National Agricultural Nitrous Oxide Research Program (NANORP)

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THE UNIVERSITY OF MELBOURNE

FACULTY OF VETERINARY & AGRICULTURAL SCIENCES

Reducing nitrous oxide (N_2O) emissions from applied nitrogen with nitrification inhibitors: Identification of the key drivers of performance

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Australian Government Department of Agriculture

N2O Network

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Background

- Part 1 : Laboratory Investigation
  - 30 soils to identify key soil property affecting how well nitrification inhibitors work
- Part 2 : Biomass productivity benefits from inhibitors
  - Different N rates applied at 2 sites, dairy (Wye, SA) and HRZ cropping (Cressy, Vic)
- Part 3 : Modelling
  - Development of algorithm to describe nitrification inhibitor impact
  - Incorporation of algorithm into model (WNMM) and validation with field data

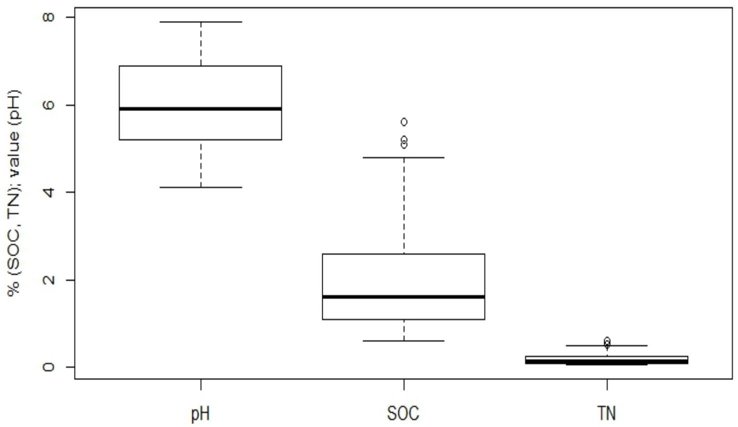

Fig 1. Range of pH, SOC and TN for the 30 soils tested

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Part 1: Laboratory Incubations : Nitrification (Part 3: Modelling)

- Nitrification inhibitors reduced average nitrification rates (14 days) by;
  - Average: 39%, Max:100%

- Effectiveness and soil properties:
  - No soil parameter had a major impact
  - But increasing soil organic C reduced inhibitor effectiveness ($R^2 < 0.29$)
- Effectiveness and land use:
  - sugarcane>cropping= vegetables>dairy

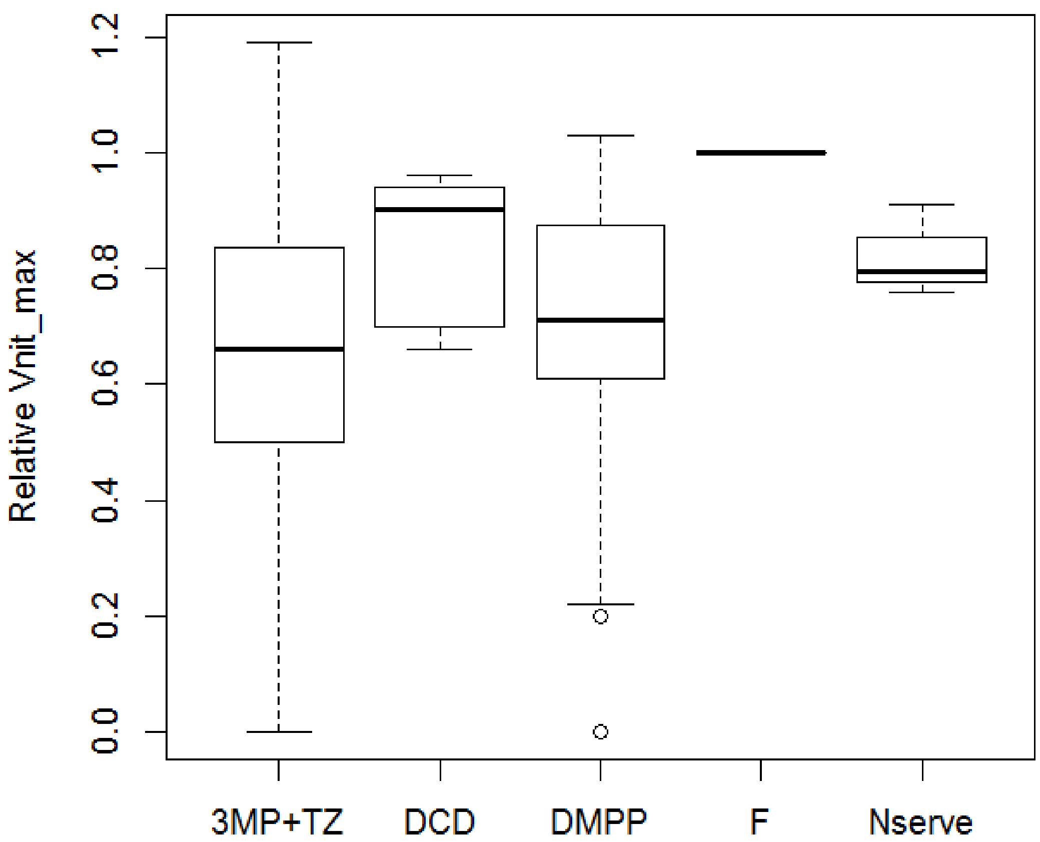

Fig 2. Relative Vnit_max : Maximum nitrification relative to control (fertiliser)

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Part 1: Laboratory Incubations : N_2O emissions (Part 3: Modelling)

- Nitrification inhibitors reduced cumulative N_2O emissions (28 days) by;
  - Average: 60%, Max:100%

- Effectiveness and soil properties:
  - No soil parameter had a major impact
  - But decreasing soil pH reduced inhibitor effectiveness ($R^2 < 0.25$)
- Effectiveness and land use:
  - vegetables>cropping >sugarcane>dairy

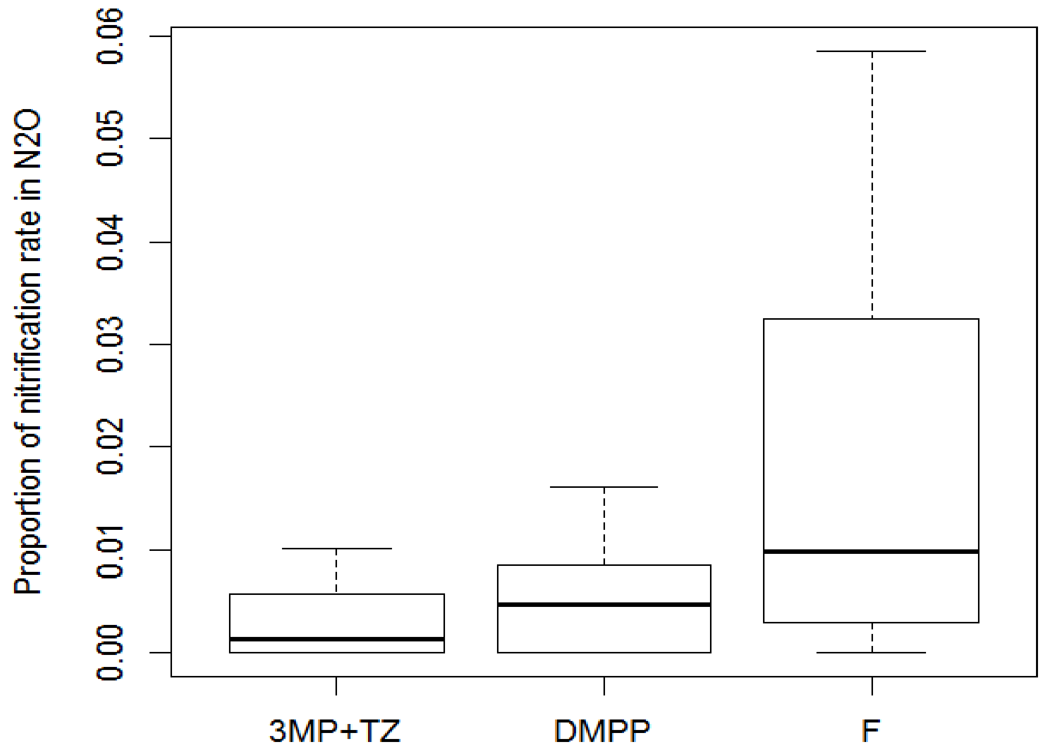

Fig 3. Proportion of nitrification rate in N_2O for inhibitors (3MPTZ and DMPP) and control (fertiliser, F)

Part 2: Field experiments : productivity benefits Wye, SA (dairy pastures) : N_2O and biomass

- The nitrification inhibitor DMPP, urease inhibitor NBPT, and polymer coated urea (PCU) reduced net-N_2O emissions and emission factors (EF). The impact on emissions intensity (EI) was variable
- Reducing N inputs reduced emissions intensity

Table1 . Biomass, N_2O, Reduction with inhibitor, EF and EI at the Wye site (average of 4 replicates ± standard error)

Treatment	Cumulative biomass+ (t ha^{-1})	Cumulative N_2O (g N ha^{-1})	Reduction (net) compared to U50 (%)	Emission factor (EF) (%)	Emission intensity (EI)**
C	2.0^{a}	353^{a}			0.18
U50*	4.5^{bc}	647^{c}		0.12	0.14
U84*	5.2^{c}	854^{d}		0.12	0.16
EU50 (DMPP)	4.2^{bc}	510^{b}	47^{a}	0.06	0.12
GU50 (NBPT)	4.3^{bc}	579^{bc}	23^{a}	0.09	0.13
PCU50	3.3^{ab}	469^{ab}	61^{a}	0.05	0.14

*Application rate; 50 = 250 kg N ha^{-1}, 84 = 420 kg N ha^{-1}. +Cumulative biomass from 6 cuts (May to February)
** Emission intensity = kg N_2O-N/t biomass
Means sharing the same superscript in the column are not significantly different from each other (P<0.05).

Part 2: Field experiments : productivity benefits Wye, SA (dairy pastures) : NUE

- Increasing N inputs increased biomass but decreased NUE

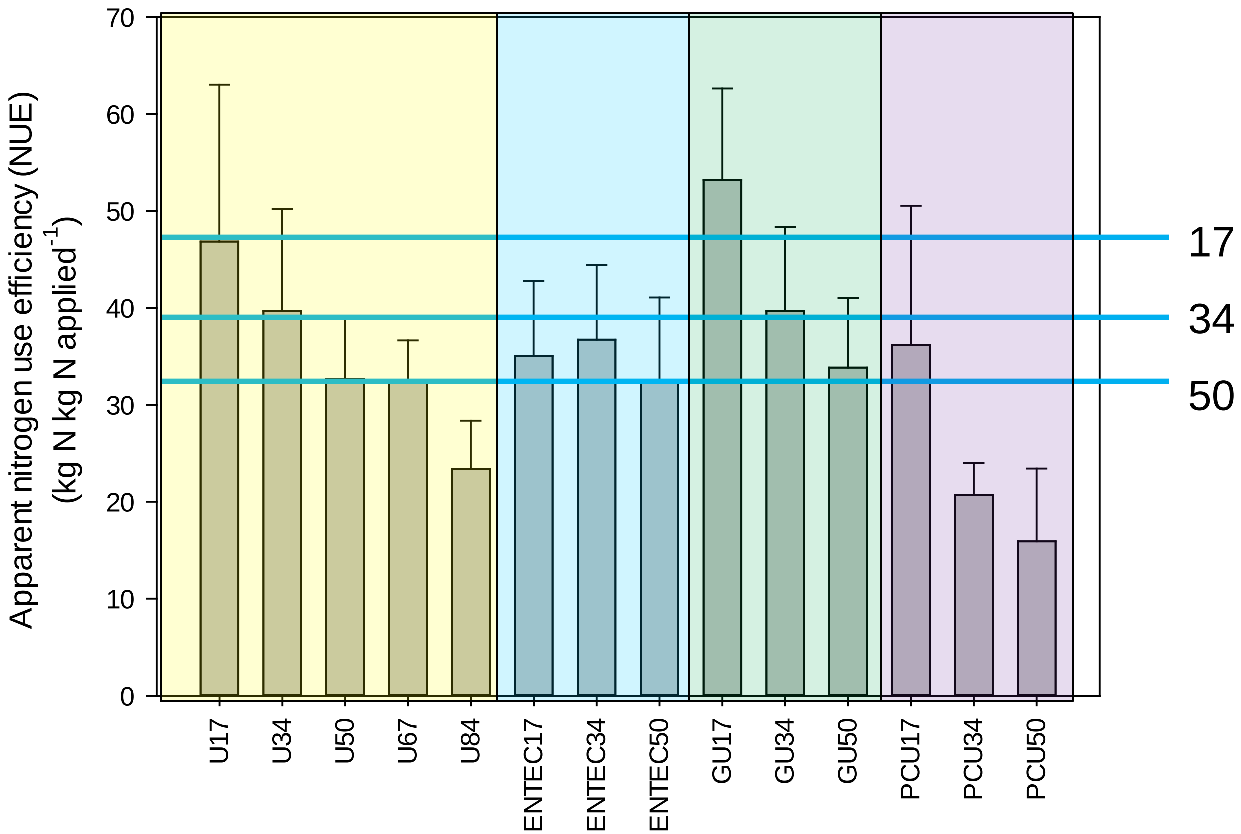

Fig 4. Apparent Nitrogen Use Efficiency (NUE) for Control (C), Urea (U), Urea + DMPP (EU), Urea plus NBPT (GU), polymer coated urea (PCU) at 17, 34, 50, 67 and 84 kg N ha^{-1} at the Wye site

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Part 2: Field experiments : productivity benefits Cressy, VIC (HRZ cropping) : Yield

- Limited N response, limited nitrification inhibitor impact
- The nitrification inhibitor increased yield for 60 kg N ha^{-1} application rate

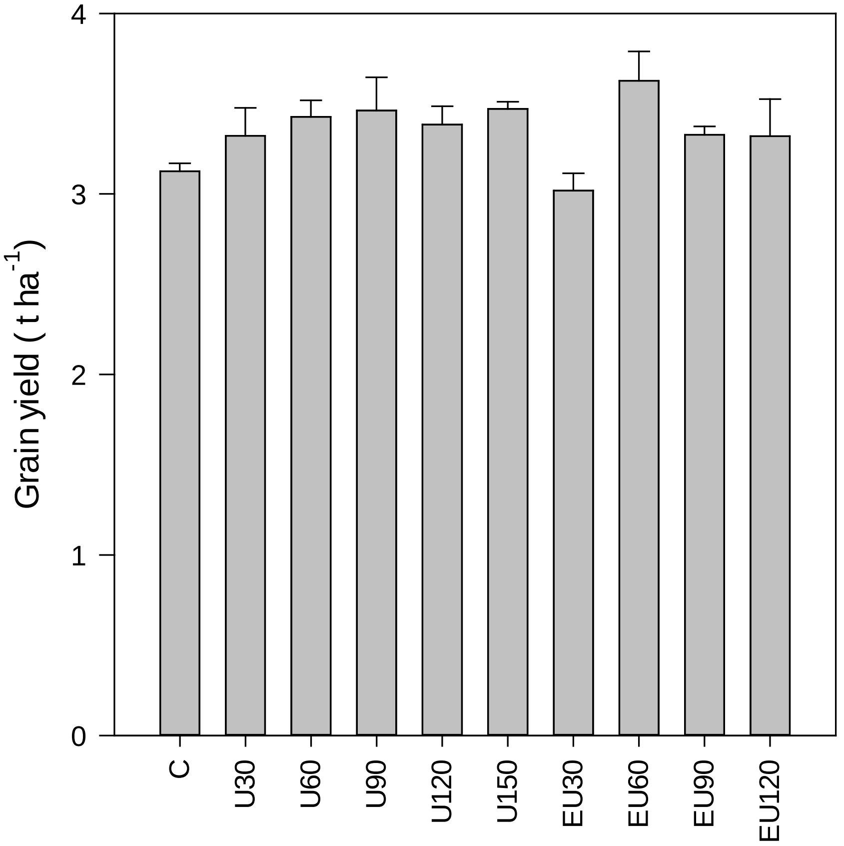

Fig 5. Grain yield for Control (C), Urea (U) and Urea + DMPP (EU) at 30, 60, 90, 120 and 150 kg N ha^{-1} at the Cressy site

^{15}N

	Recovery (%)	
plant	30-36	
soil	27-42	Most 0-10 & EU30

Part 2: Field experiments : productivity benefits Cressy, Vic (HRZ cropping) : N_2O emissions

- The nitrification inhibitor DMPP reduced net-N_2O emissions, the emission factor and emissions intensity relative urea (U)
- Reducing N inputs reduced emissions intensity

Table 2 . Yield, N_2O, Reduction with inhibitor, EF and EI at the Cressy site (average of 4 replicates ± standard error)

Treatment	Grain yield (t ha^{-1})	Cumulative N_2O (g N ha^{-1})	Reduction (net) (%) compared to U60 (%)	Emission factor (EF) (%)	Emission intensity (EI)*
C	3.1^a	215^a			0.07
U60	3.4^a	391^c		0.29	0.12
U120	3.4^a	514^d		0.25	0.15
EU60 (DMPP)	3.6^a	299^b	23	0.14	0.08

* Emission intensity = g N_2O-N/t biomass, based on net-N_2O and net biomass production
Means sharing the same superscript in the column are not significantly different from each other (P<0.05).

Part 3: Modelling – incorporation of algorithm into WNMM (Cressy field and laboratory data)

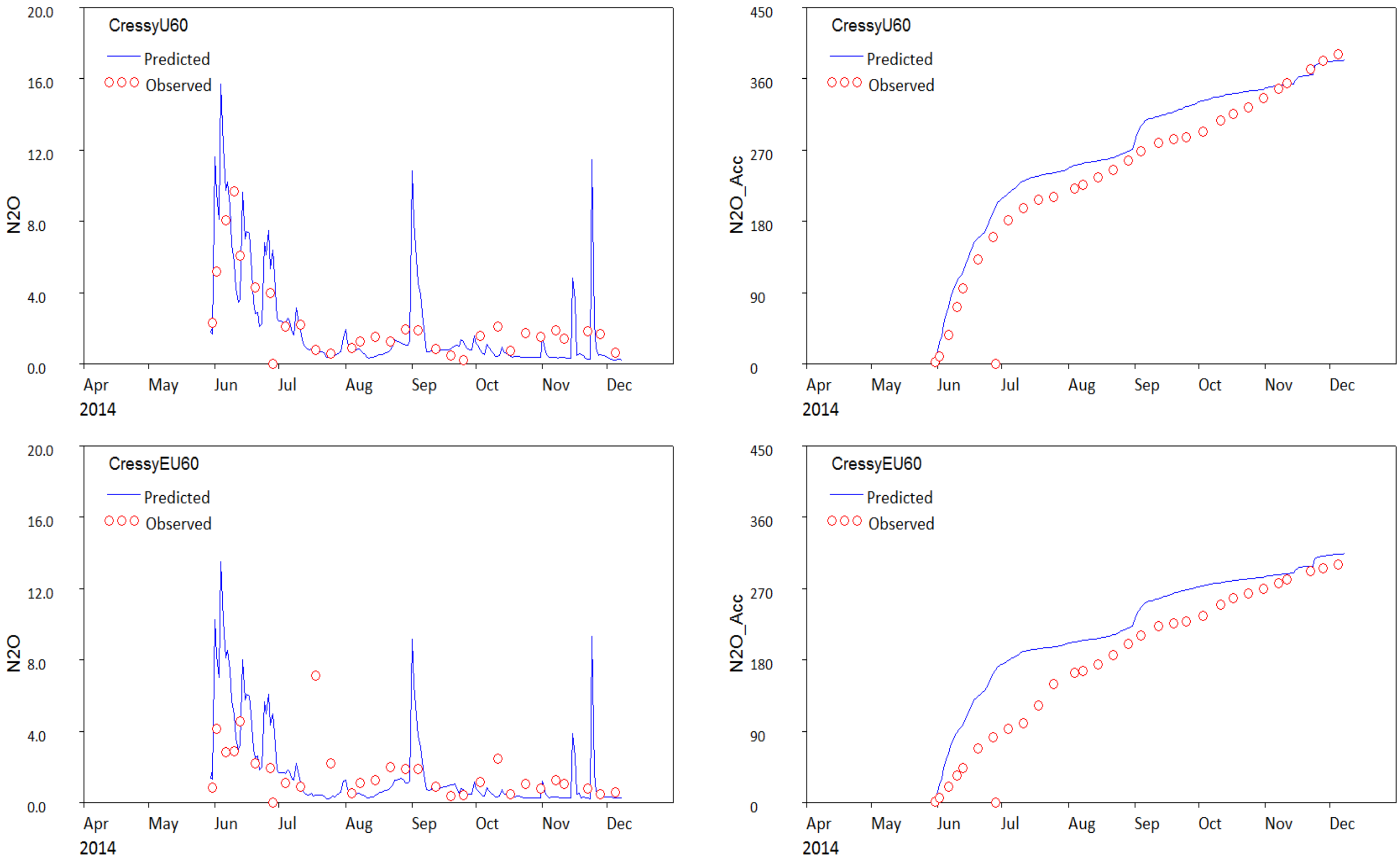

Fig 6. Modelled daily and cumulative N_2O emissions from the Cressy site for urea (U) and urea plus DMPP (EU) at 60 kg N ha^{-1}, using WNMM and the algorithms developed from the laboratory results

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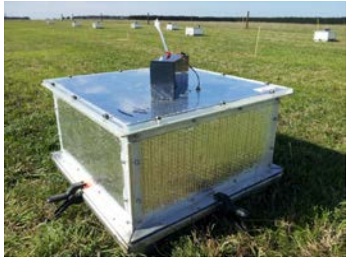
Three possible mitigation strategies for N_2O emission reduction



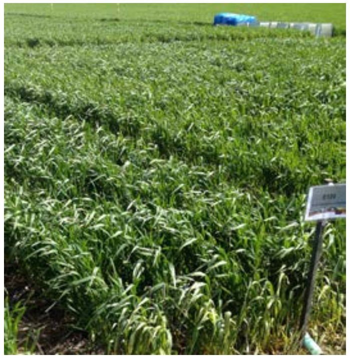
1) <u>Nitrification inhibitors</u>

Majority of times beneficial

Particularly systems like vegetables

Potentially greater benefits on higher pH soils

Incentives required



2) <u>Reducing N inputs</u>

In situations where there is adequate soil N supply

3) <u>Choice of product</u>

Balance N_2O reduction, biomass, NUE and cost-benefit

Consider non-target loss pathways

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