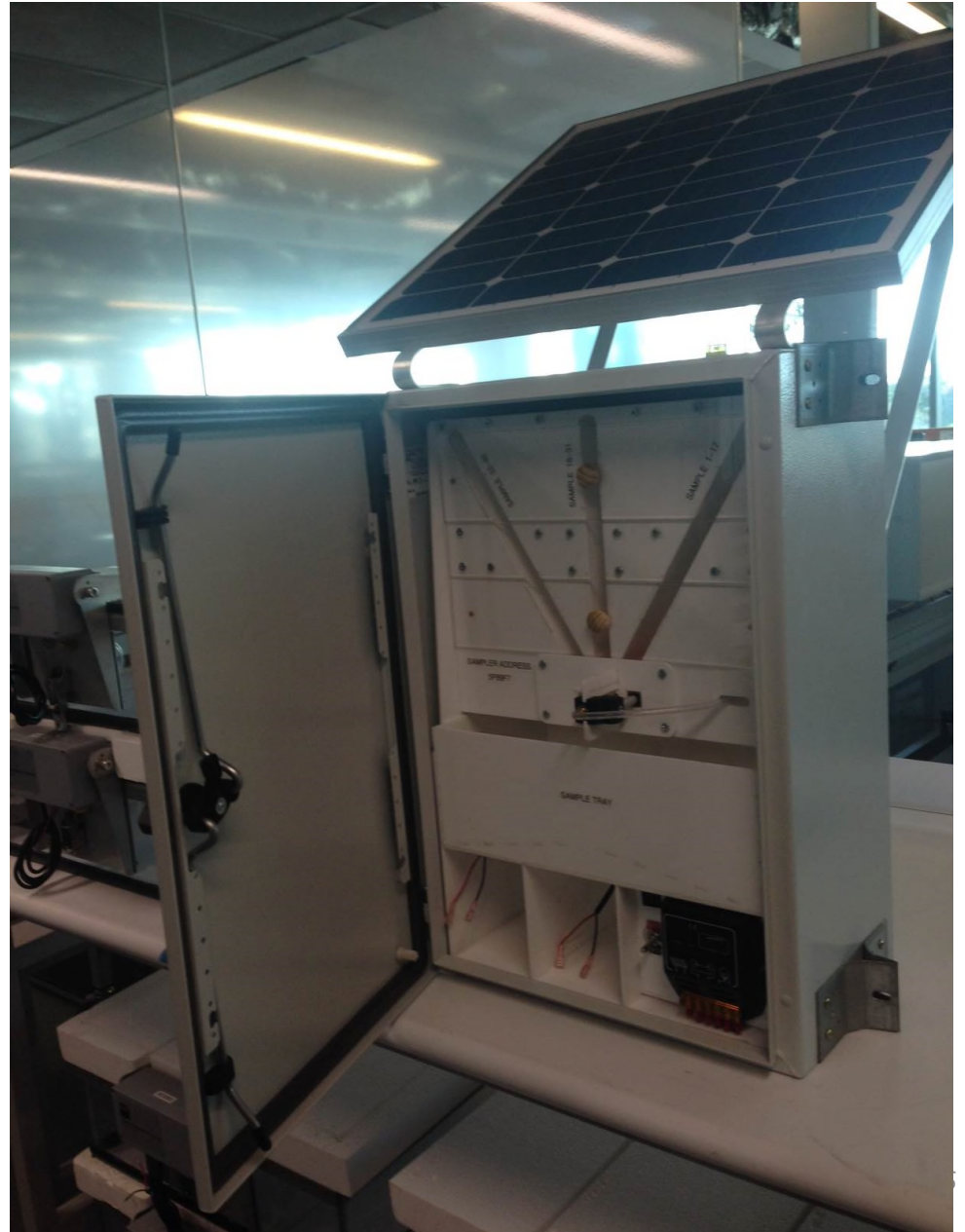
Grace (2014)

NANORP – Core sites

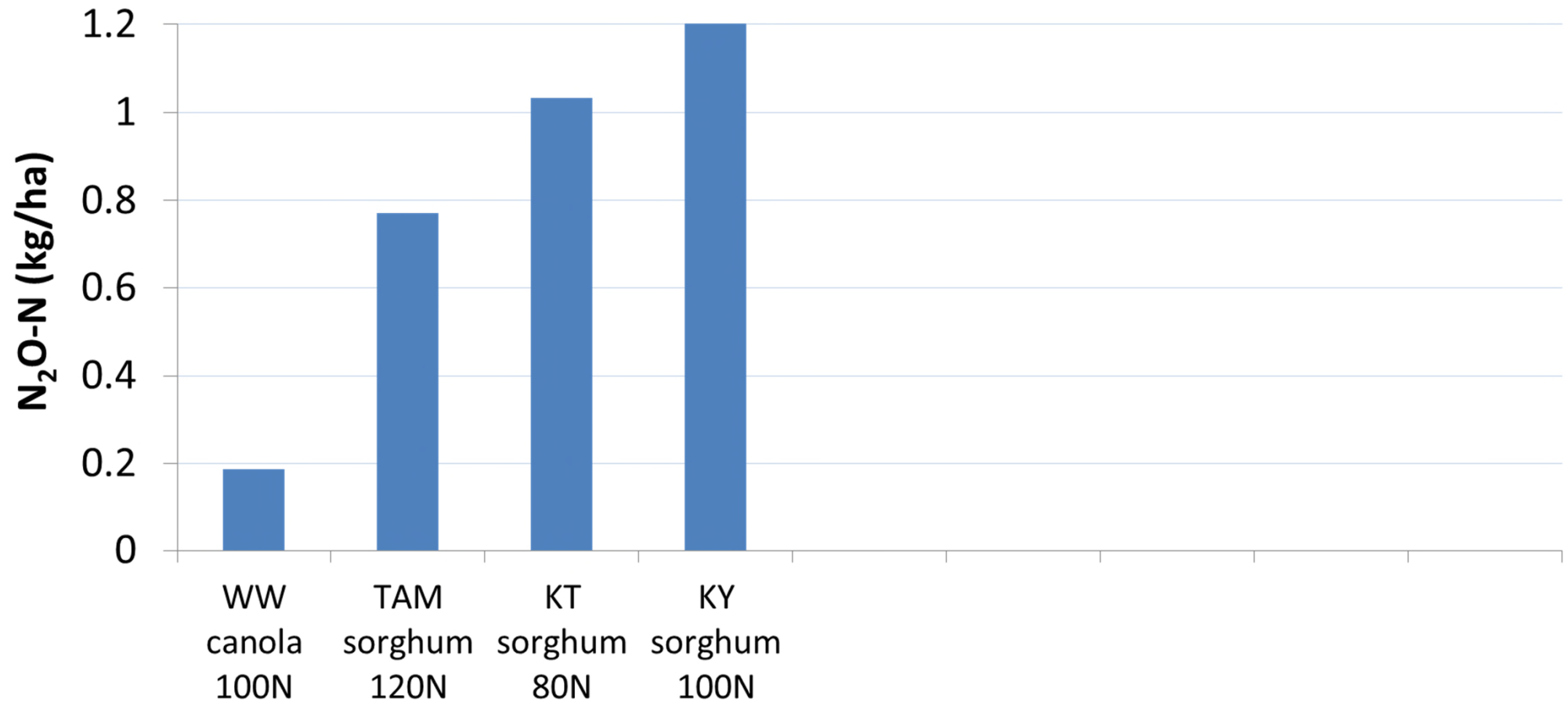






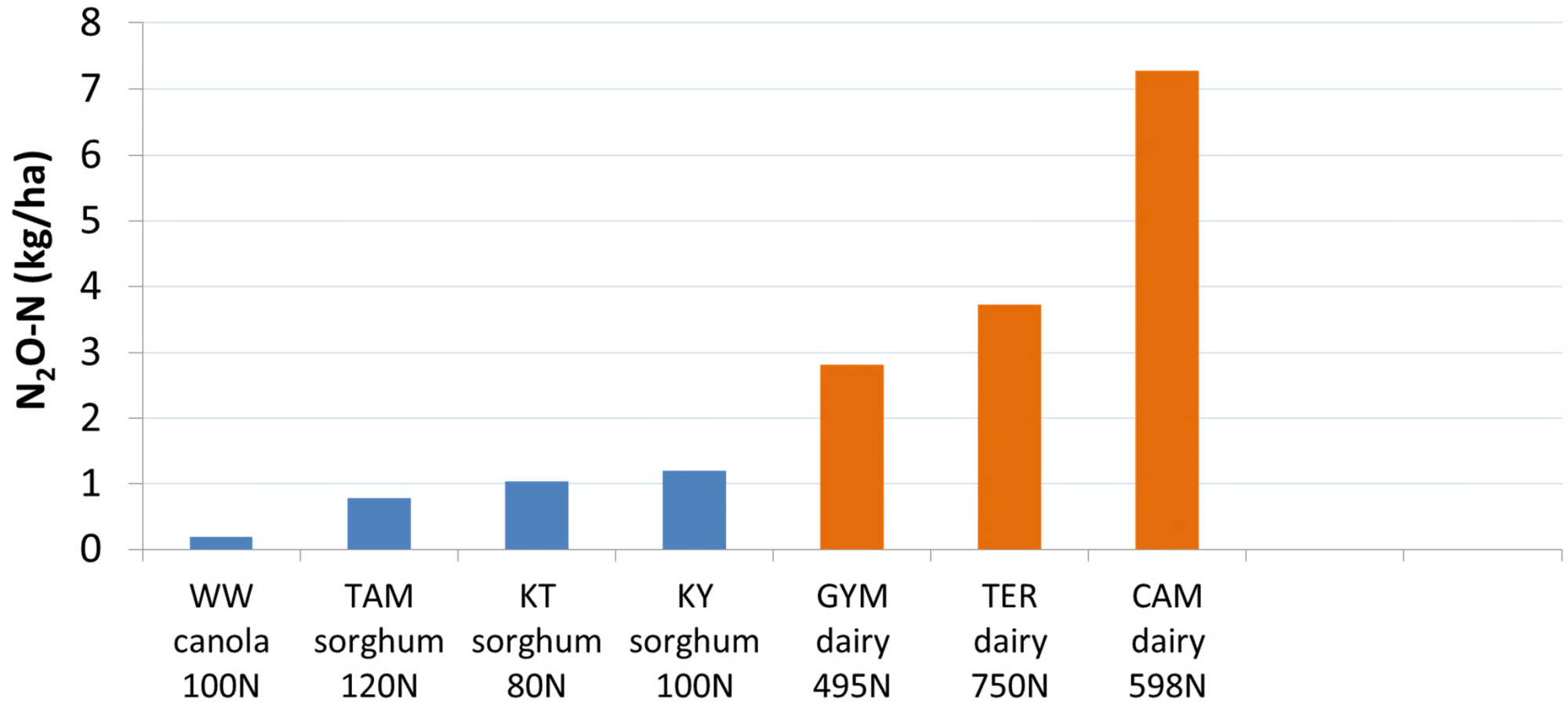


N₂O Emissions per Annum



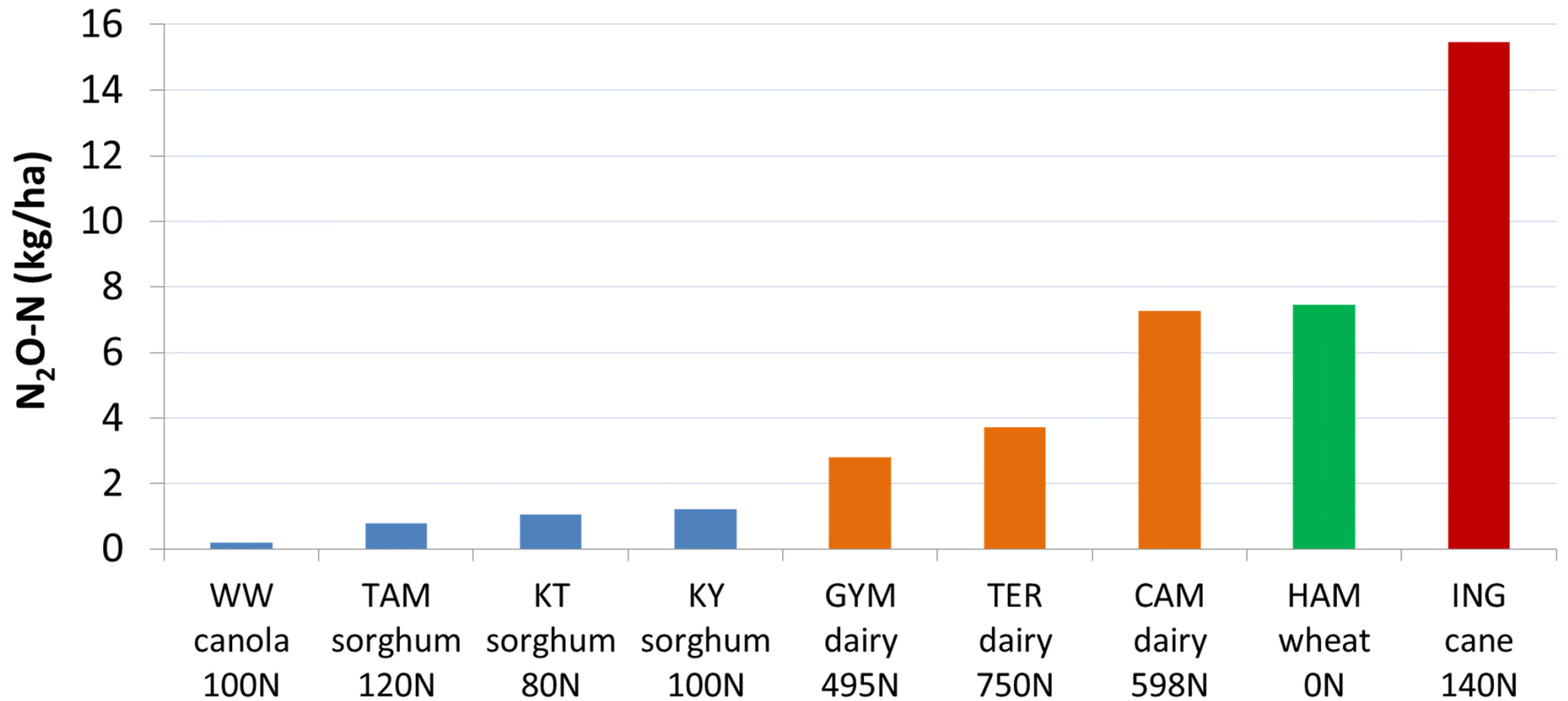
Grace & Shcherbak (2015)

N₂O Emissions per Annum



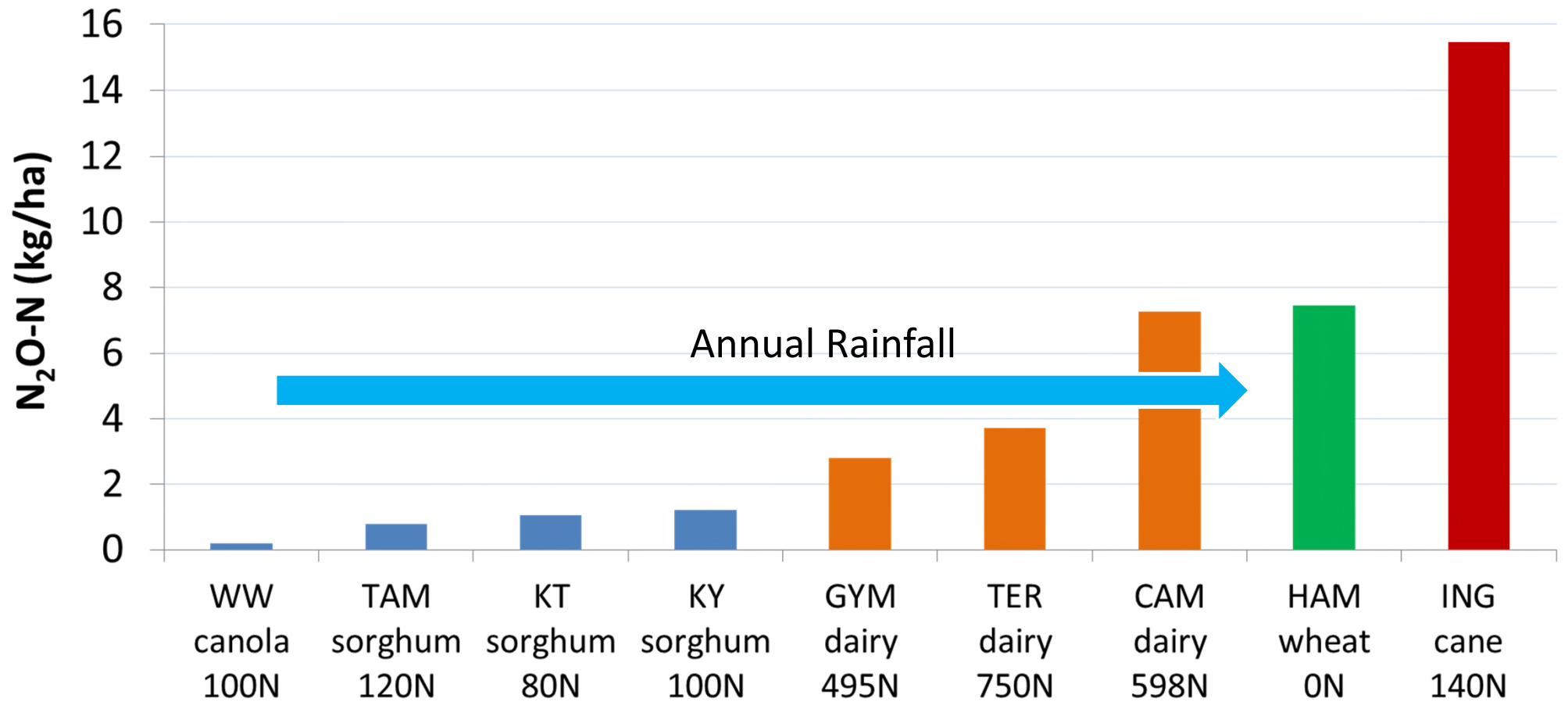
Grace & Shcherbak (2015)

N₂O Emissions per Annum



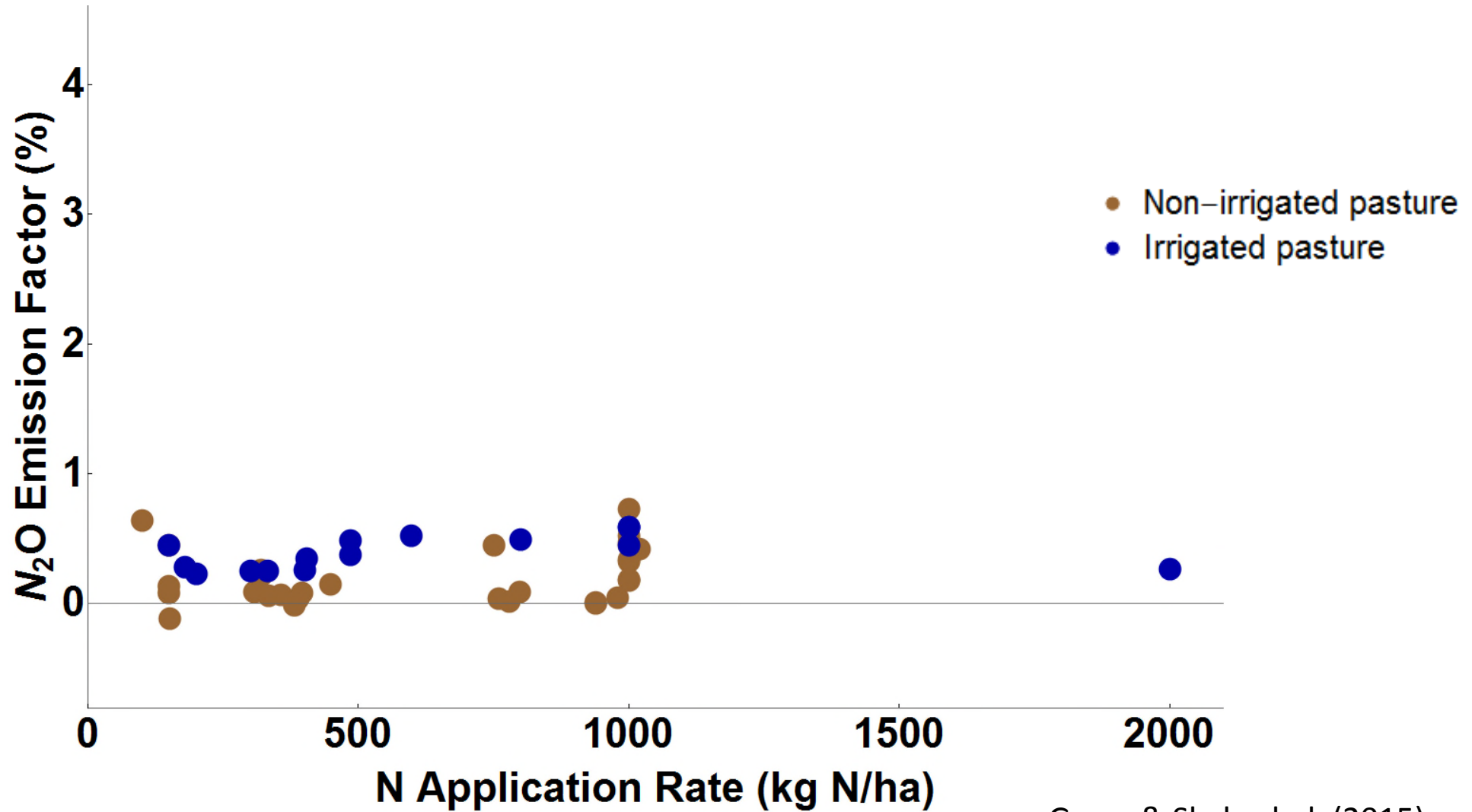
Grace & Shcherbak (2015)

N₂O Emissions per Annum



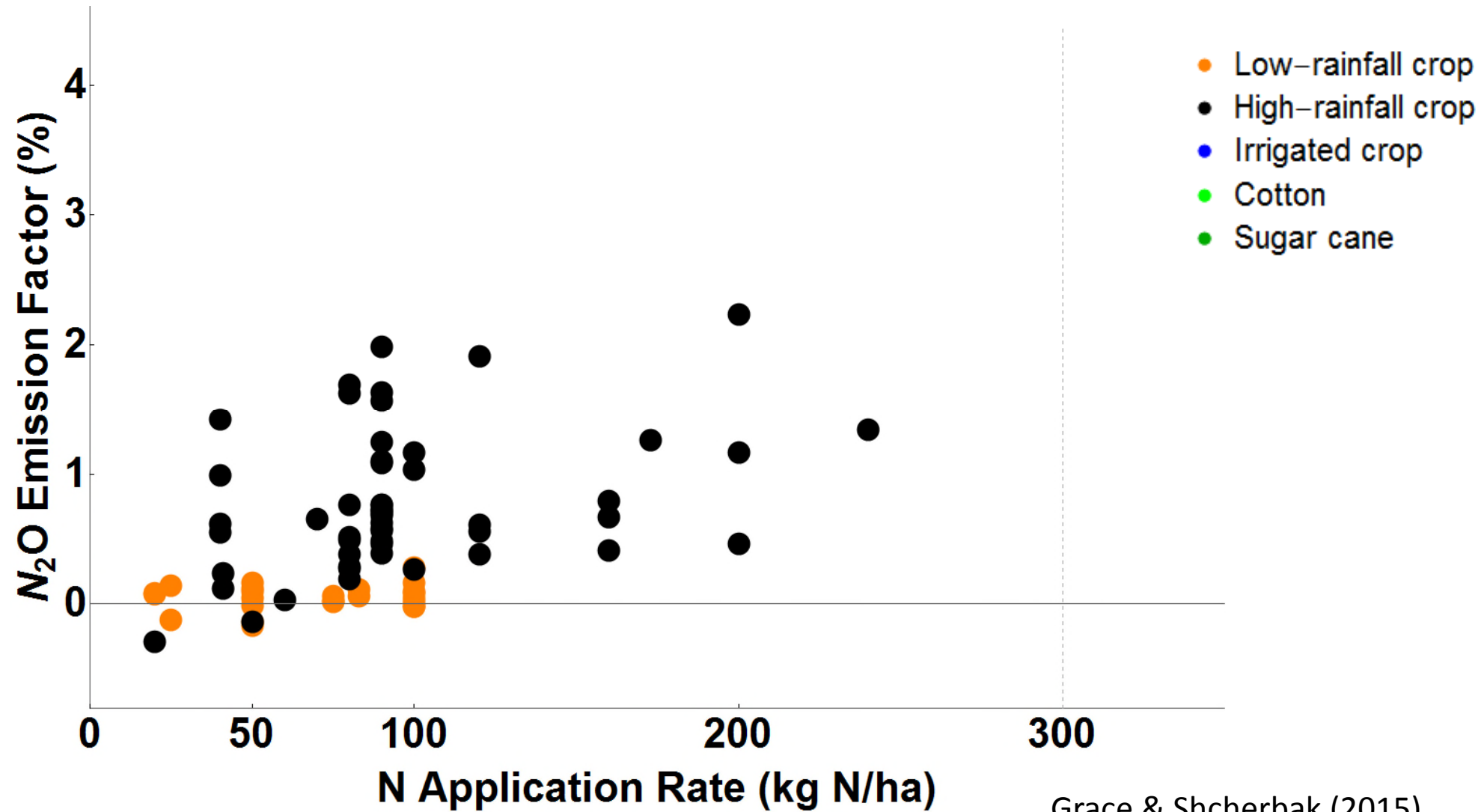
Grace & Shcherbak (2015)

N₂O Emission Factors (% of applied N)



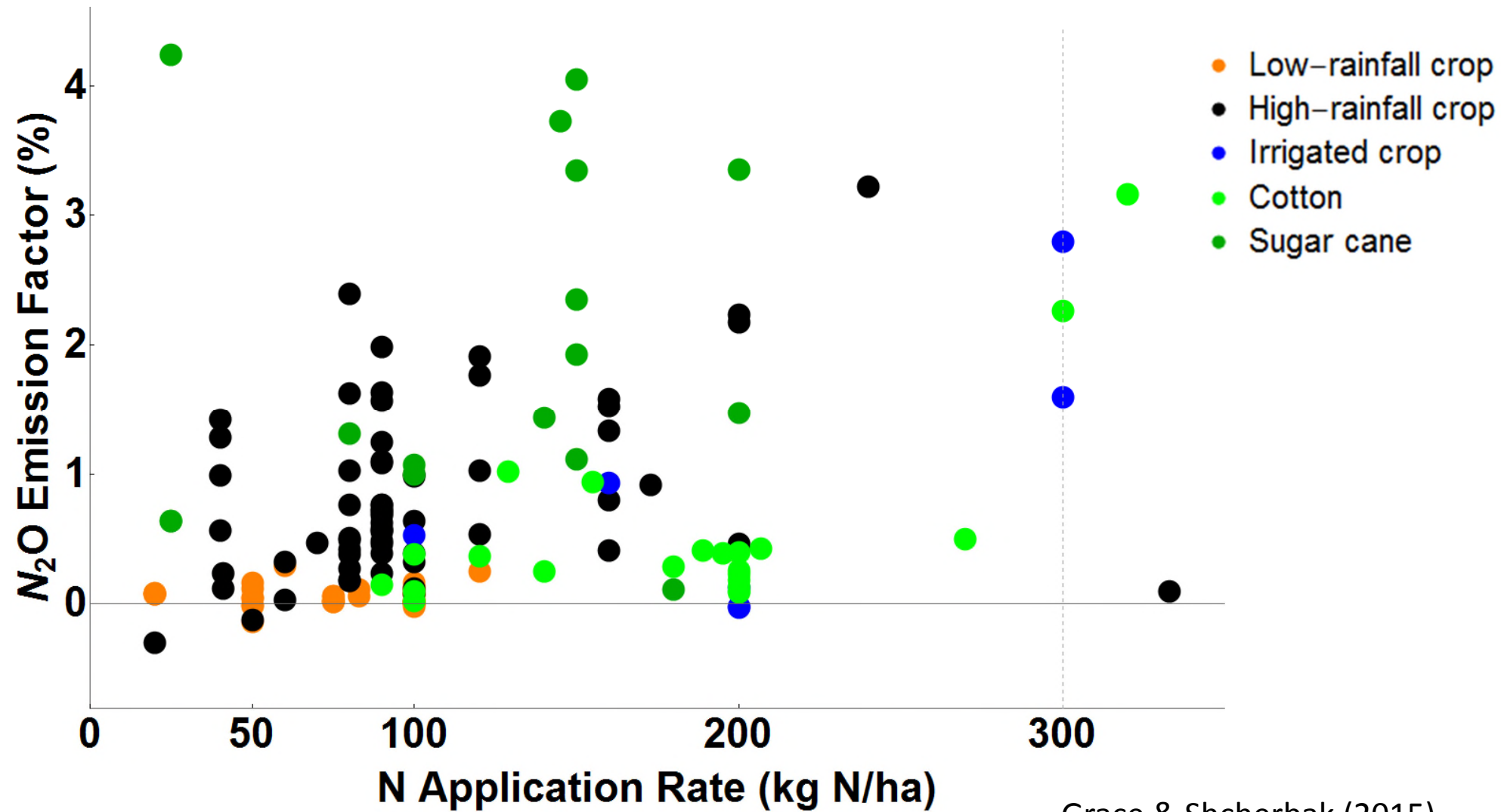
Grace & Shcherbak (2015)

N₂O Emission Factors (% of applied N)



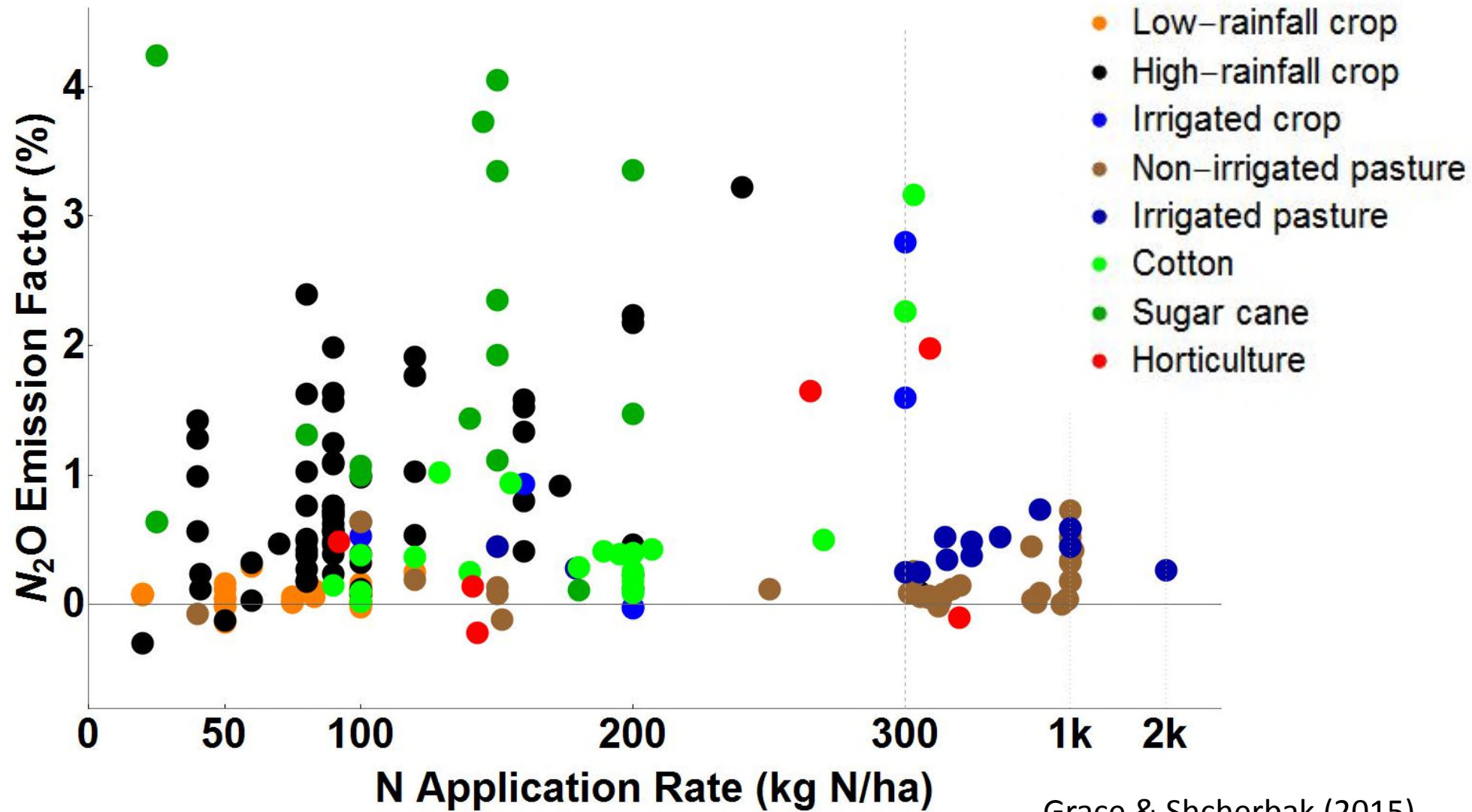
Grace & Shcherbak (2015)

N₂O Emission Factors (% of applied N)



Grace & Shcherbak (2015)

N₂O Emission Factors (% of applied N)

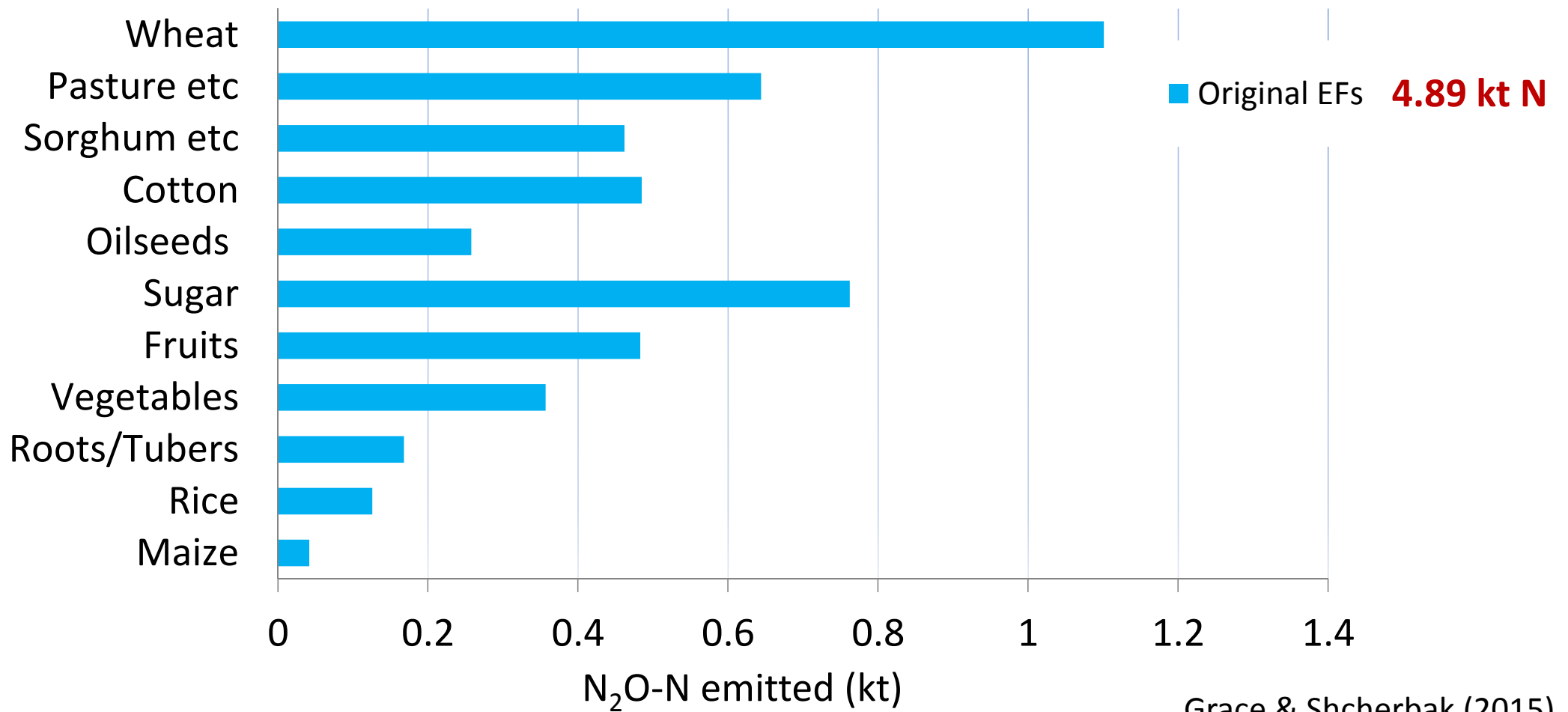


Grace & Shcherbak (2015)

Total N Applied National Basis – (IFIA, 2013)

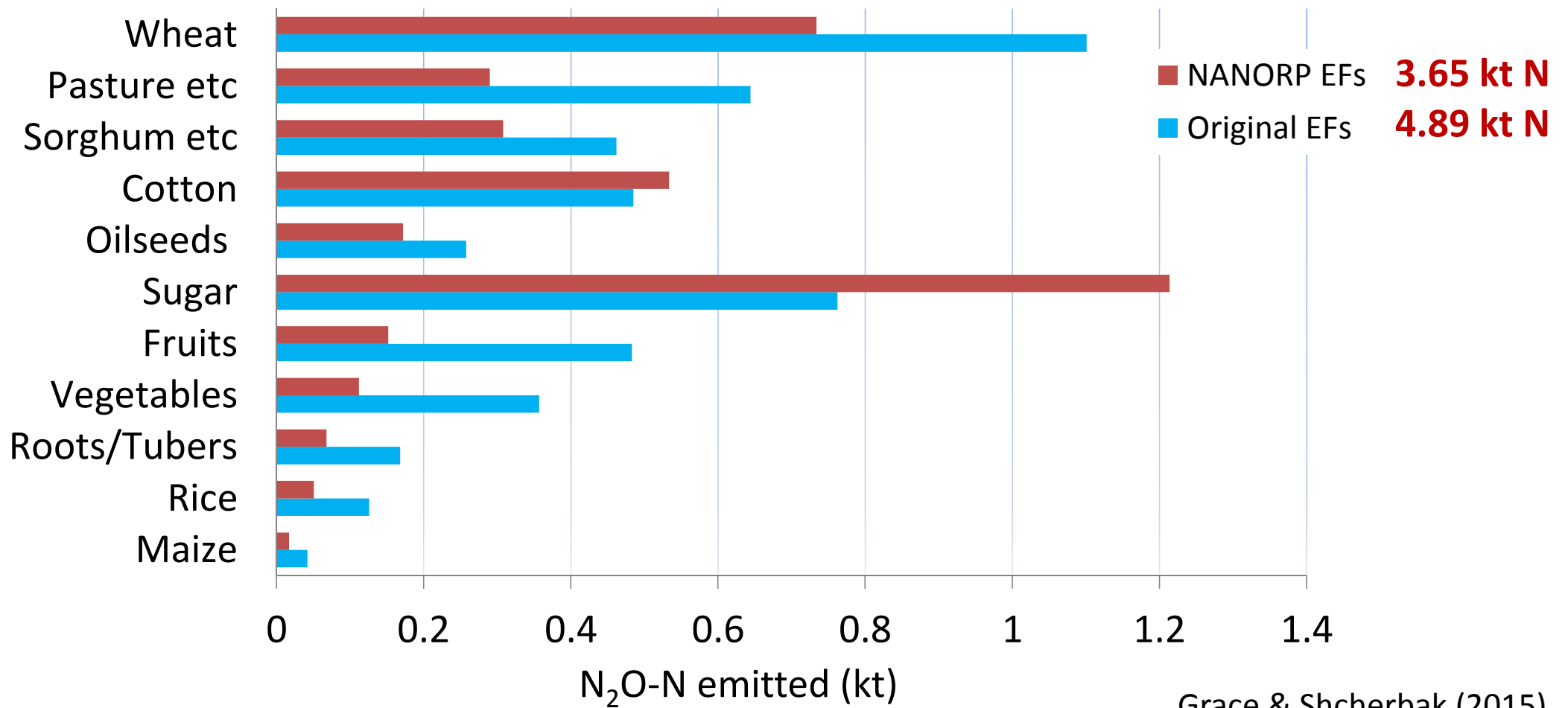
Commodity	N applied (kt)
Wheat	367
Pasture etc	161
Sorghum etc	154
Cotton	97
Oilseeds	86
Sugar	61
Fruit	23
Vegetables	17
Roots/tubers	8
Rice	6
Maize	2
TOTAL	982

N₂O Emitted (using Total N Applied National Basis - IFIA)



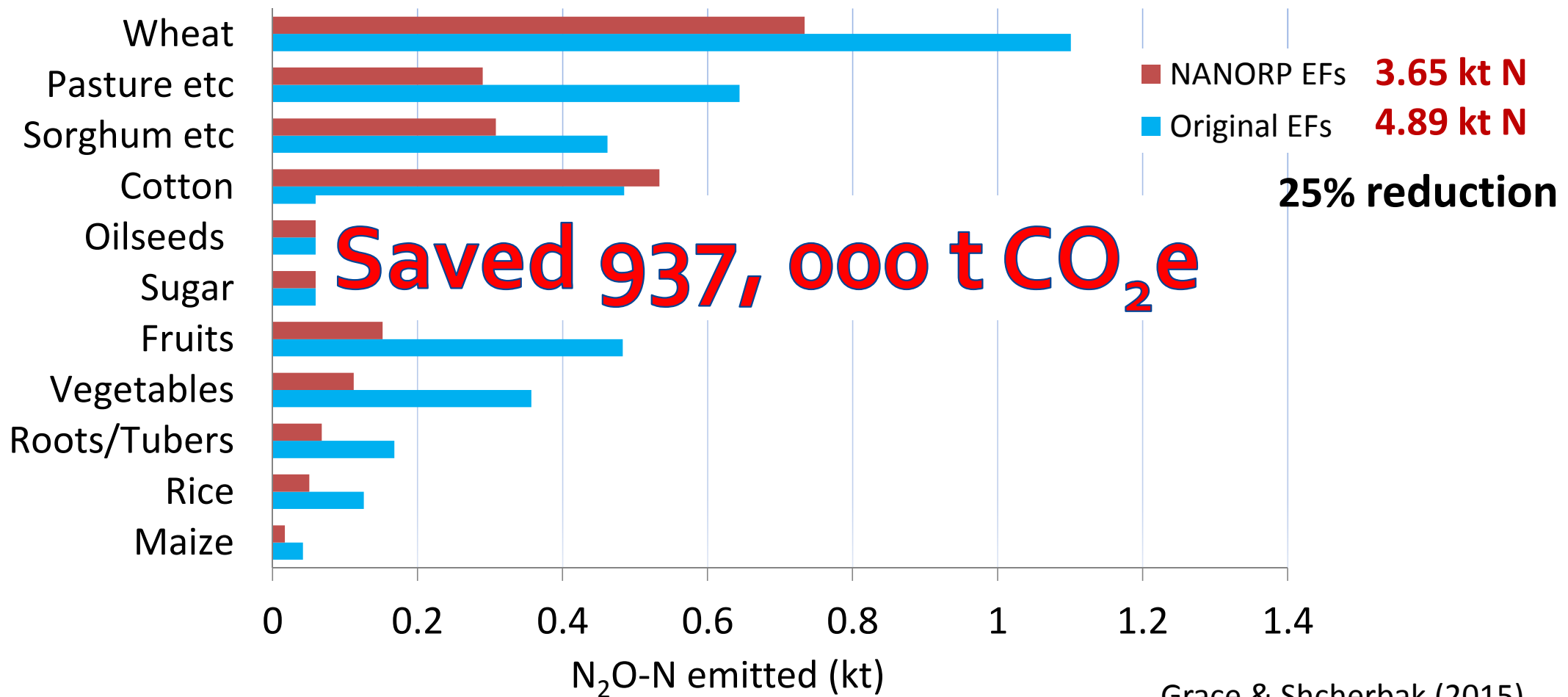
Grace & Shcherbak (2015)

N₂O Emitted (Total N Applied National Basis - IFIA)



Grace & Shcherbak (2015)

N₂O Emitted (Total N Applied National Basis - IFIA)



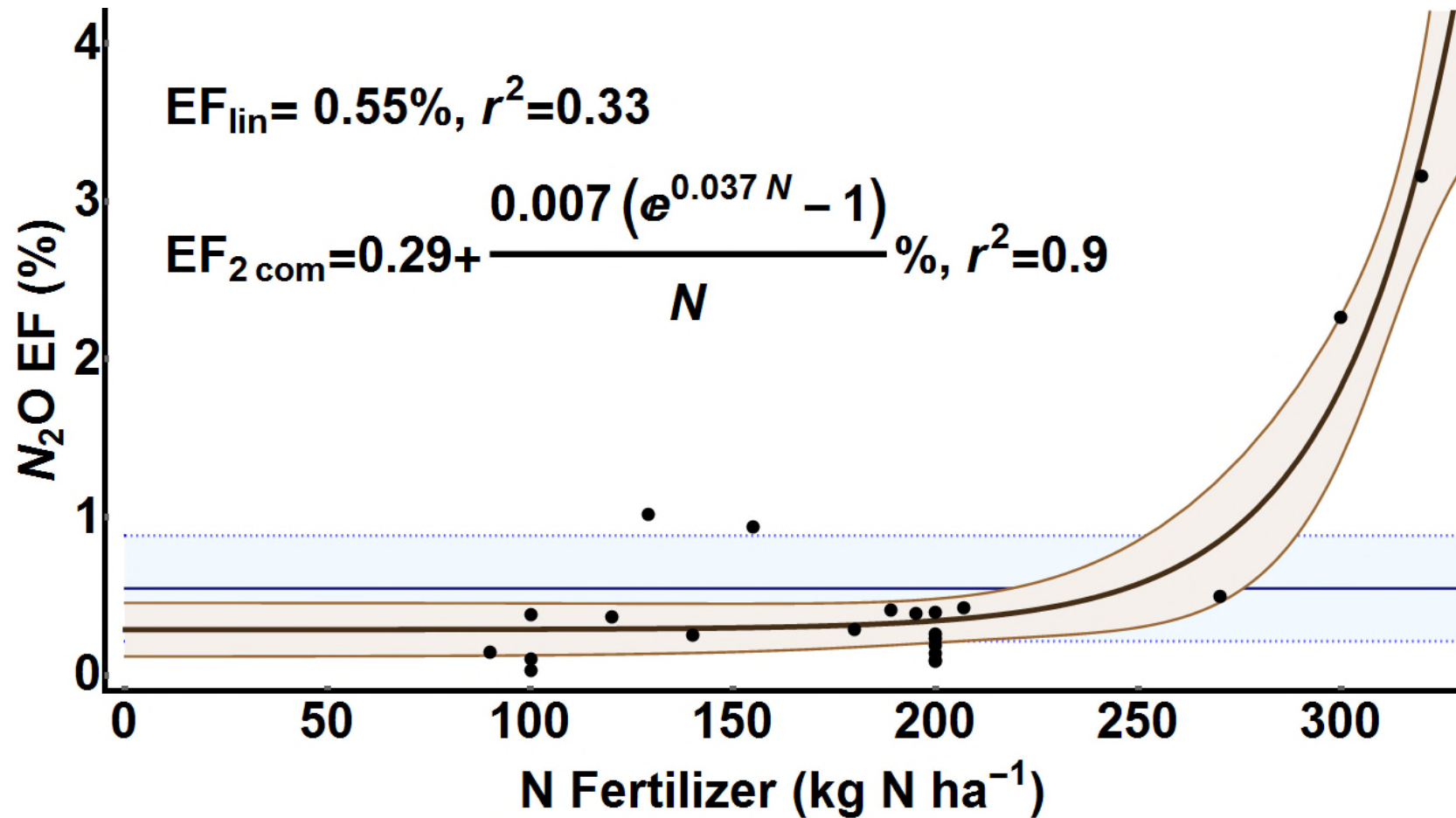
Grace & Shcherbak (2015)

N₂O Emission Factors (% of applied N)

Land Use	Treatments #	Mean N rate (kg/ha)	Original EF (%)	NANORP Revised EF (%)	New NGA EF (%) ^a
Non-irrigated crop	104	93	0.3	0.2 ^a	0.2^b
• <i>Low rainfall (<600 mm)</i>	<i>40</i>	<i>78</i>	<i>0.1</i>	<i>0.06</i>	0.06
• <i>High rainfall (>600 mm)</i>	<i>64</i>	<i>102</i>	<i>1.25</i>	<i>0.84</i>	0.84
Irrigated crop	7	209	2.1	0.85	0.85
Non-irrigated pasture	39	596	0.4	0.18	0.2
Irrigated pasture	15	622	0.4	0.42	0.4
Cotton	22	182	0.5	0.55	0.55
Sugar cane	16	123	1.25	1.99	1.99
Horticulture ^c	6	241	2.1	0.66	0.85

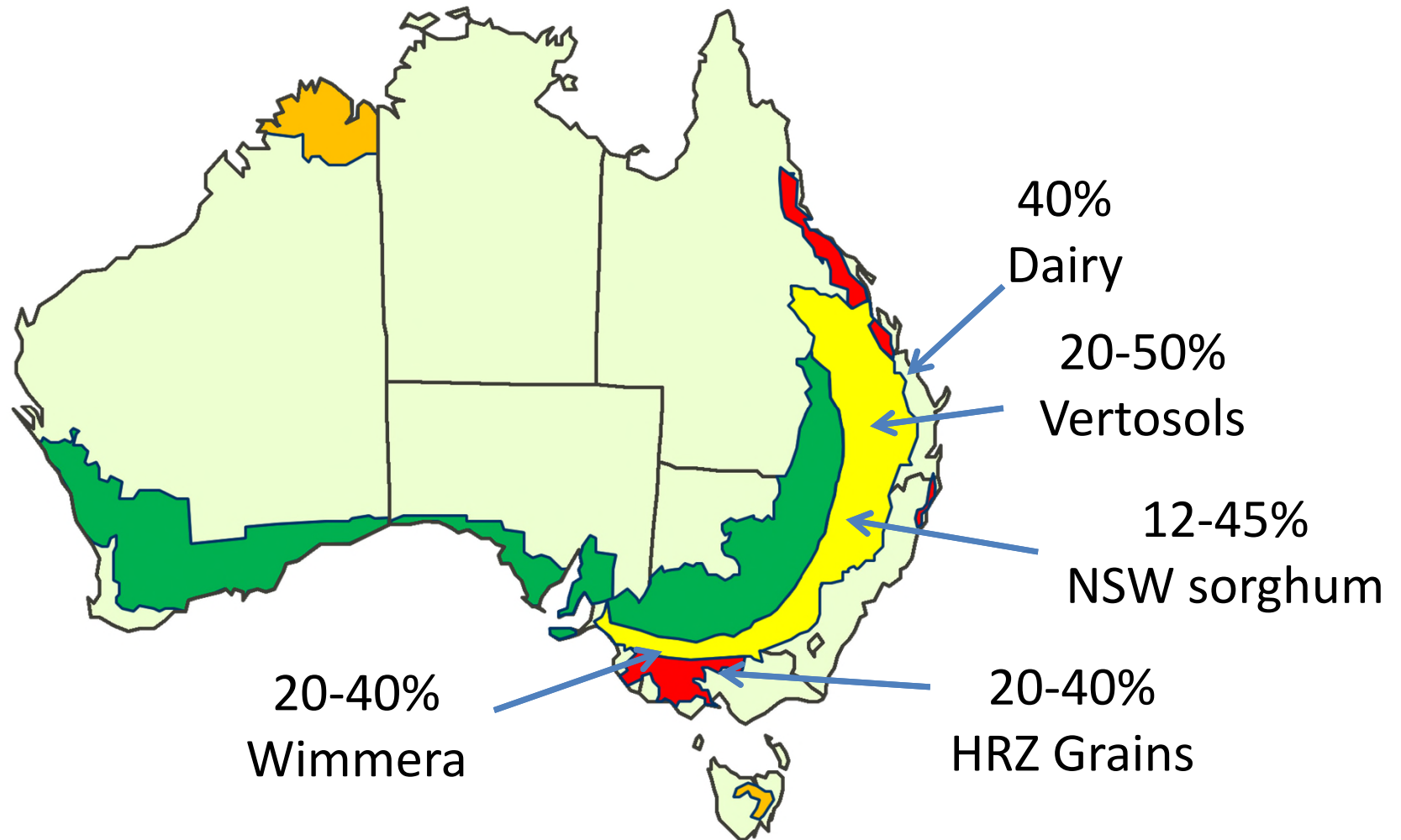
^aGrace & Shcherbak (2015); ^b weighted EF - 81% low rainfall & 19% high rainfall cropping; ^cbased on irrigated cropping EF

Department of Environment Cotton N₂O Methodology



Grace et al. (2015)

Nitrogen Use Inefficiency / ^{15}N Losses



¹Grace (2015)

NANORP Outcomes

- Nitrogen losses reduced and production increased by:
 - Matching fertiliser N supply with plant N demand
 - Reducing fert N inputs by increasing N supply from SOM/legumes
 - Enhanced efficiency fertilisers
 - Better soil structure/drainage

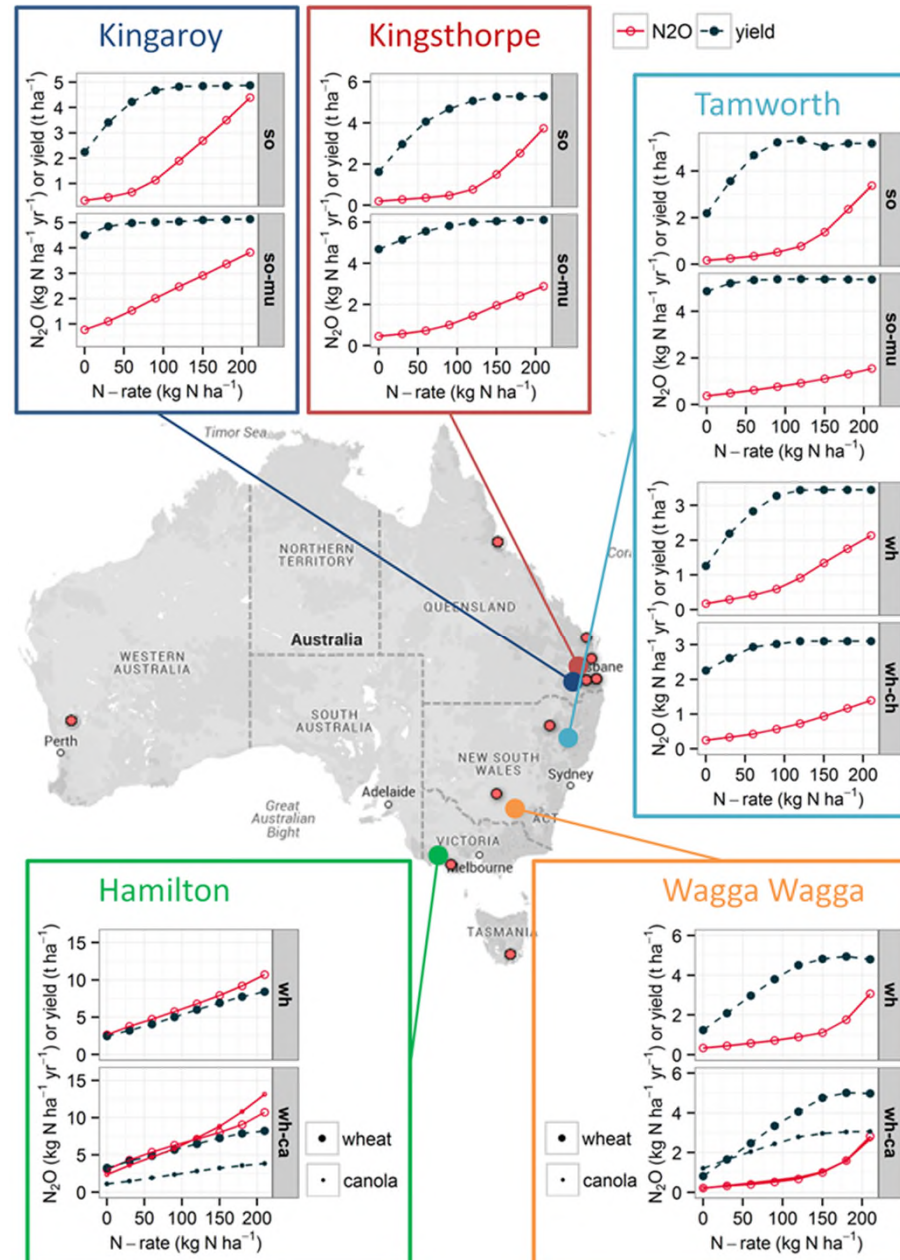
NANORP NUE / N₂O Mitigation Strategies

- N Fertiliser Management
 - o Rate
 - o Timing
 - o Placement
 - o Enhanced Efficiency Fertilisers (EEFs)
- Rotations

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Grains industry: N₂O vs Yield (APSIM)¹



¹Mielenz et al. (2016)

NANORP NUE / N₂O Mitigation Strategies

- N Fertiliser Management

- o Rate

- o Timing

- o Placement

- o *Enhanced Efficiency Fertilisers (EEFs)*

- ❖ *Polymer coated urea*

- ❖ *Urease inhibitors*

- ❖ *Nitrification inhibitors*

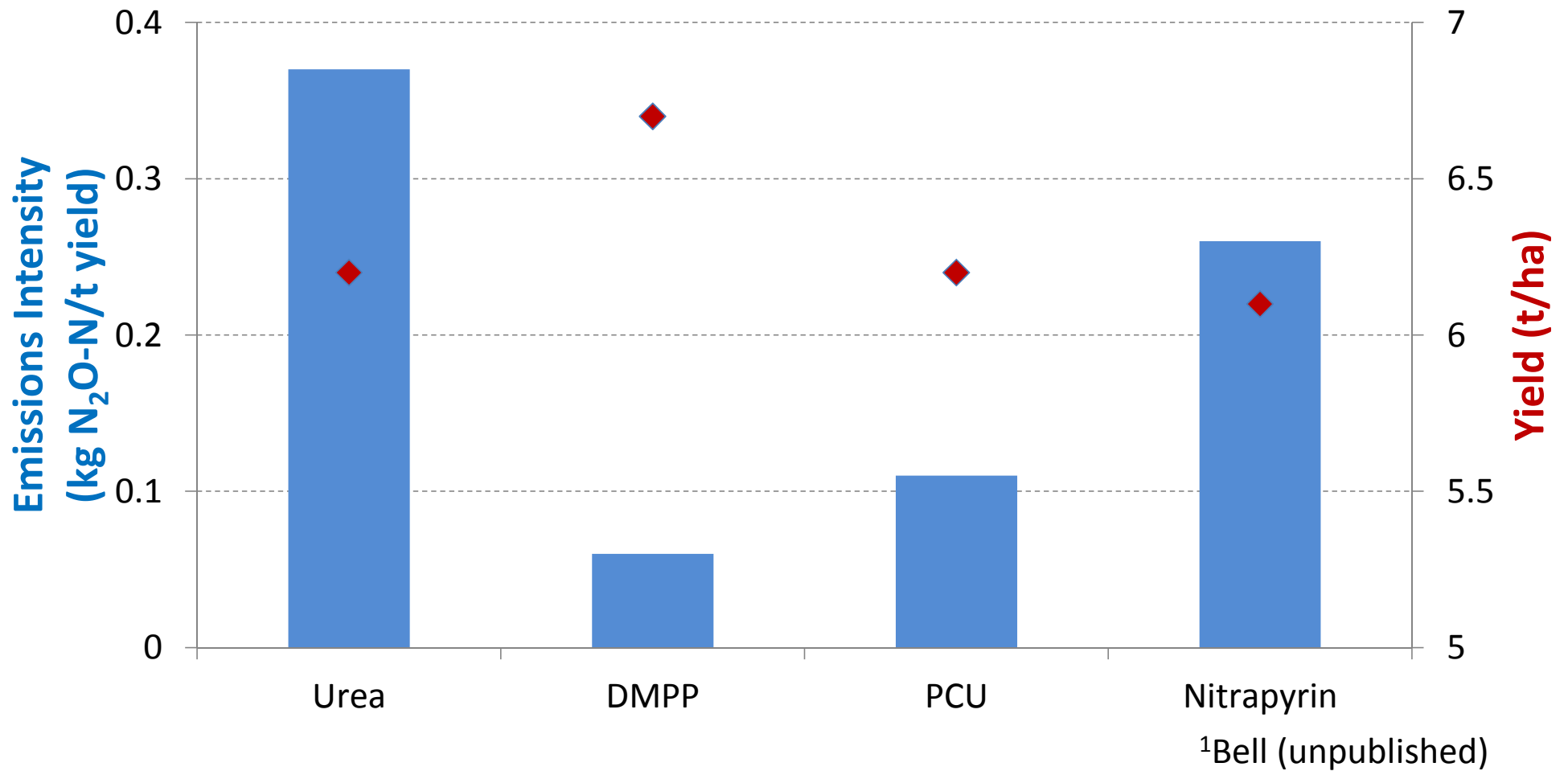
- *DMPP*

- *Nitrapyrin*

- Rotations

EEFs: Yield vs Emissions Intensity

Sorghum – Kingsthorpe (Qld)



Emissions Factors vs EEFs¹

Land use	Number	Mean N Rate	DMPP EF (%)	Regular EF (%)
Non-irrigated crop	28	96	0.163	0.2
--High-rainfall crop	18	112	0.181***	0.84
--Low-rainfall crop	10	66	0.131	0.06
Pasture	8	311	0.260*	0.3
Sugar cane	5	105	-0.089*	1.99
Horticulture	4	170	-0.269*	0.85

*statistical significance

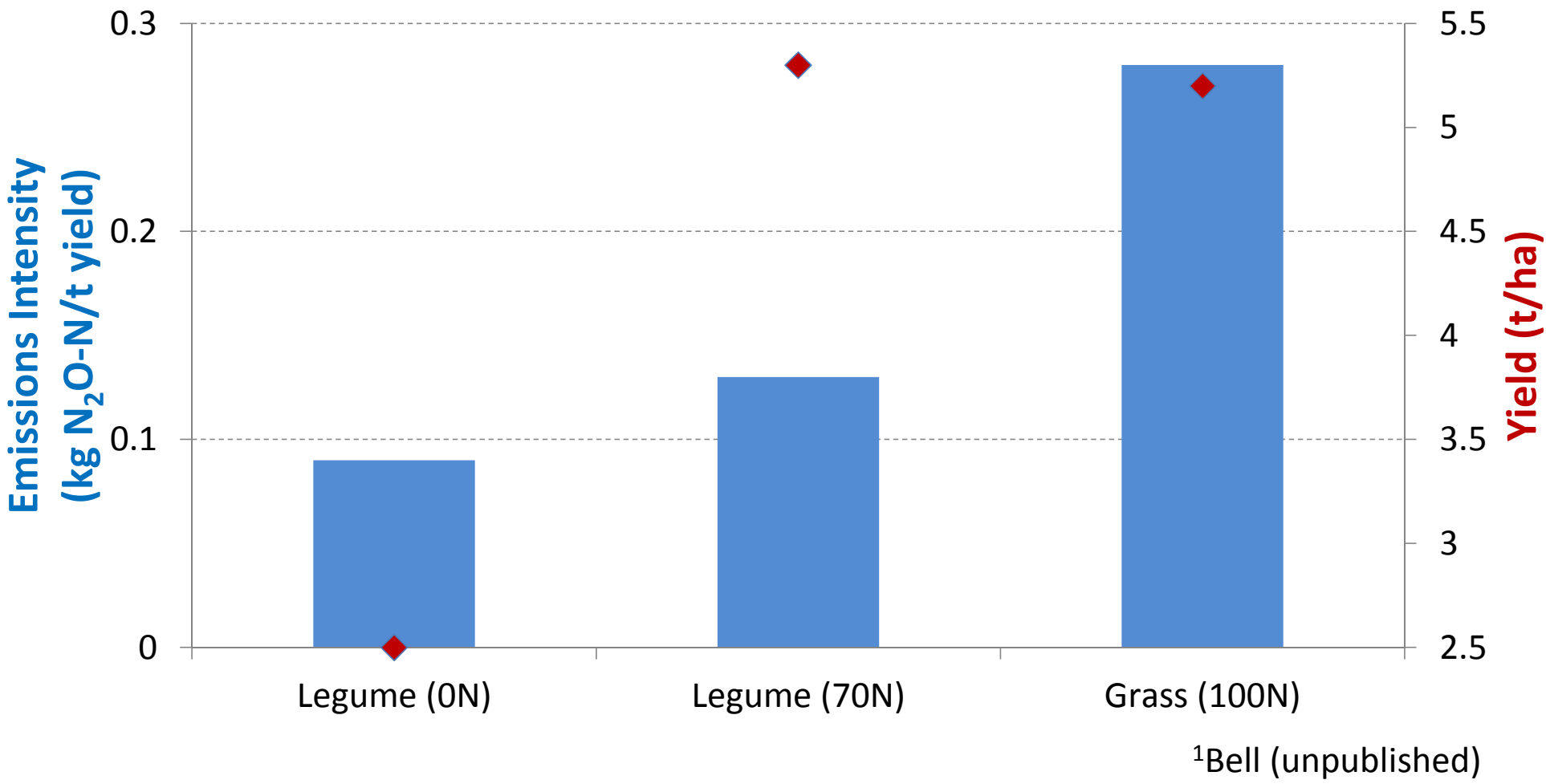
¹Grace & Shcherbak (2015)

NANORP NUE / N₂O Mitigation Strategies

- N Fertiliser Management
 - o Rate
 - o Timing
 - o Placement
 - o *Enhanced Efficiency Fertilisers (EEFs)*
 - ❖ *Polymer coated urea*
 - ❖ *Urease inhibitors*
 - ❖ *Nitrification inhibitors*
 - *DMPP*
 - *Nitrapyrin*
- Rotations

Rotations: Yield vs Emissions Intensity¹

Sorghum – Kingsthorpe (Qld)



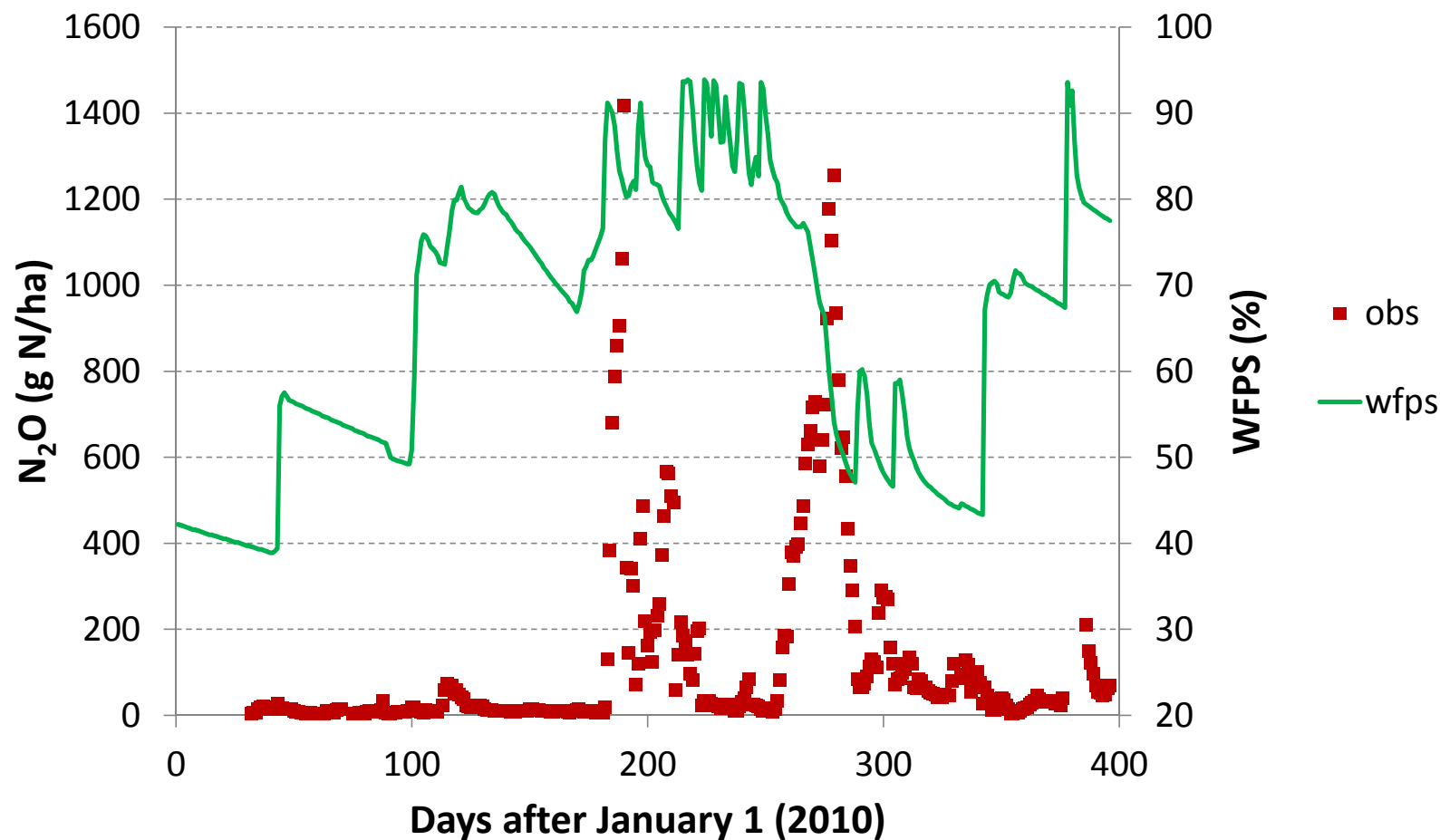
NANORP Cost-Benefit¹

Region/Industry	Area (1000 ha)	NUE Strategy	+NUE ¹ \$M	N ₂ O savings (1000 t CO ₂ e)	C credit ² \$M
NGA reduction				937	13
Vic HRZ grains	150	< 25-50 kg N	6	22	0.3
Northern summer grains	750	< 8 kg N	6	24	0.3
North + legume	750	< 30 kg N	23		
Wimmera grains	350	+ 50 kg N	75	4	0.1
SMDB	20	Smaller irrigations		40	0.6
High rainfall grain		DMPP		356	5
Sugar		DMPP		485	7
Sub-tropical dairy	30	DMPP < 80 kg N	5		
			\$115M	2M	\$26M

¹Grace (2015), ²100% adoption; ³\$14/ tCO₂e

CAUTION

N₂O (Wheat after Pasture) – Hamilton (Vic)



Officer et al (unpublished)



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Emissions Research in Australia

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The N₂O Network

The N₂O Network is a collaborative research program established to study nitrous oxide (N₂O) emissions from Australian agriculture soils.

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