UNIVERSITÀ DEGLI STUDI DI PADOVA

DAFNAE

Nutrient balances at different scale as indicator of sustainability

M. Tolomio, A. Berti and M. Borin

Environment, Sustainable Agriculture and Forest Management - Padova, 25-29th September 2016

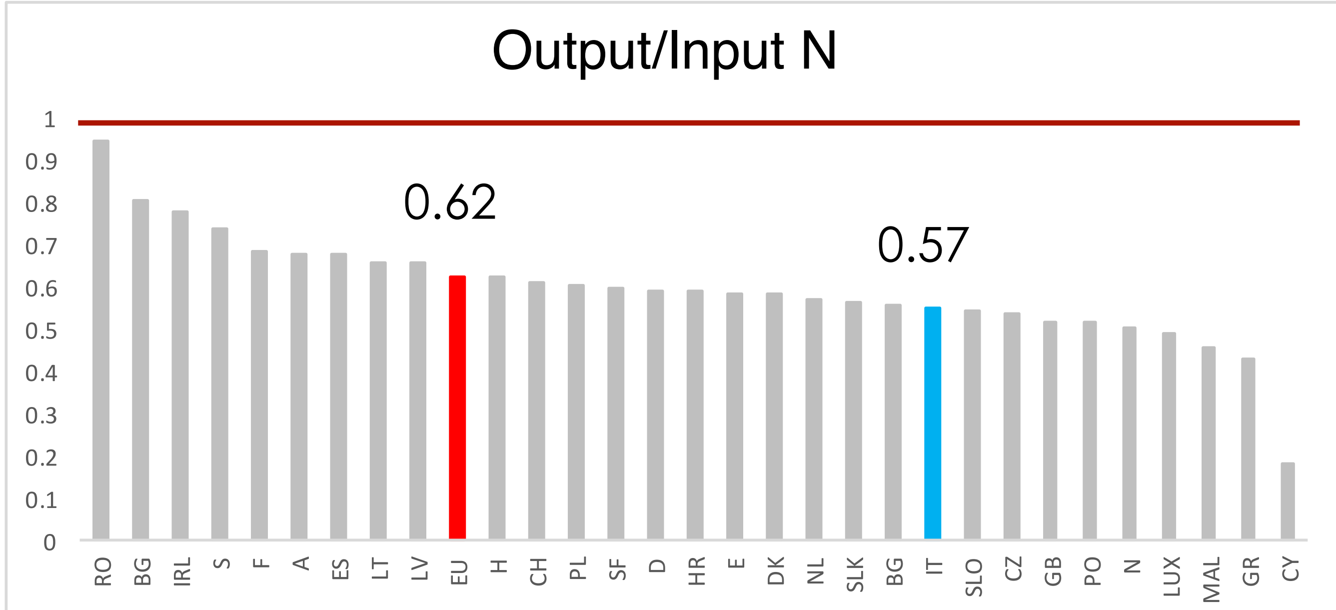
PADOVA-SYDNEY

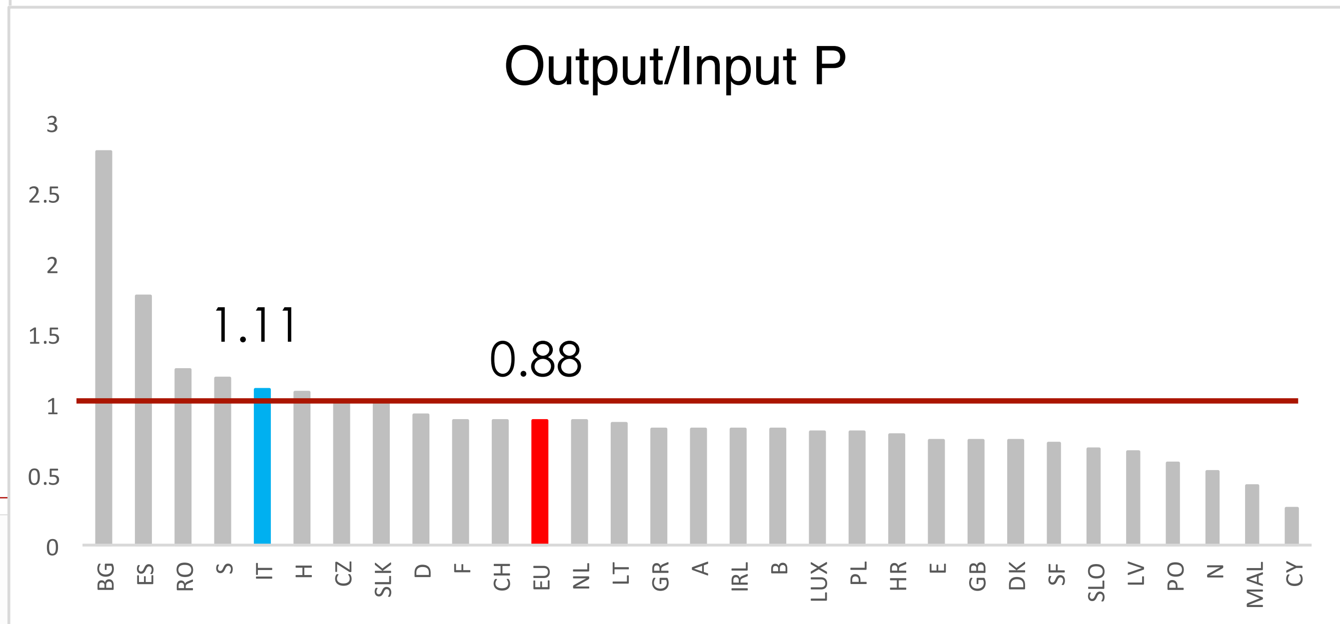
Nutrient budgets in EU

- European agriculture contributes 30–80% of nitrogen (N) and 20–70% of phosphorus (P) loads to water bodies (OECD, 2008)
- The Water Framework Directive (2000/60/CE) aims to reduce pollution from all agricultural, promoting the use of Agro-environmental indicators (AEIs)
- Among AEIs used for fertilisation management, nutrient budgets are the most common (Langeveld et al., 2007)

Nutrient budgets in EU (Source: Eurostat)

- Gross balances are computed per hectare of agricultural land, on a one-year basis
- The indicators estimate the potential surplus of phytonutrients and are used as proxies for the pollution risk





Are estimates reliable?

Estimation of nutrient balances

Observed 'real' fields

Reproduce real conditions

Observed values are affected by carry-over effects of past fertilisations

Long-term Experiments (LTE)

Stable effects

Productivity depends on ratio between nutrients

Data from LTEs are applicable in real fields, with different cropping sequences and fertilisation in time?

Materials & Methods - LTE

- Nutrient balances (N and P_2O_5) from a Long-Term Experiment (LTE) going on from 1962
- Period considered: 1989 to 2015
- Rotations:
  - wheat and maize monocultures
  - Two-year (wheat-maize)
  - Four-year (sugarbeet, soyabean, wheat, maize)
  - Six-year (maize, sugarbeet, maize, wheat, alfalfa, alfalfa)

Cattle slurries or residues

Slurries or FMY

- Crops considered:
  - Winter wheat
  - Maize
  - Soybean (only P_2O_5)

Materials & Methods – normal fields

- Fields of the Experimental Farm of the University of Padova conducted with standard agricultural practices, both Conventional and Organic
- Years 1997 to 2015
- Fertilisations used:

Similar pedo-climatic conditions as LTEs

	Crop	Type	n	Average	Min	Max
N	Winter Wheat	Organic	12	104.8	0.0	150.2
		Conventional	17	157.5	32.0	227.0
	Maize	Organic	14	154.0	54.0	264.0
		Conventional	23	333.2	264.0	604.0
P_2O_5	Winter Wheat	Organic	12	2.5	0.0	29.6
		Conventional	17	82.7	36.0	106.7
	Maize	Organic	14	44.4	14.4	117.3
		Conventional	18	130.4	17.7	396.0
	Soybean	Organic	14	29.6	11.6	47.5
		Conventional	14	59.1	0.0	79.7

Estimation of nutrient budgets

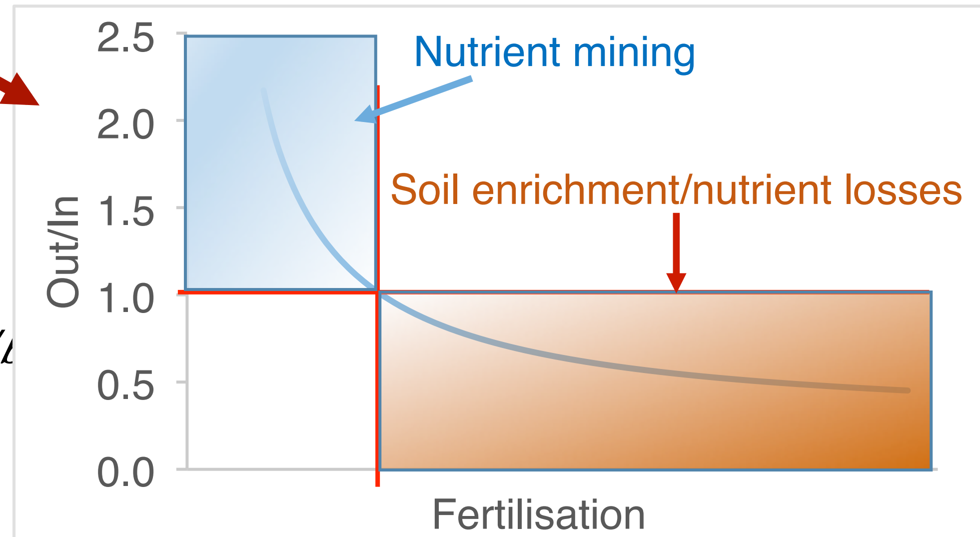
- Gross nutrient balance:

  GB = fertilisers+manures+others–harvested

- Data expressed as Output/Input in relation to nutrient supply

- Data from LTEs interpolated with an hyperbolic model:

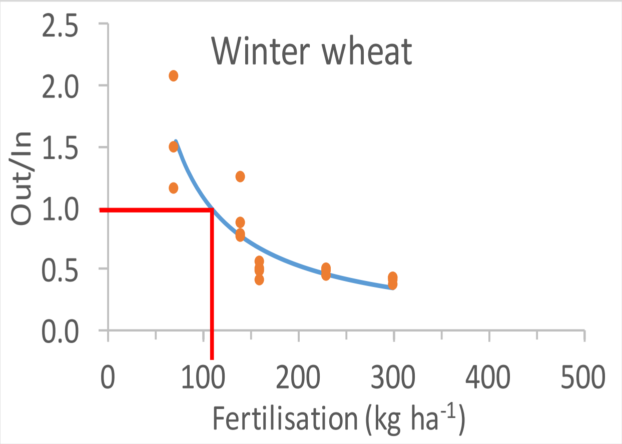
$$Out/In = Max \cdot (1 - a \cdot Input/1 + a \cdot Input/L$$

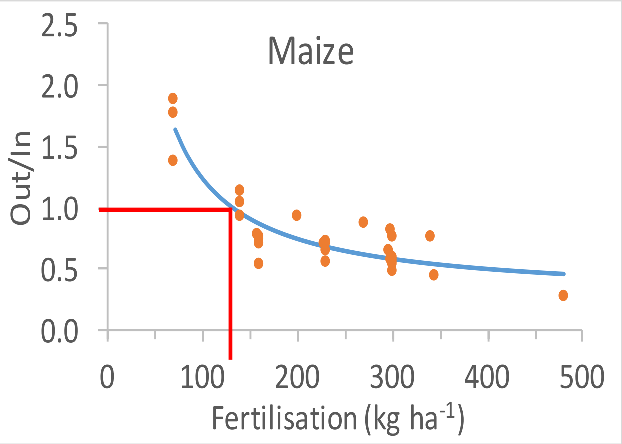


- Adaptation of values from real fields evaluated through Residual Mean Square Error (RMSE)
- Confidence intervals of RMSEs estimated through Bootstrap procedure

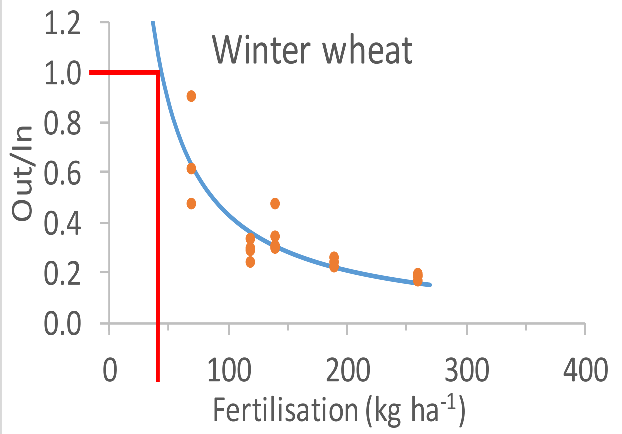
Ratio Output/Input on LTE

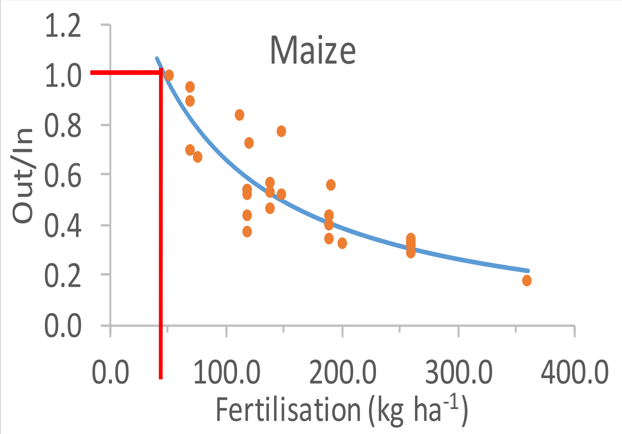
N

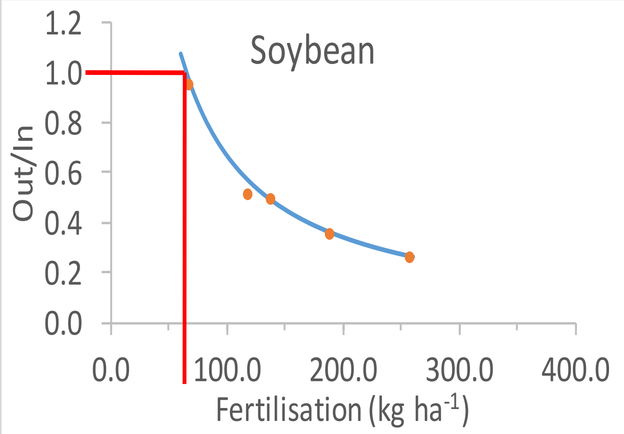




P_2O_5







Ratio Output/Input on LTE

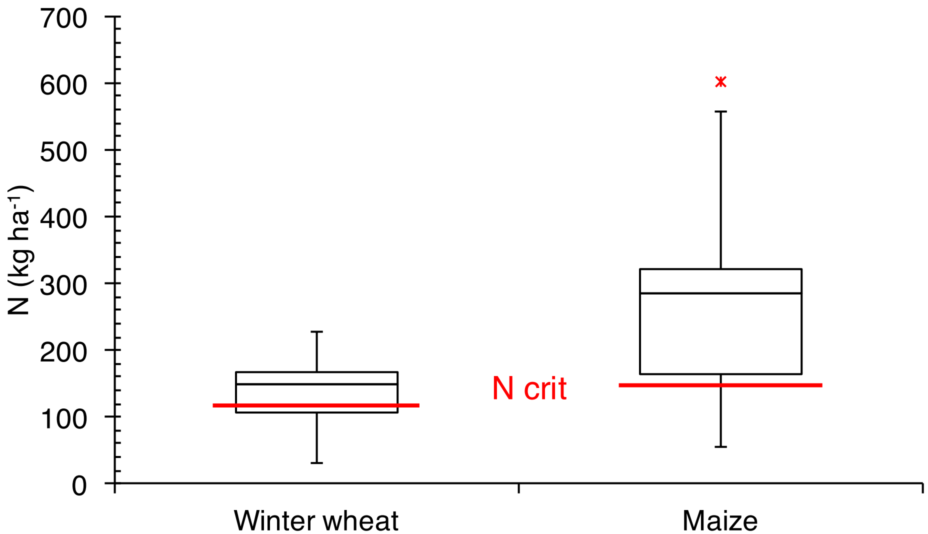
Amount of fertiliser required for Out/In = 1

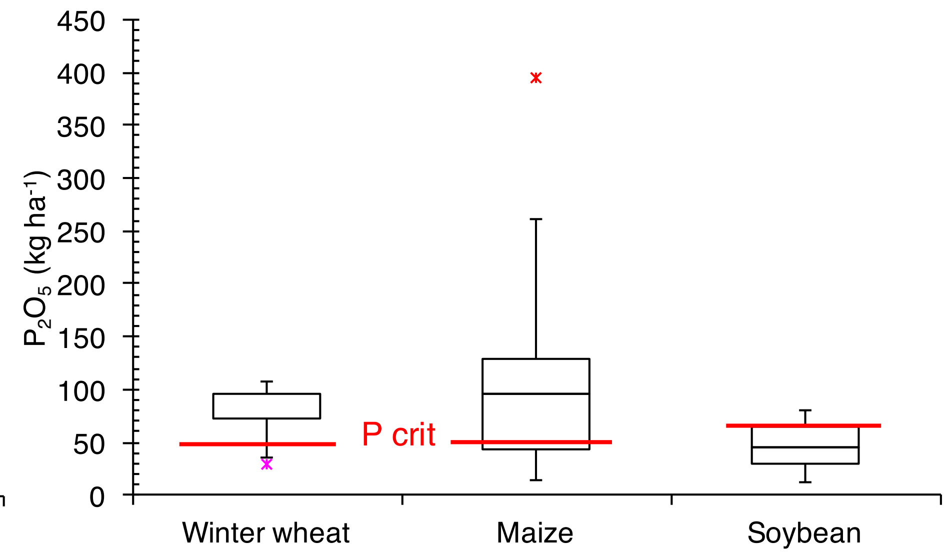
Crop	Winter wheat	Maize	Soybean
		kg ha^{-1}	
N	123	147	-
P_2O_5	44	46	65

Critical values (N and P crit)

- These are not optimal fertilisations but just balancing points
- Considering nutrient efficiency, a Output/Input ratio < 1 should be desirable

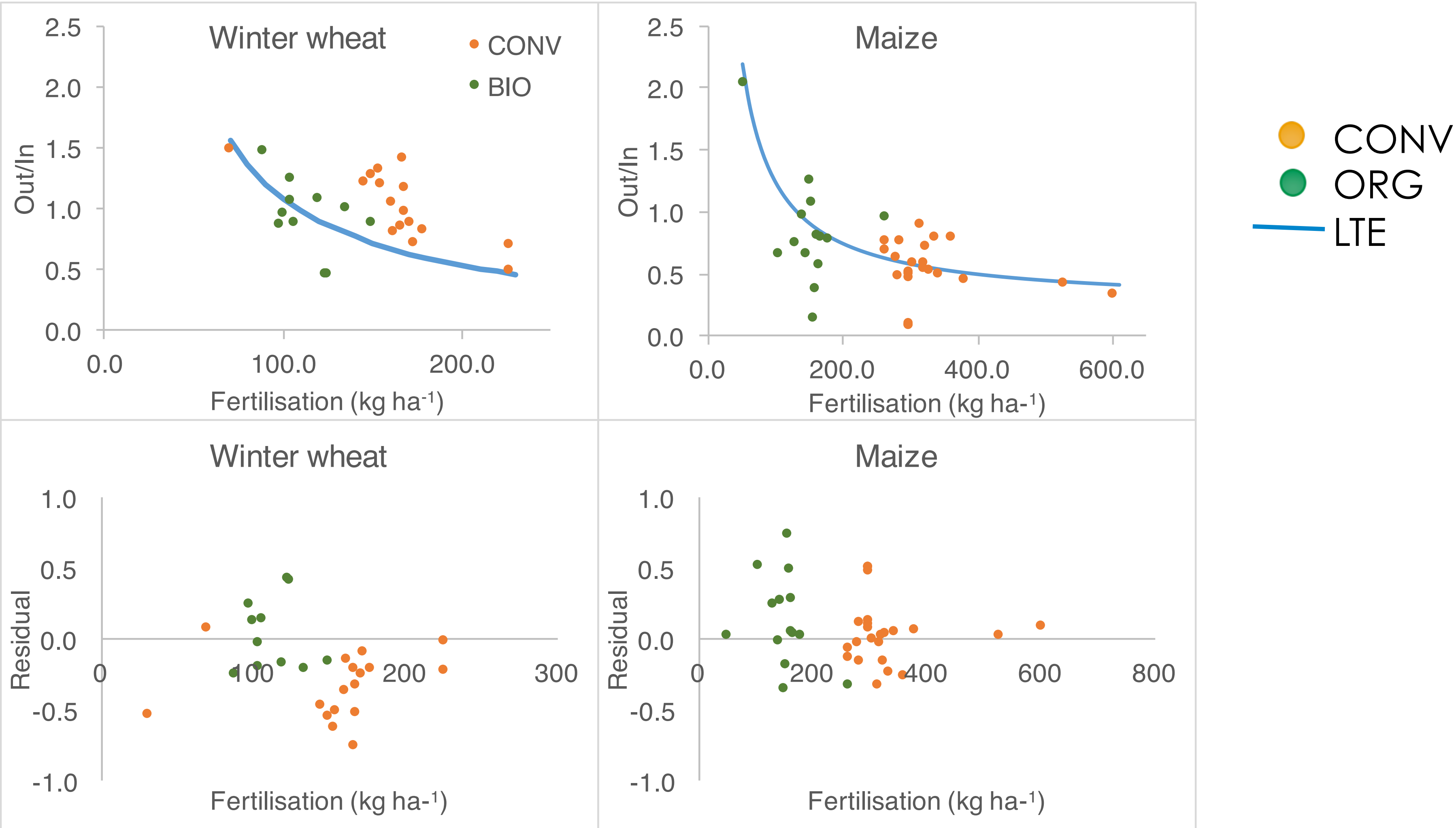
Fertilisations in real fields





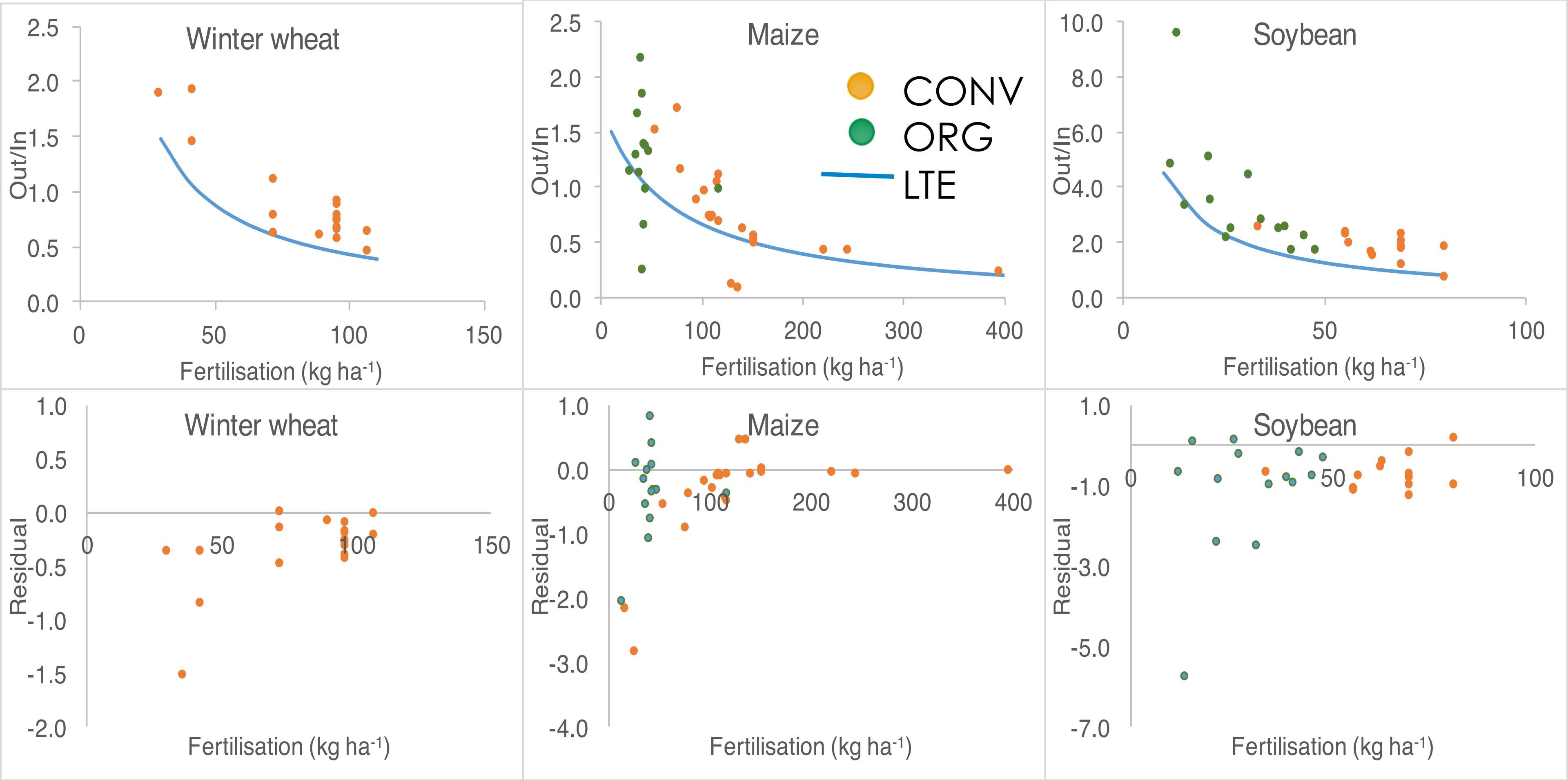
- Nutrient supply tends to be higher than critical values
- Very high N input in Maize and of P in Wheat (organic fertilisation)
- Soybean underfertilised with P

N in real fields



- Observed field data tends to follow the forecasts from LTE

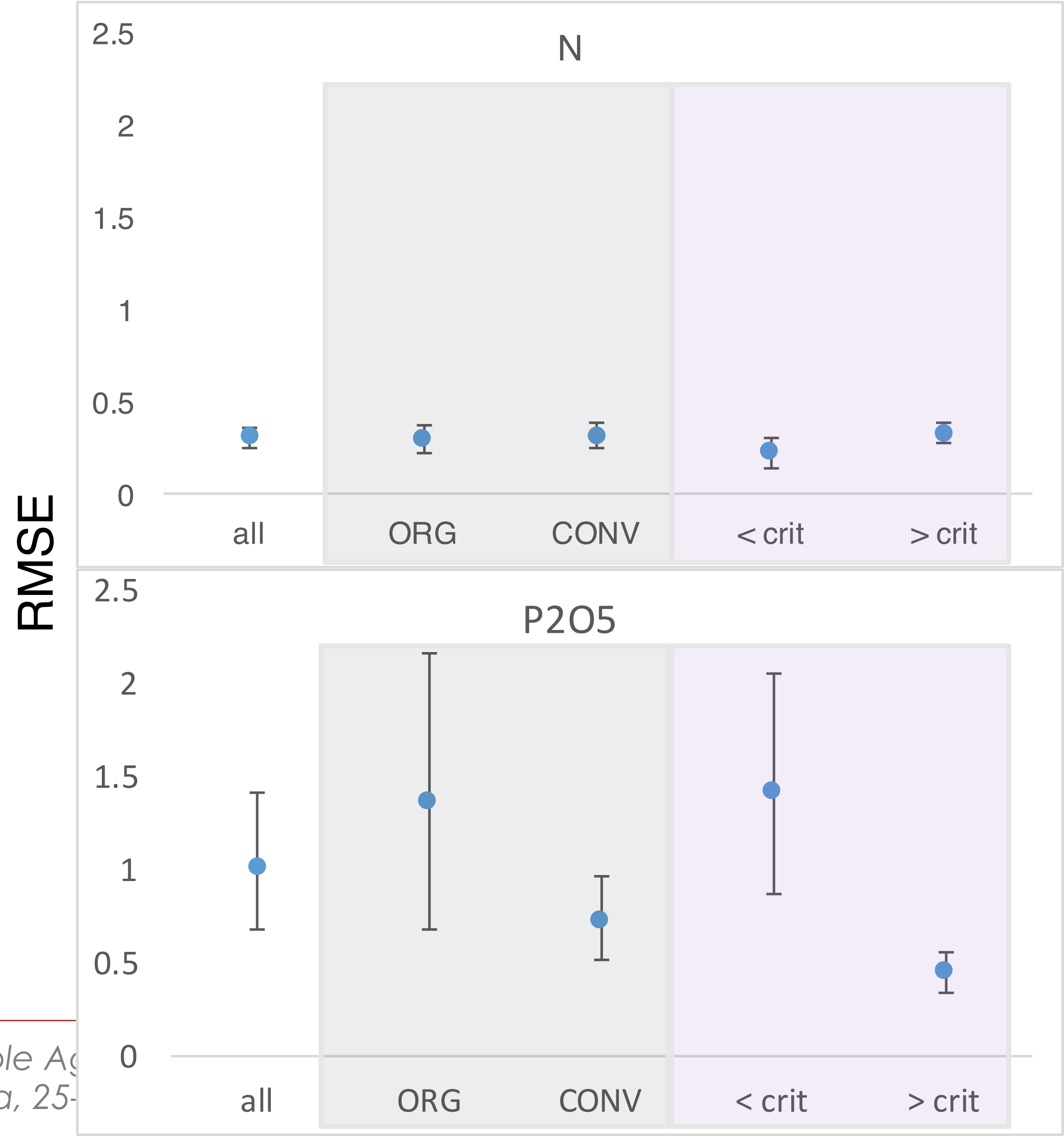
P_2O_5 in real fields



- Observed field data have frequently negative GB (Out/In>1)
- Discrepancy from LTE particularly at low Inputs

RMSE - prediction based on LTE

- N: low RMSE independently from type of Ag and fertilisation level
- P_2O_5: Higher RMSE, effect of type of Ag and of fertilisation level



Conclusions

- Gross balances of P from real fields tends gave higher estimates of Out/In than those from LTEs
- The discrepancy is higher for low fertilisations (carry-over effect of past distributions?)
- What's the truth?

Basing on LTE: field fertilisations are higher than those required,
→ over use of fertilisers; risk of pollution

Basing on field: P fertilisation can even be increased (by ~50%),
→ risk of nutrient mining if decreased