LA TROBE UNIVERSITY

Benchmarking and Mitigation of Nitrous Oxide Emissions in Temperate Vegetable Cropping Systems in Australia Resulting in Improved NUE

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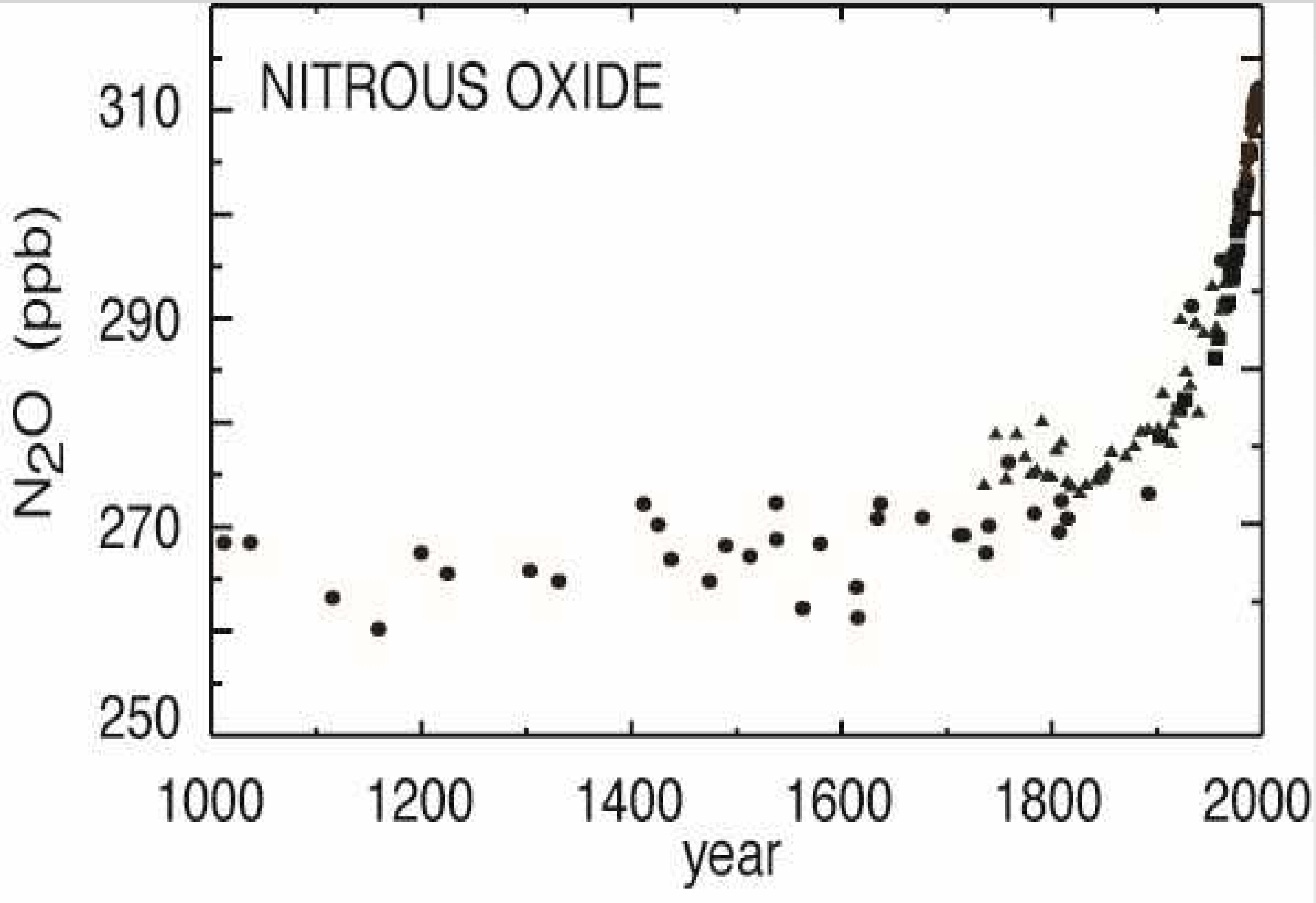
- BASF Rohan Davies

(Linkage to Melbourne University Projects - Helen Suter, Deli Chen

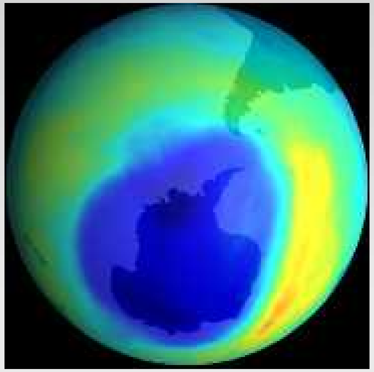
A significant part of N_2O emission is of human origin

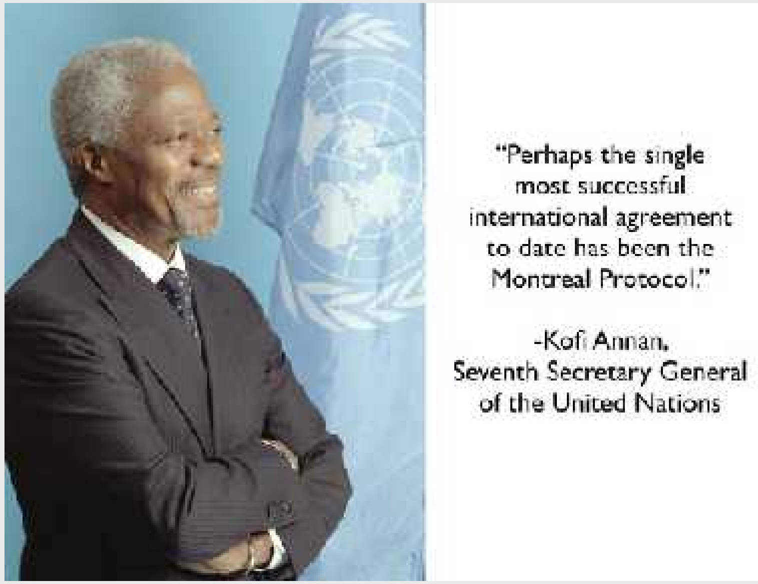


- All increases in N_2O are due to anthropogenic activity

Nitrous Oxide is the largest known anthropogenic threat to the stratospheric ozone layer'.

- ODP=0.017
- High GWP - 298 (311)
- 10% of total greenhouse gas emissions
- 60% of all N_2O is from agriculture





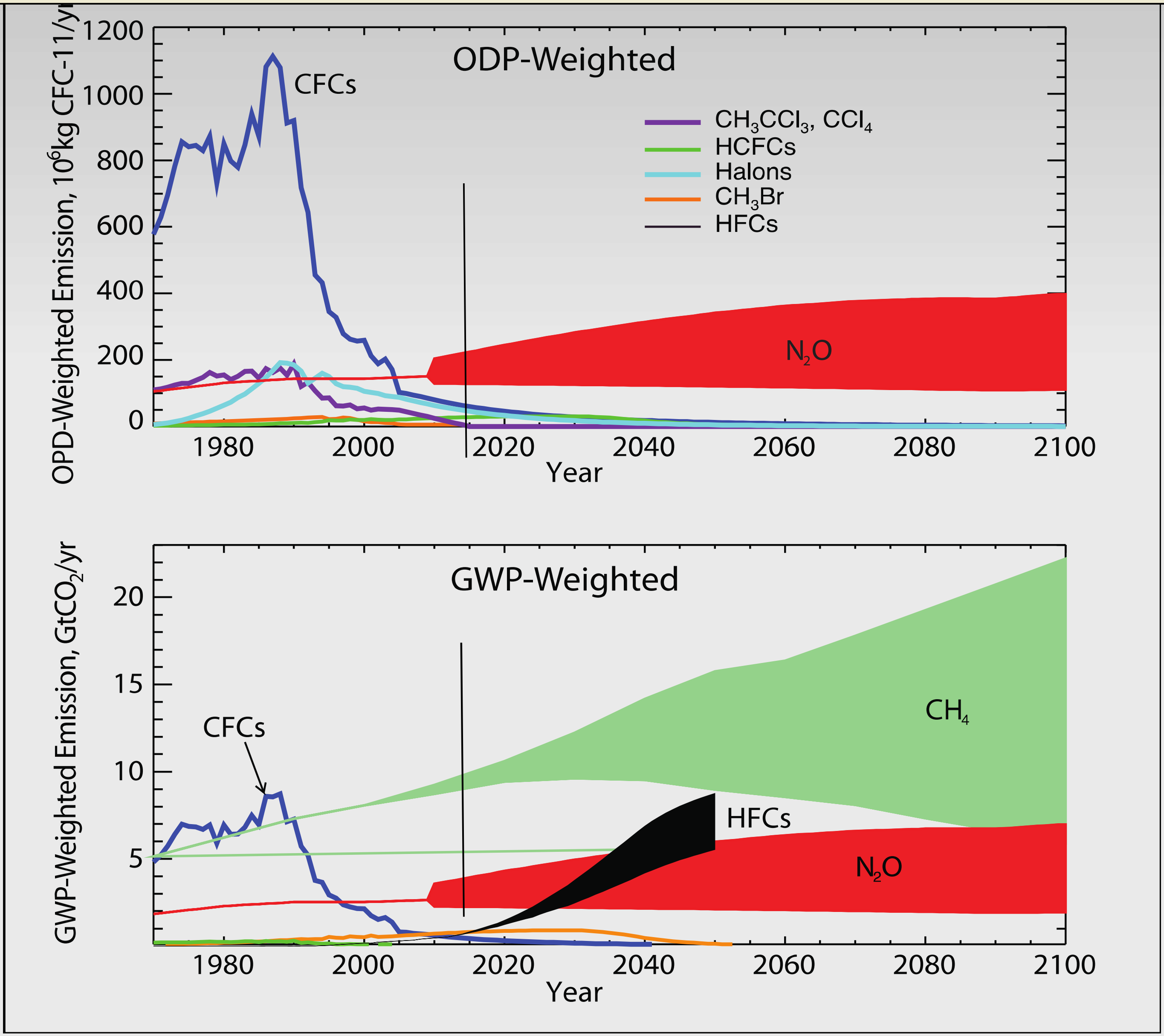
Impact of N_2O in International Agreements

Ozone

Montreal Protocol

Climate

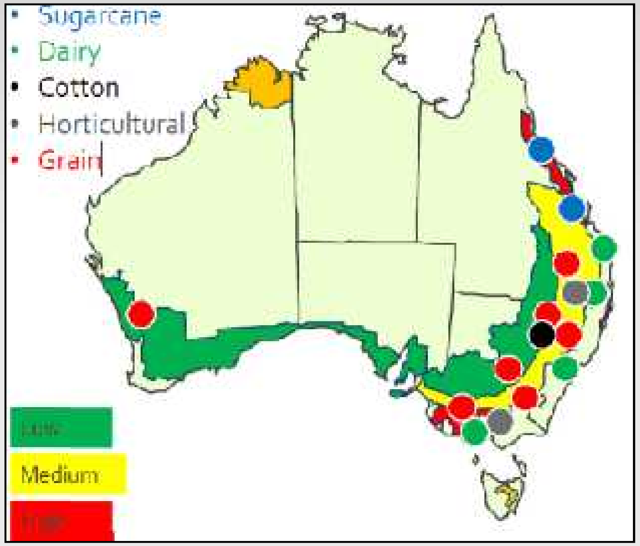
Kyoto Protocol



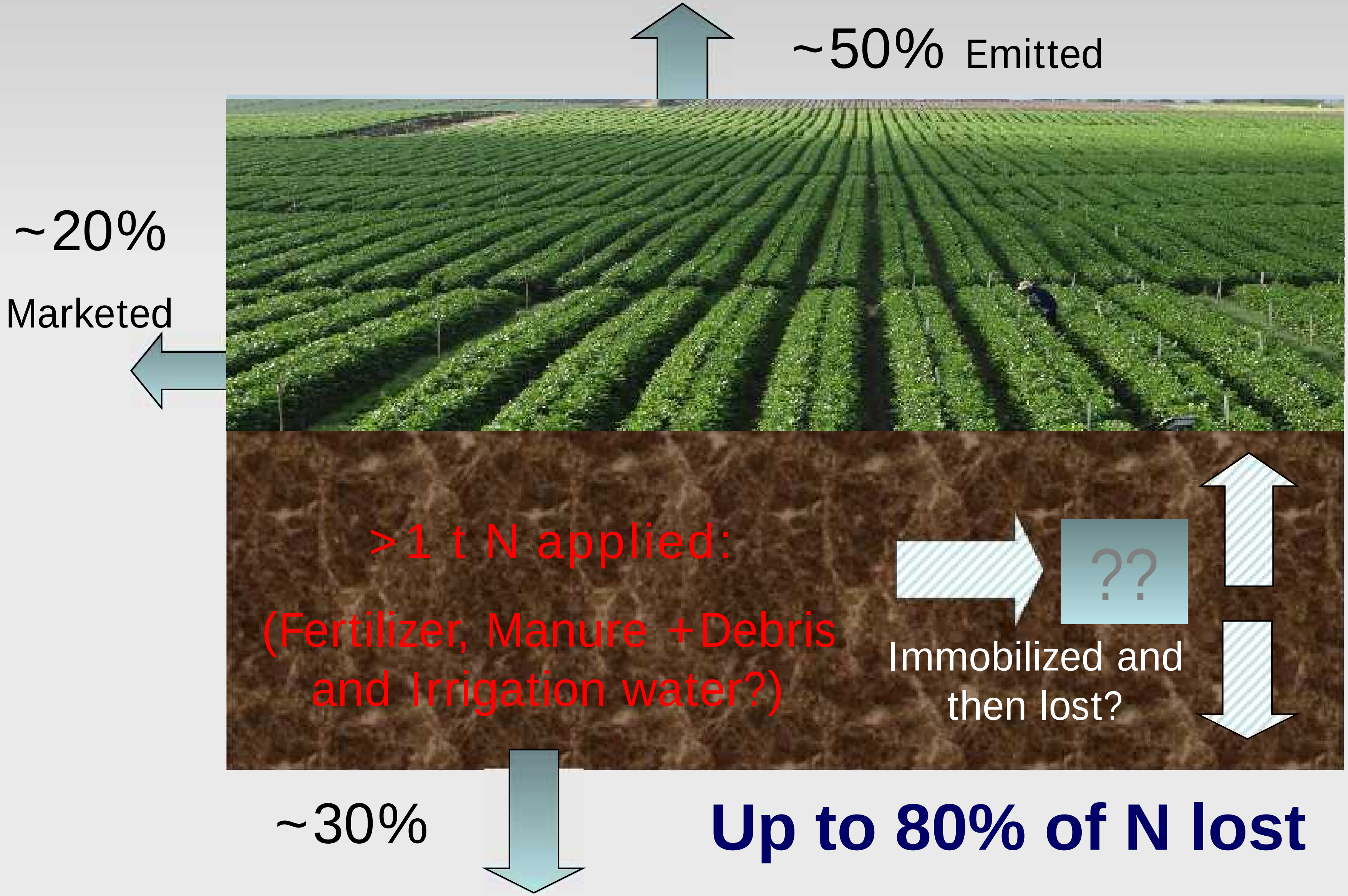
Ravishankara et al, SCIENCE, Vol. 326, 2009

2013-2016: Carbon and Nitrous Oxide Management Programs (NANORP) (P. Grace)

1. Benchmark Emissions
2. Nitrification Inhibitors
3. Reduced rates & Irrigation
4. Whole Farm N Budgets
5. Perverse Outcomes (Disease, crop quality)



Estimated losses of N (fertilizer/manure) in Vegetable Crops



Improve Efficiency of Management of N and C

Intensive >3 crops/yr

>10 tillages

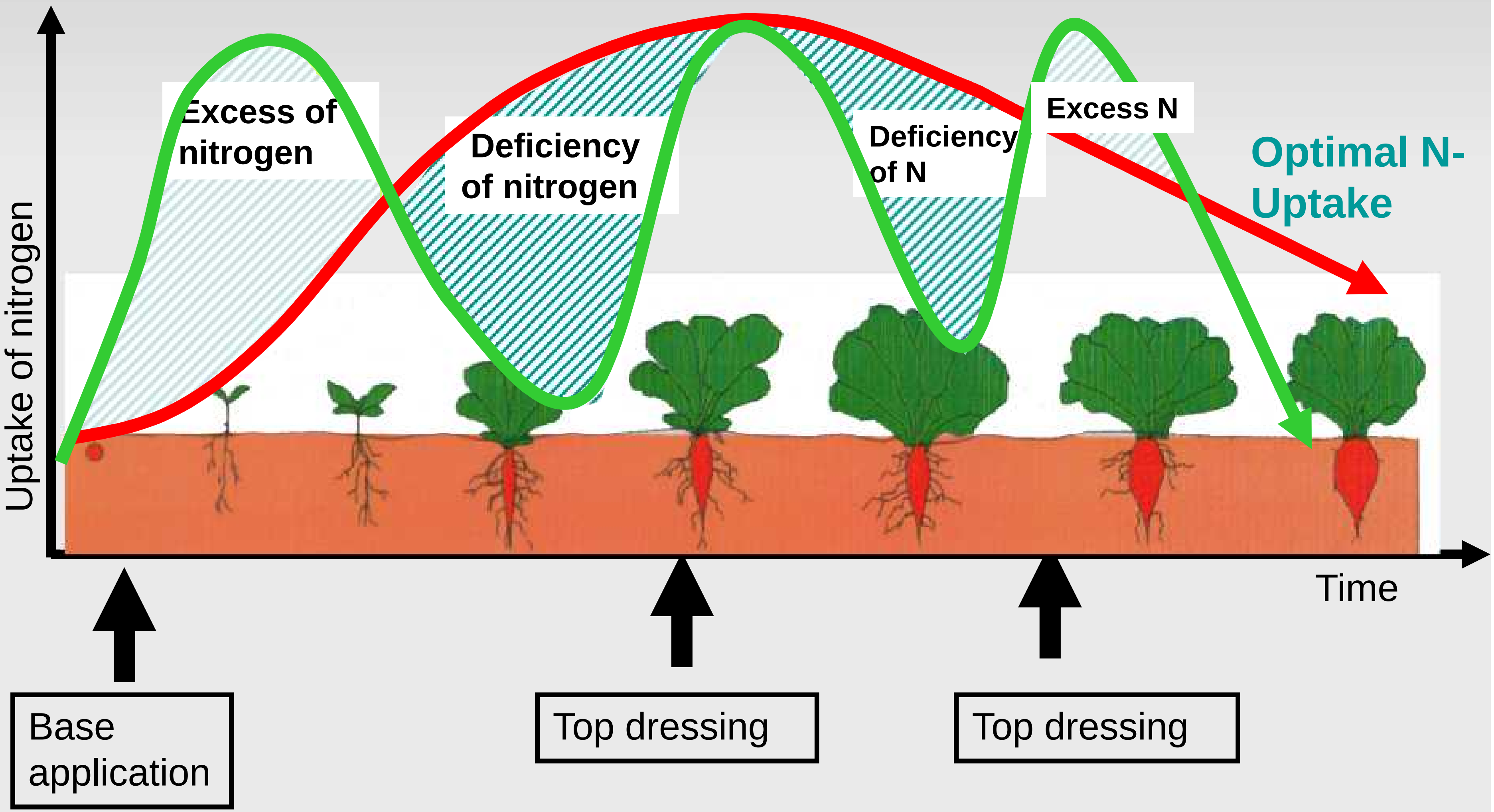
O/H Irrigation

>1 t N

5-10 t/ha 4x/year

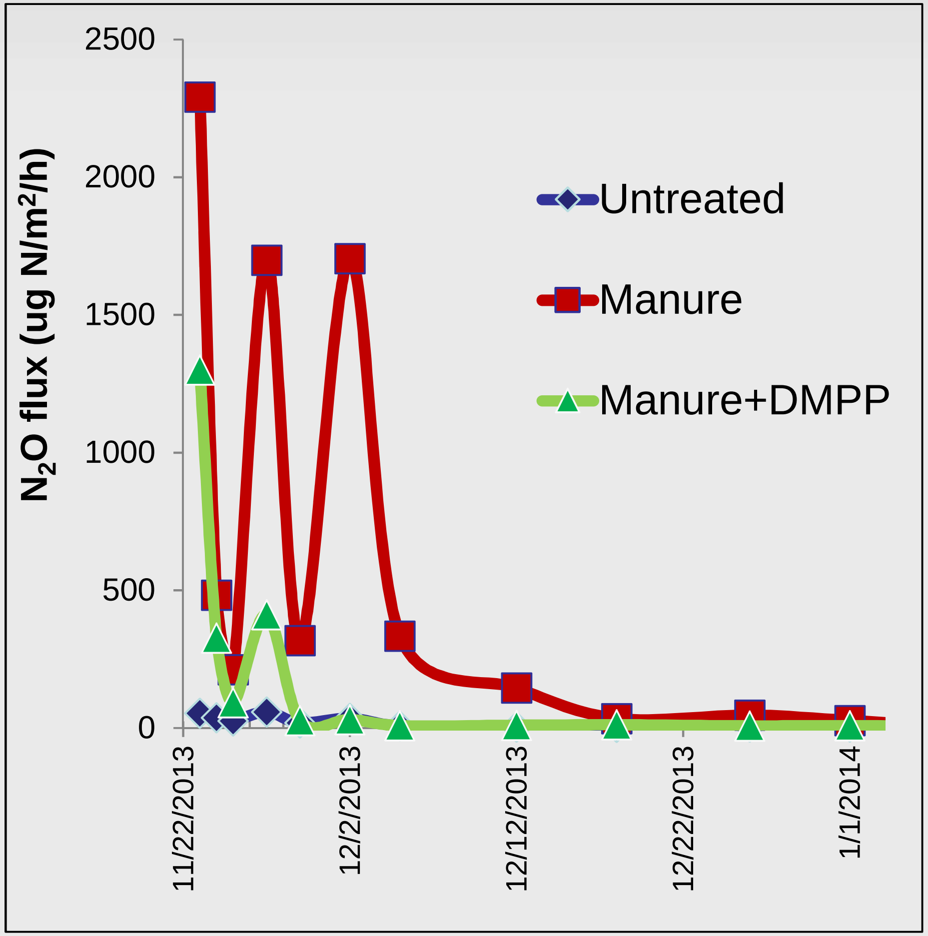
Trials 2008-2013 (EEF benefit)

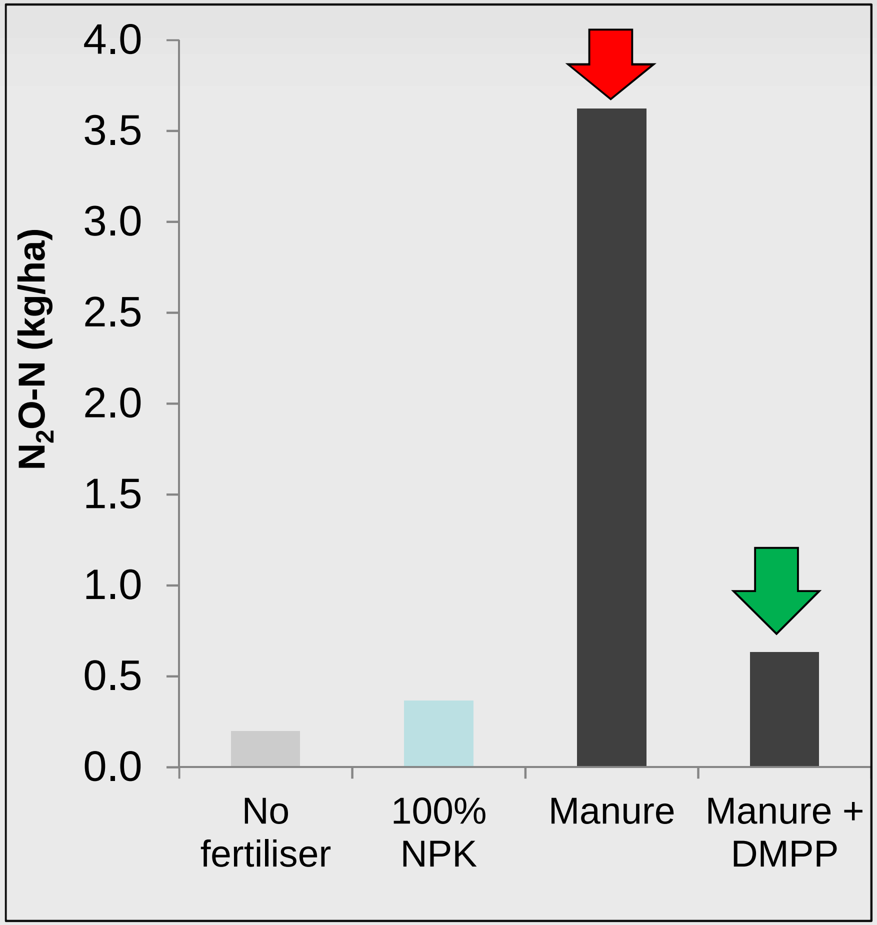
Traditional Fertilisation: Excess and Deficiencies of N



Effect of EEFs on N_2O Emissions - Werribee 2013/14

- 10 x higher emissions from manures
- 10-fold decrease in flux and 80% decrease in cumulative N_2O emissions





Victorian Trials 2014-2016

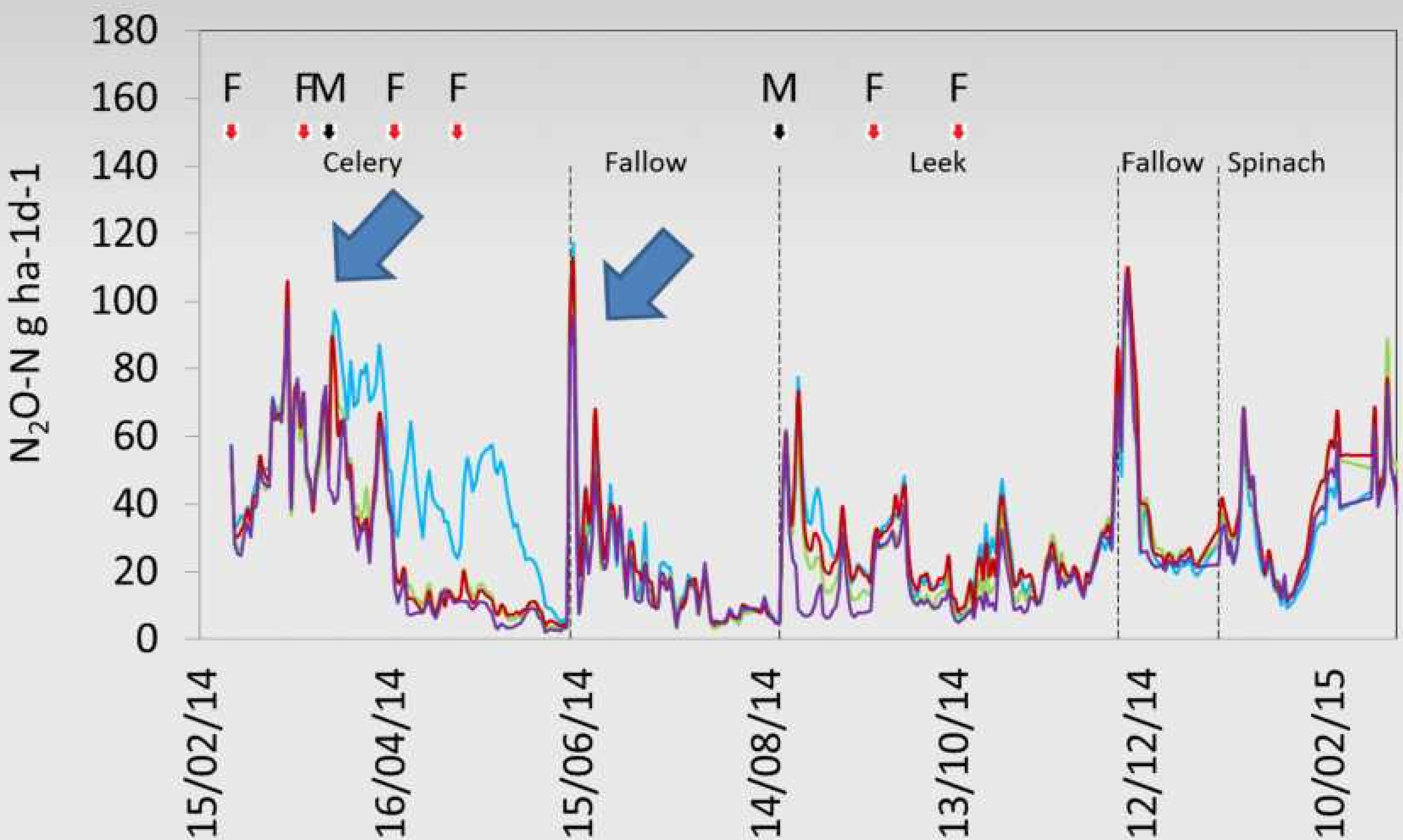
- Sandy soil (kudasol)
- Composted chicken manure used
- Crops grown – Celery, leeks, baby leaf (spinach, etc.)
- Automated GHG system for gas measurements

Crop	Date 2014/15	Activity	N Rate (kg ha^{-1})
Celery	25/2/14	Celery planting	-
	25/2, 20/3,18/4,8/5	Fertiliser application	192
	28/3	Manure application (Surface)	167
	5/6	Celery harvest	-
	13/6	Residue incorporation	-
		Total N applied*	**473***
Leek	19/8	Manure application (Incorporated)	291
	20/8	Leek planting	-
	18/9, 15/10	Fertiliser application	48
	2/12	Leek harvest	-
	4/12	Residue incorporation	-
		Total N applied	**425***
Spinach	13/1	Spinach planting	-
	6/2	Spinach harvest	-
	17/2/15	Residue incorporation	-
		Total N applied	9.5*
All Crops	(*Water =160 N)	**Total N applied/yr**	**907 (238)**

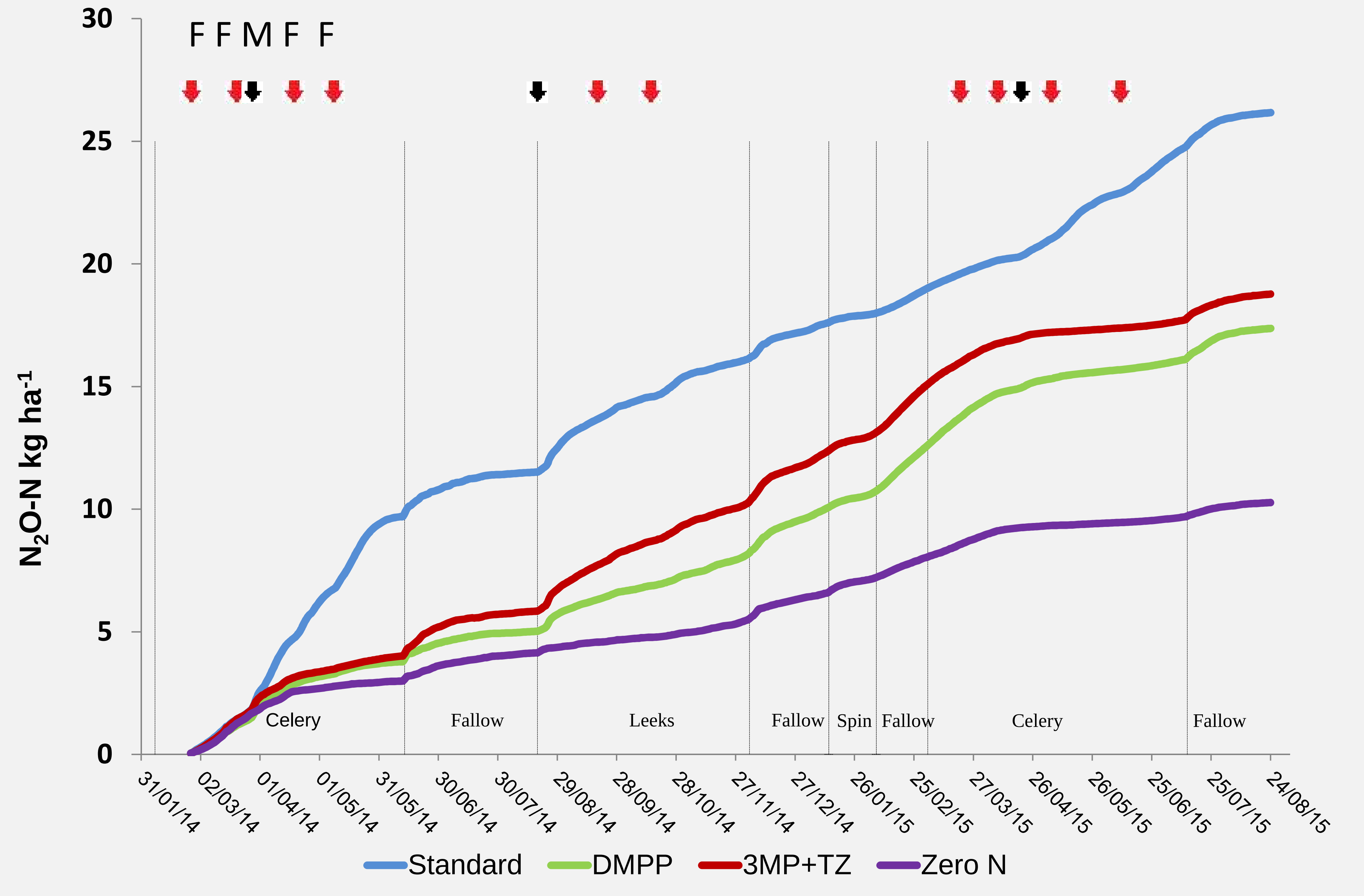
Trials 1 & 2. Clyde: Celery (Feb 2014 – Jun 2014)

Treatment	Base, Poultry Manure	Base, Top dress 1		Top dress 2		Top dress 3,4		Total N units
	N units	Product	N units	Product	N units	Product	N units	
No fertiliser		-	-	-	-	-	-	0
Standard	238	Calgran	38	Manure	162	Calgran	38	**552**
DMPP	238	DMPP Calgran	38	Manure	162	DMPP Calgran	38	**552**
3MP+TZ	238	3MP+TZ Calgran	38	Manure	162	3MP+TZ Calgran	38	**552**

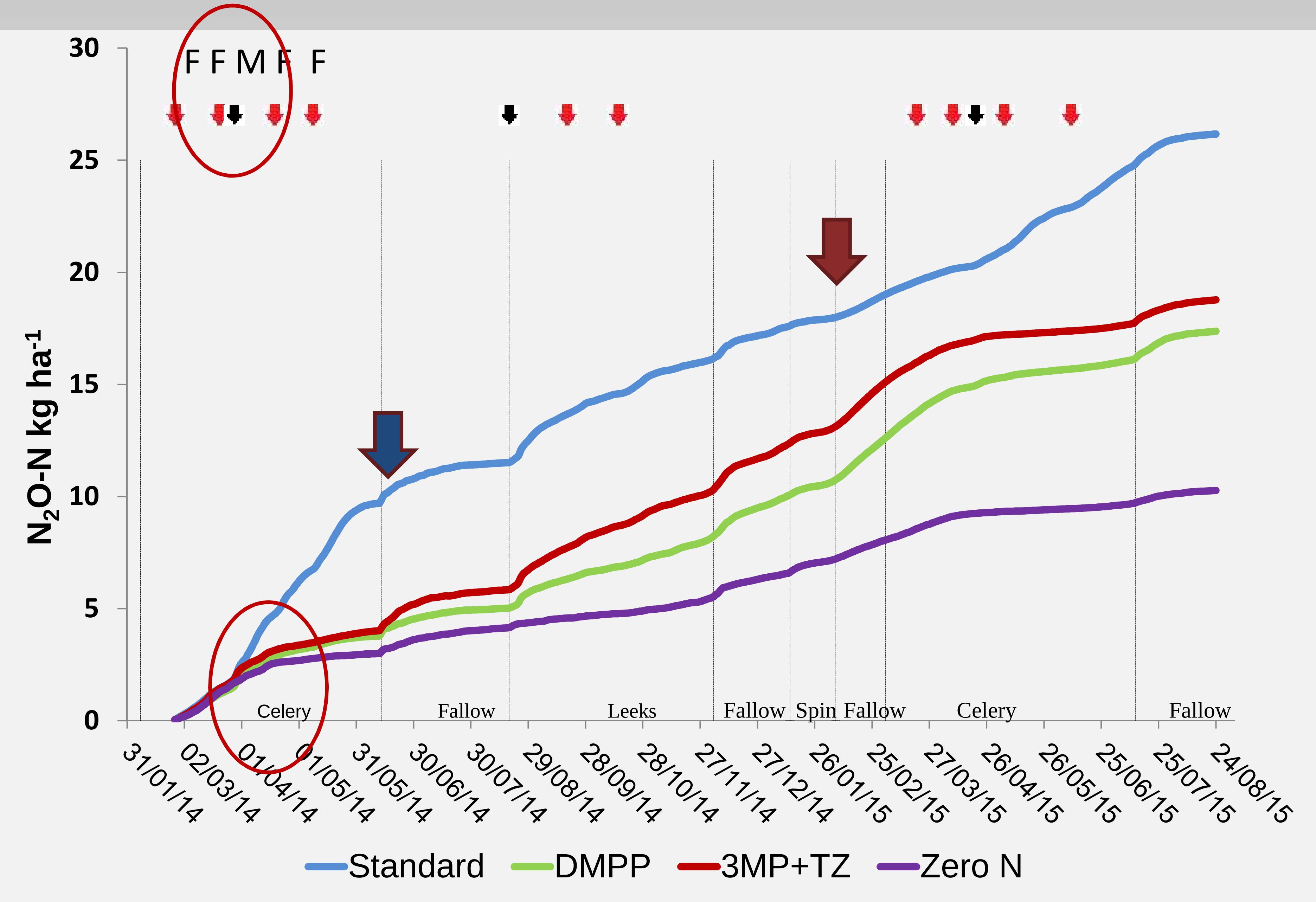
Daily N_2O Emission Flux: Victoria Site 2



Cumulative N_2O emissions: Clyde



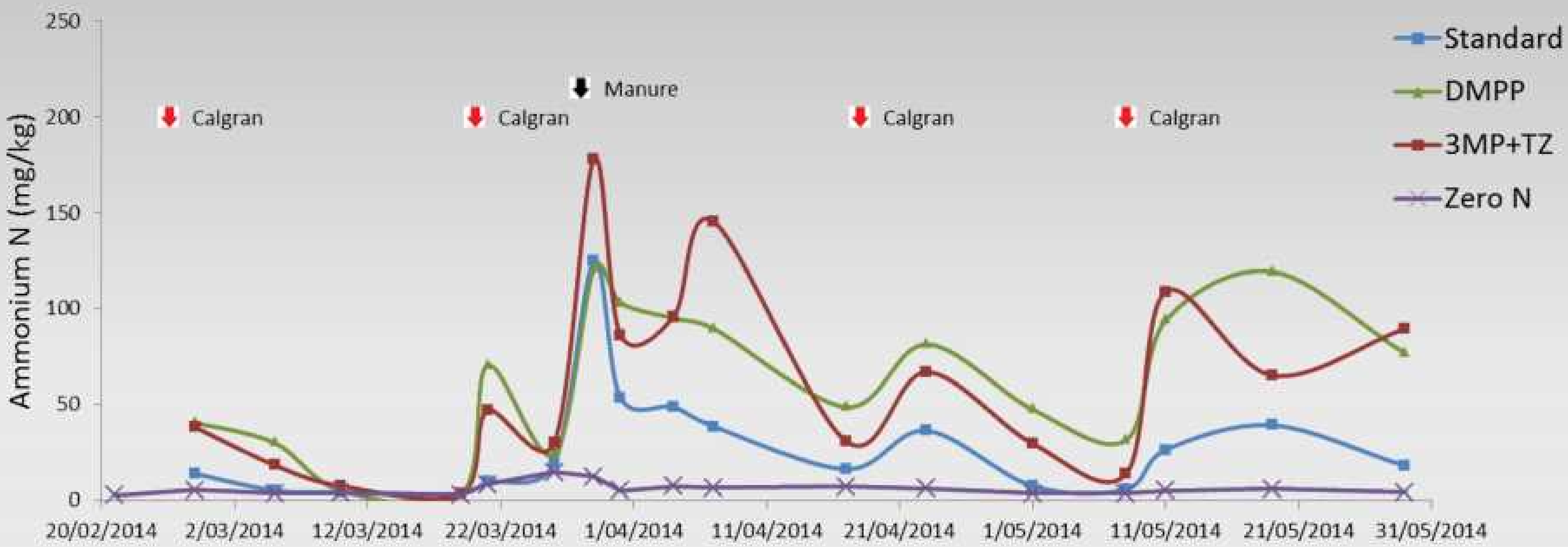
Cumulative N_2O emissions: Clyde

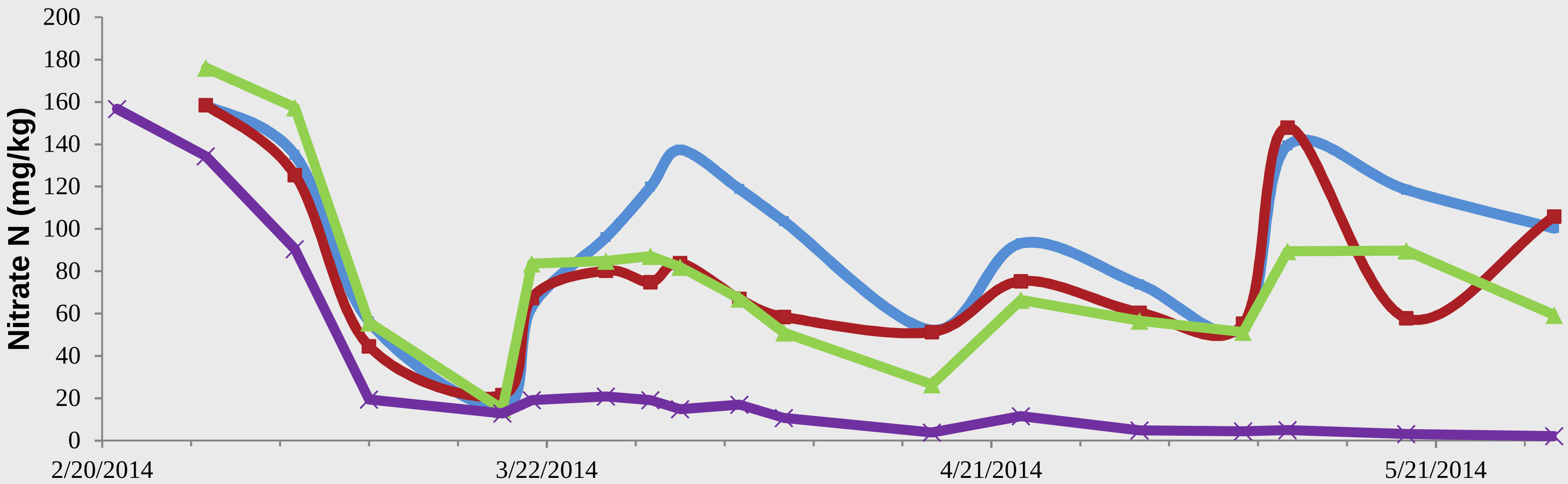


% Decrease in N_2O Emissions with EFFs

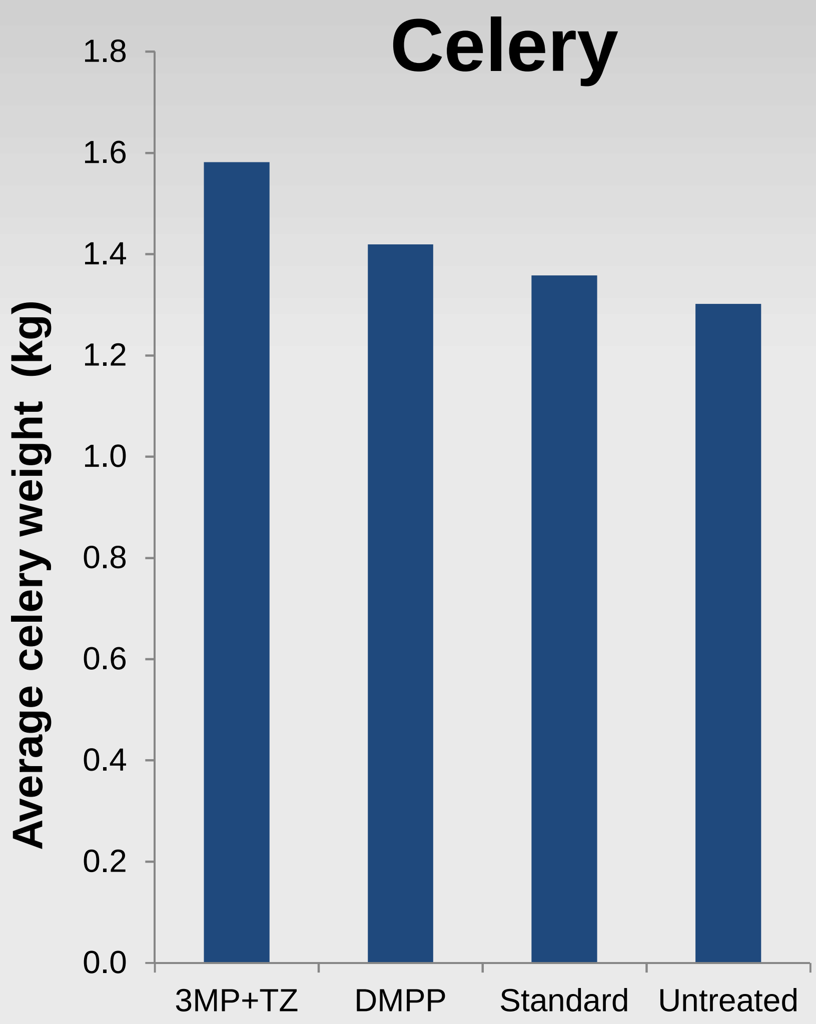
Crop	Manure	Treatment	Total N_2O-N (kg ha^{-1})	Net total N_2O-N	Red^n in net N_2O-N (%)
Celery-Leek-Spinach	No	**No Fertilizer**	8.8 (47%)	-	
(372 days)	Yes	**SGP**	18.7	9.9	
	Yes	**DMPP**	12.1	3.3	67.1
	Yes	**3MP+TZ**	14.5	5.7	42.3

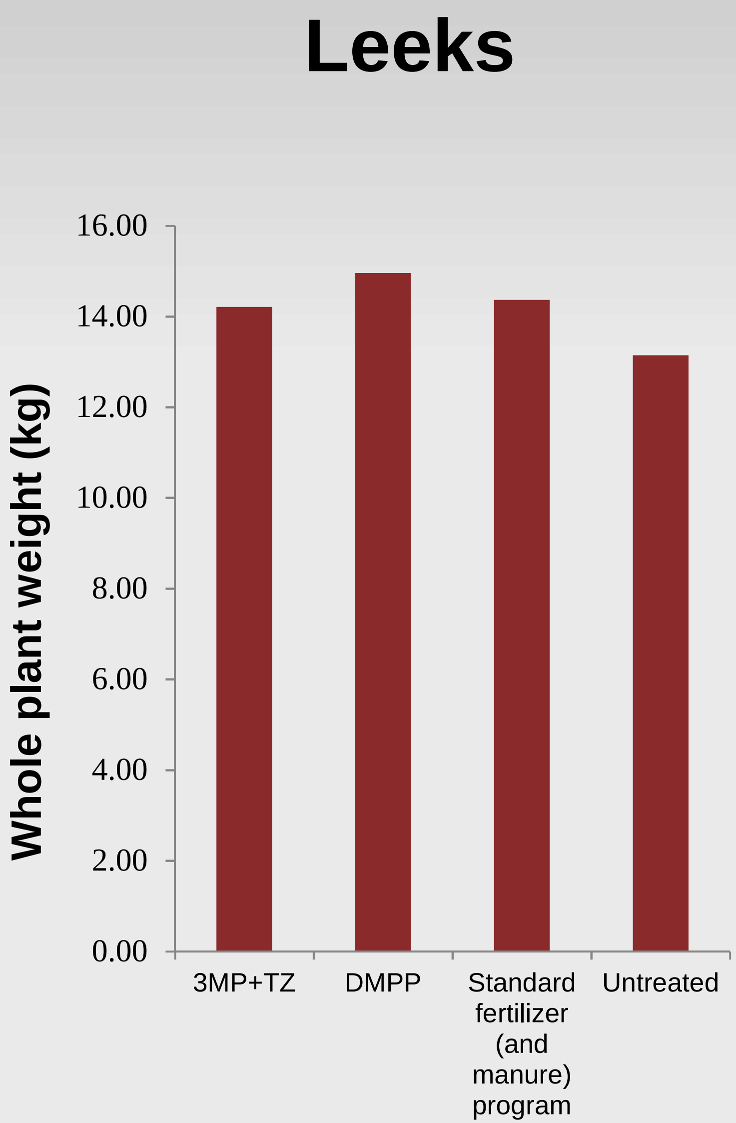
Soil Mineral N: Celery 2014





Yields

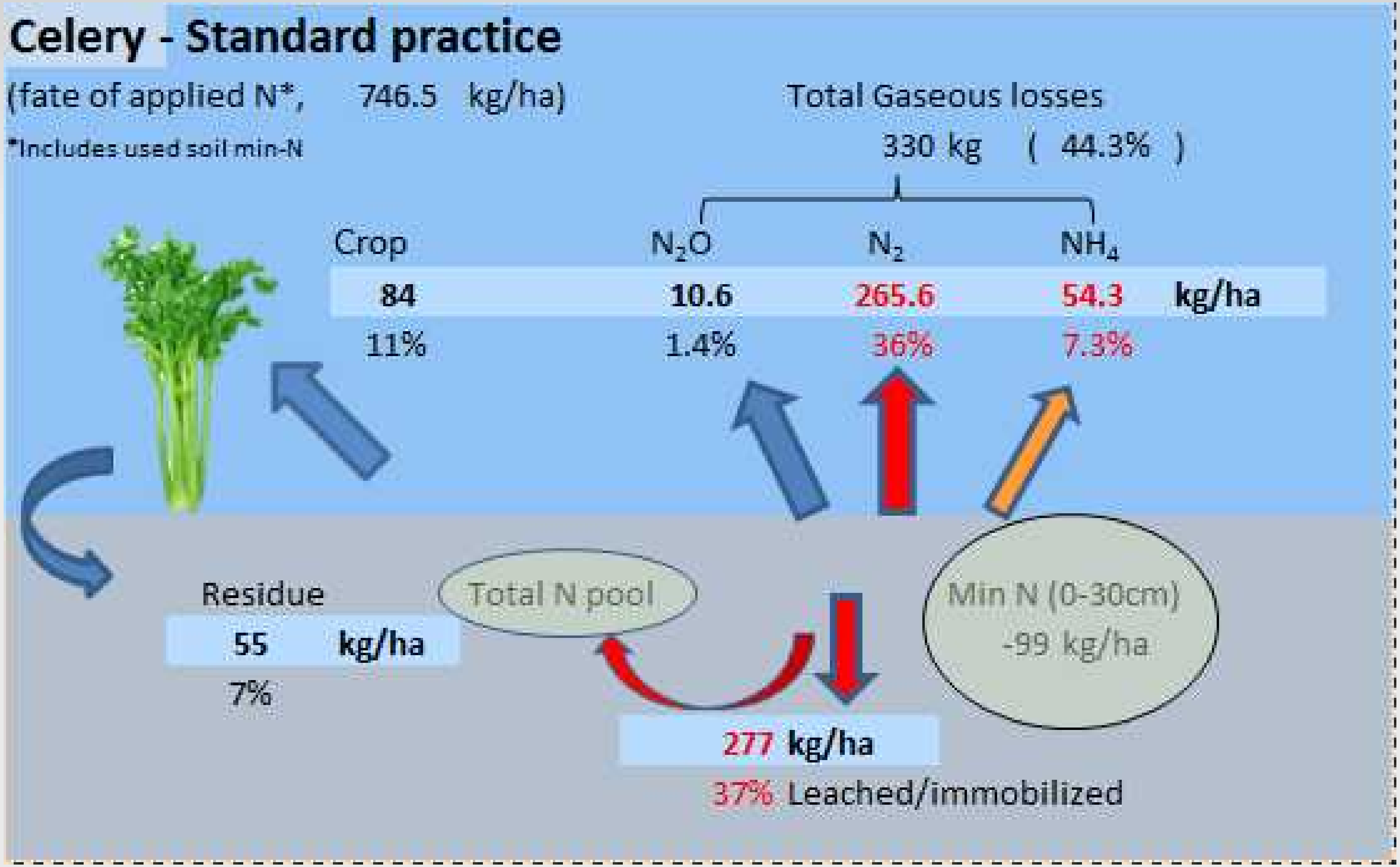

Celery
Average celery weight (kg)
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
3MP+TZ
DMPP
Standard
Untreated


Leeks
Whole plant weight (kg)
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
3MP+TZ
DMPP
Standard fertilizer (and manure) program
Untreated

Yield

- No Yield difference with inhibitors
- Irrigation water 160 kg/ha of N (nitrate) applied per annum through irrigation water (25% in recycled Melbourne water, 75% property runoff)

Actual N Budget on large Commercial Farm 2015 - Nutrient Use Efficiency and offsite issues



Farm Nitrogen budget - EEFs

Unknowns

N2:N2O ratio

25	

NH4 emission as % of applied NH4-N

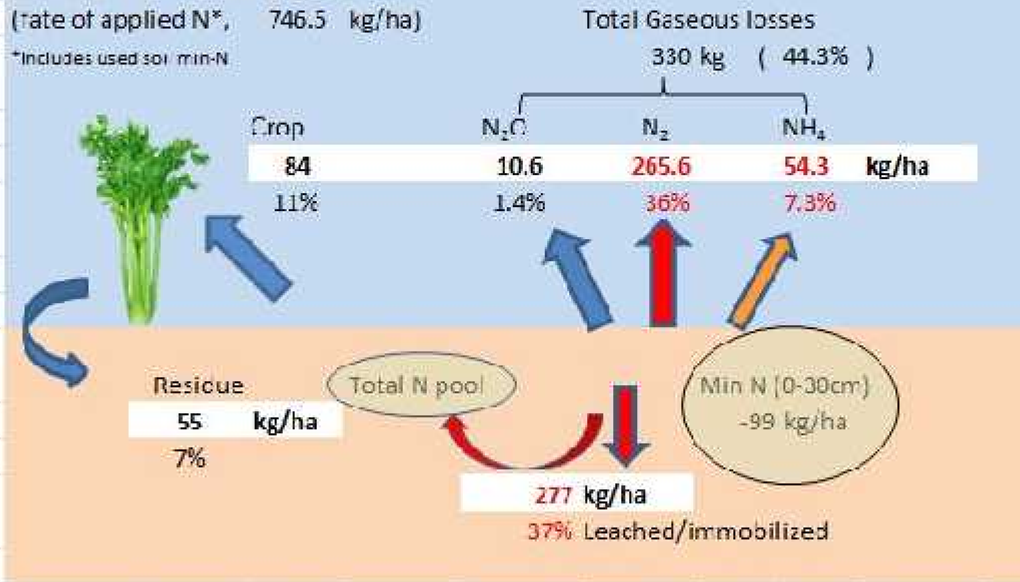
7.8	TD manure	Bai et al 2014 (Lamattinas)	
9.4	TD manure (+DMPP)		(20% higher than -DMPP)
0.73	Incorp manure		(90% lower than TD ?)
0.94	Incorp manure (+DMPP)		
30	Calgran		
36	Calgran+DMPP		
37%	Leaching/immobilized		
54%	Leaching/immobilized (DMPP)		

Cumulative N2O (kg/ha)		Standard	DMPP	No fertilizer
Date	12/06/2014	10.52	4.46	3.33

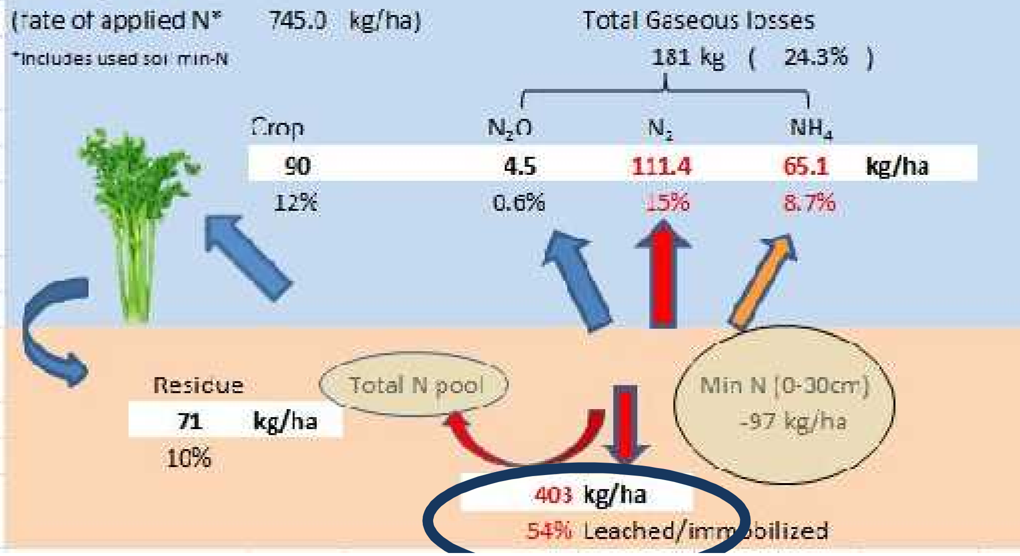
Include soil mineral N pool	yes

	Standard	DMPP	No fertilizer
N2O	10.5	4.5	3.3
N2	265.5	111.4	83.3
NH4	54.3	65.1	0.0
Export	84.0	90.0	53.0
Residue	55.0	70.8	41.8
Leaching/immobilized	277.0	403.2	58.3
Total	746.5	745.0	239.7
Soil min N	-99.0	-97.5	-183.2

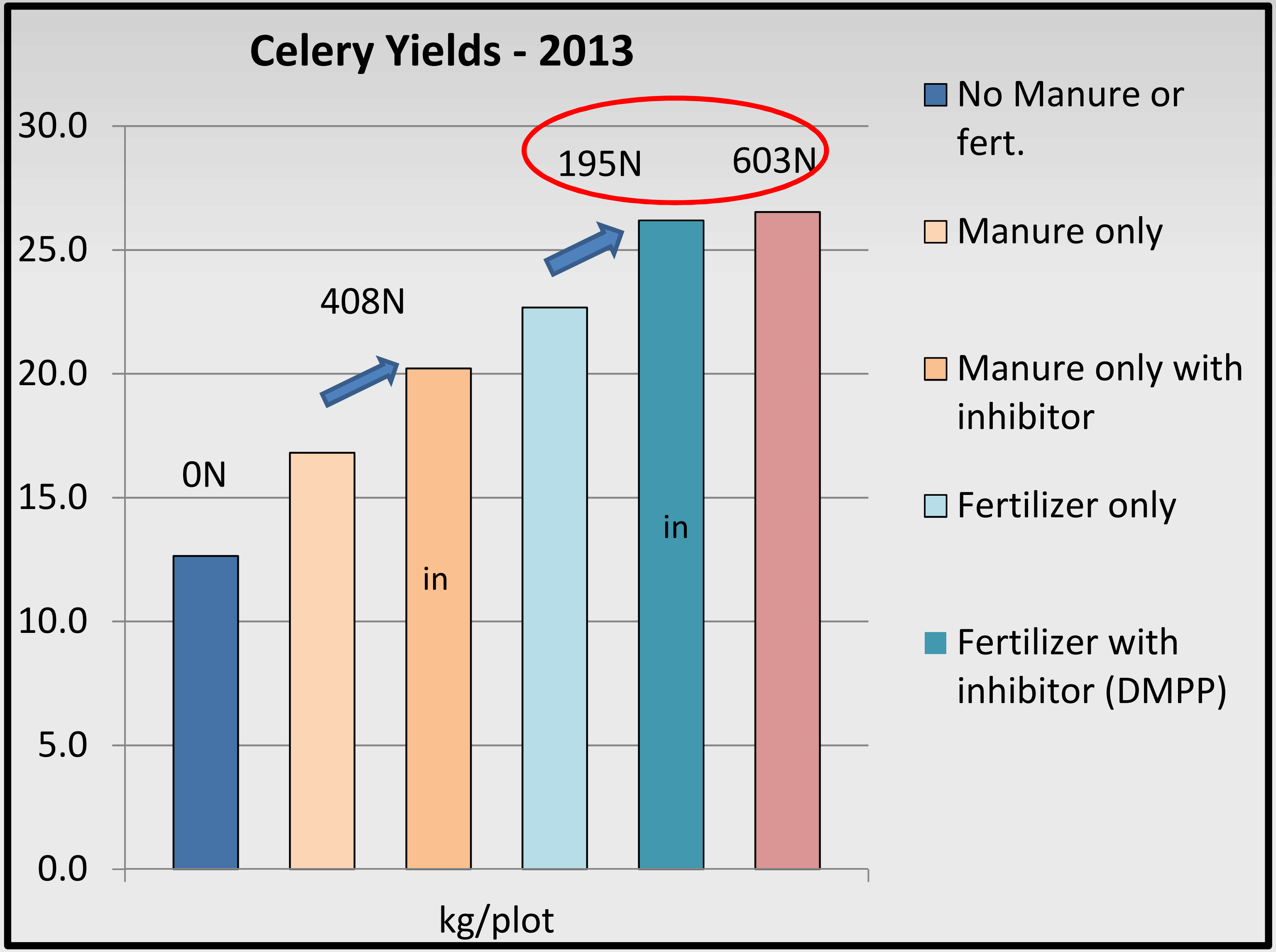
Celery - Standard practice



Celery - DMPP



Inhibitors improved NUE & Yields (Balanced sites



Effect of Inhibitors on Manure on Yield and Profit in vegetable production systems

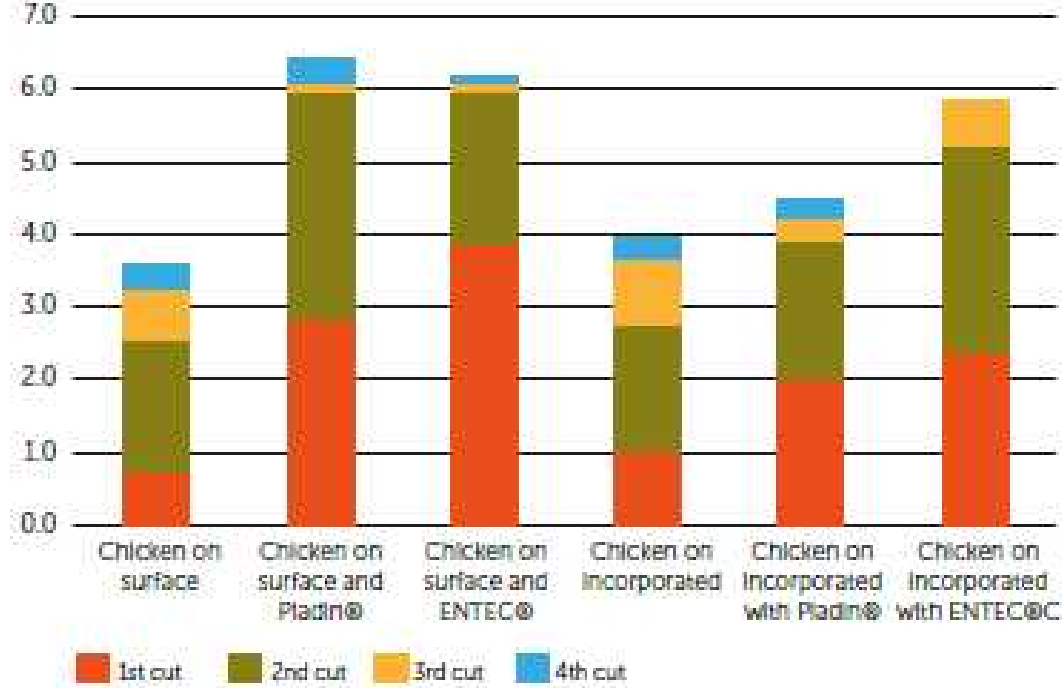


Figure 2. Effect of nitrification inhibitors on fertiliser (ENTEC®) or on chicken manure (Piadin®) on the yield (kg/plot) from plots which had manure either left on the surface or incorporated at Boneo in Victoria in 2012.

Treatment	Yield (kg/5m)	Gross income at $1.80/kg (adjusted	Potential extra profit compared to the existing commercial practice
Chicken on surface and NPK base (SGP)*	3.86	$7,195	–
Chicken on surface and Piadin+NPK base	6.19	$13,247	$6,052
Chicken on surface and ENTEC+NPK base	6.17	$12,647	$5,452

60% increase

Conclusions and Recommendations

1. **Benchmarking N_2O mitigation (Manure x fertilizer systems):**

•Highest in Australia -**18 kg** N_2O-N/ha/yr

•**Manures** (10x higher than fertilizers)

2.EEFs:

•**30-60%** decrease in N_2O emissions/yr

•**90%** reduction on manures

3.Nutrient Use Efficiency:

•Potential to reduce fertilizer and manure dose by **25%-50% without yield penalty.** Will require timing adjustments

4.Offsite impacts/Leaching reduced:

5.Yields:

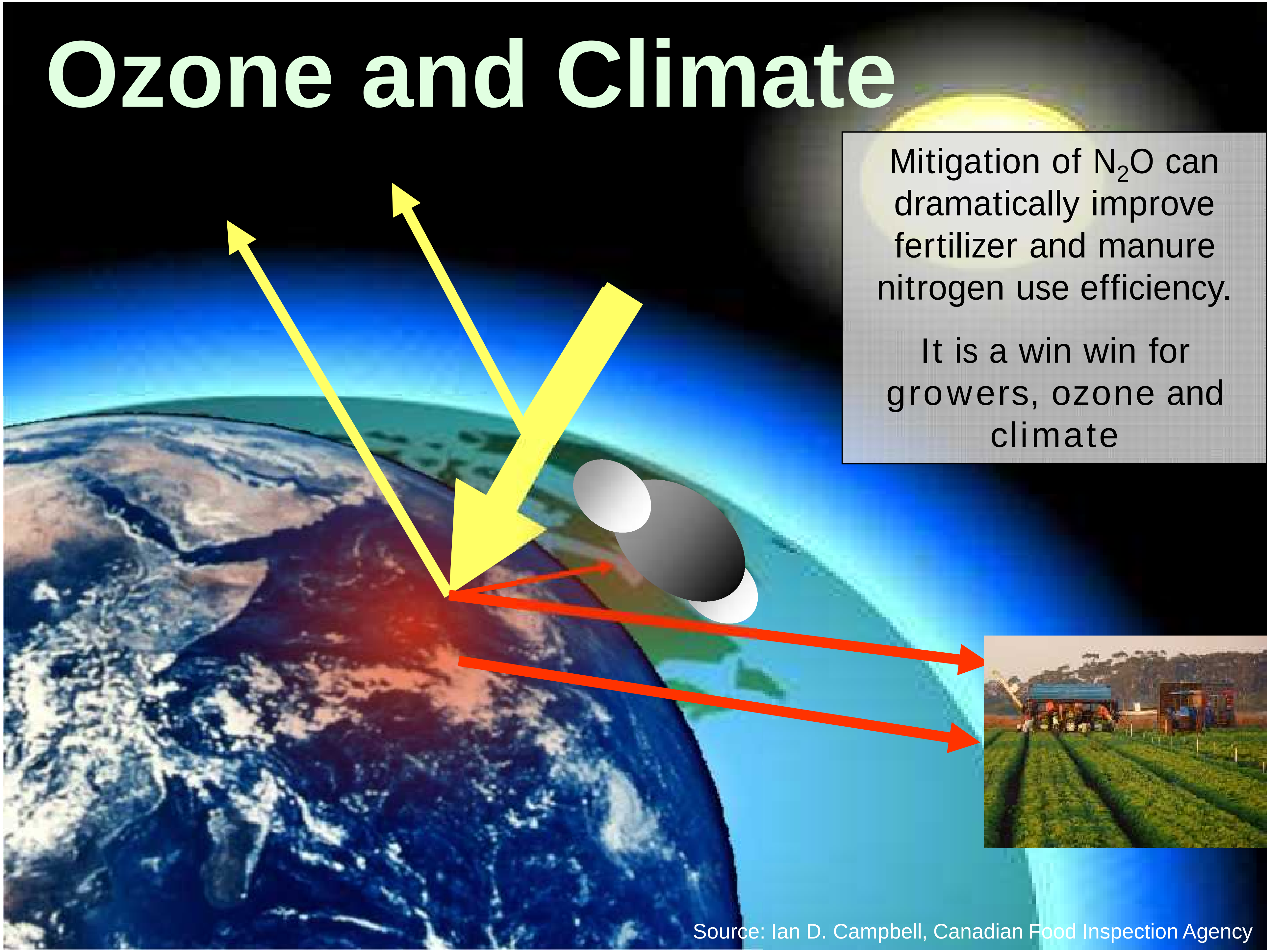
•Can be equivalent or better

6. Economics:

• > $AUS1,500/ha gain - reduced energy/ labour costs /fertlizer

How to improve adoption of mitigation practices (EEFs) in temperate Horticultural Systems

- **Must** work in nutrient balanced **systems (not the present over fertilized/manured systems)** to prove benefits to growers
- **Must** consider changed management to manage soil carbon.
- **Must** value all on/offsite benefits to sell the full cost benefit


Ozone and Climate
Mitigation of N_2O can dramatically improve fertilizer and manure nitrogen use efficiency.
It is a win win for growers, ozone and climate
Source: Ian D. Campbell, Canadian Food Inspection Agency