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Legume supported cropping systems for Europe

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Some background

- Europe imports 12% world soybean production (13 M t or 15 M ha of borrowed land)
- Growing meat consumption drives increased plant protein imports
- Fertiliser and soya bean prices are increasing
- Policy intervention has failed to increase areas of European legumes

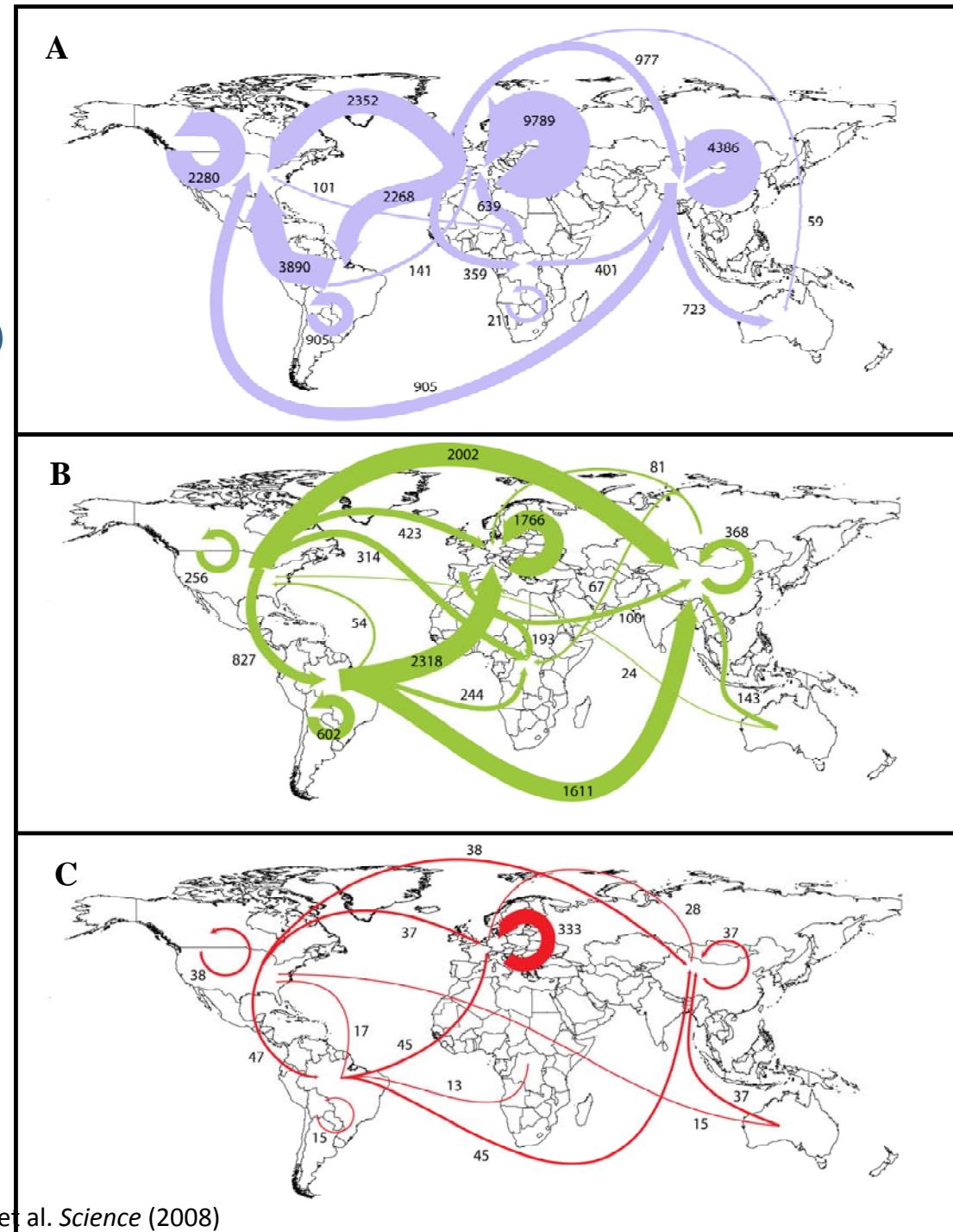


Internationally traded reactive nitrogen

Fertilizer (31 Tg)

Grain (12 Tg)

Meat (0.8 Tg)



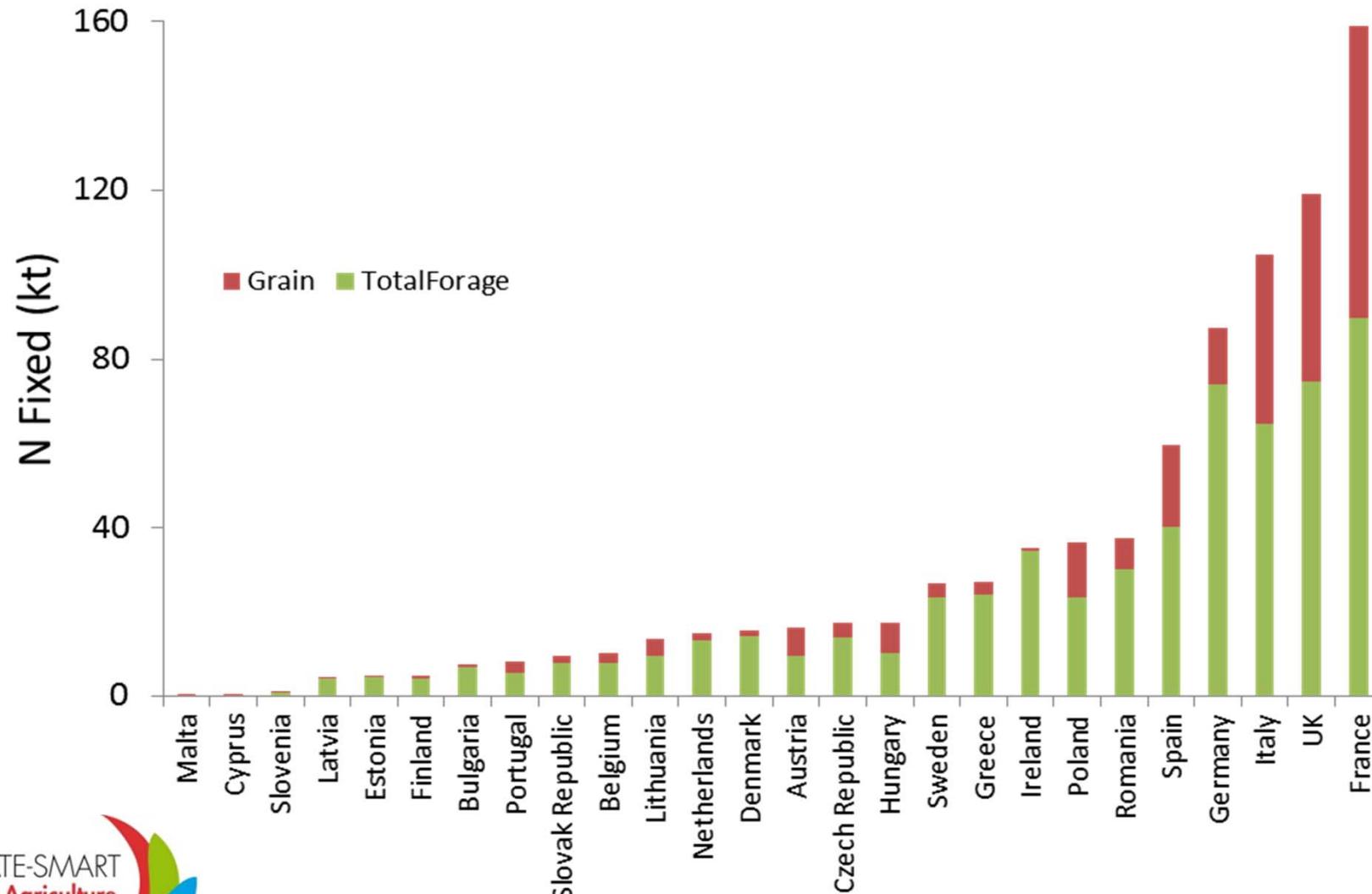
What contribution can legumes make to climate smart agriculture?

- How much do legumes contribute to N inputs in European agriculture?
- What affect do legumes have on N budgets?
- Can legumes contribute to greenhouse gas mitigation?
- What are the economics/barriers to legume production in Europe?

Estimating continental scale N fixation

- Many estimates exist of BNF per hectare in different crops in different countries
- BNF depends greatly on biomass
- >10-fold range in biomass from best to worst growing conditions, even within a country
- Area and yield data available for grain legumes, but hard to obtain for forage legumes

Estimated BNF in EU27 in 2009



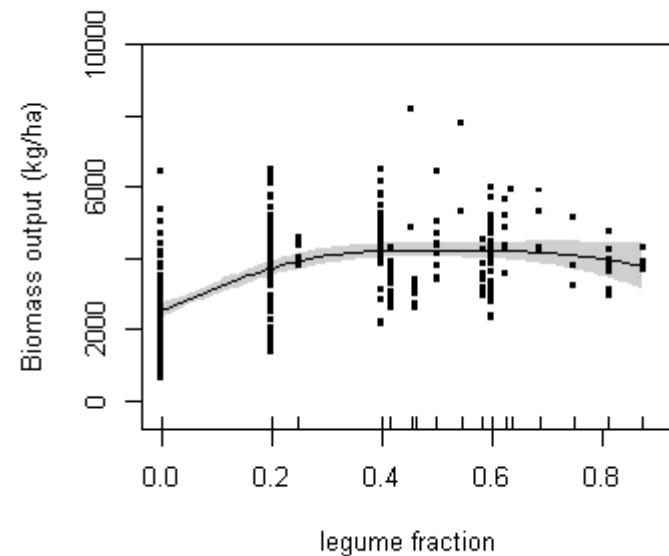
The Totals

| | BNF (kt) |
|------------------------|------------|
| • Grasslands | |
| • Temporary | 173 |
| • Extensive | 114 |
| • <u>Intensive</u> | <u>305</u> |
| • Total Grassland | 592 |
| • <u>Grain legumes</u> | <u>247</u> |
| • <u>Total EU27</u> | <u>839</u> |

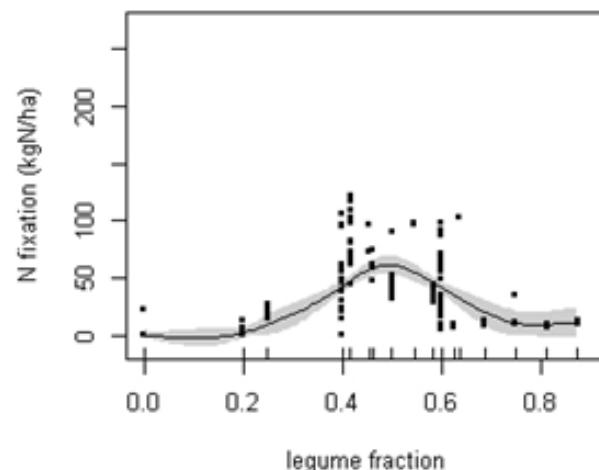
- Fertiliser value at 0.9€ kgN⁻¹ €755M
- Synthetic fertiliser application (2000) 11,200 kt N

Historical data analysis

- The biomass harvested from each crop sequence increased as the proportion of legume crops with the cropping sequence grew



- Maximum N fixation rates associated with legume/non legume mixtures

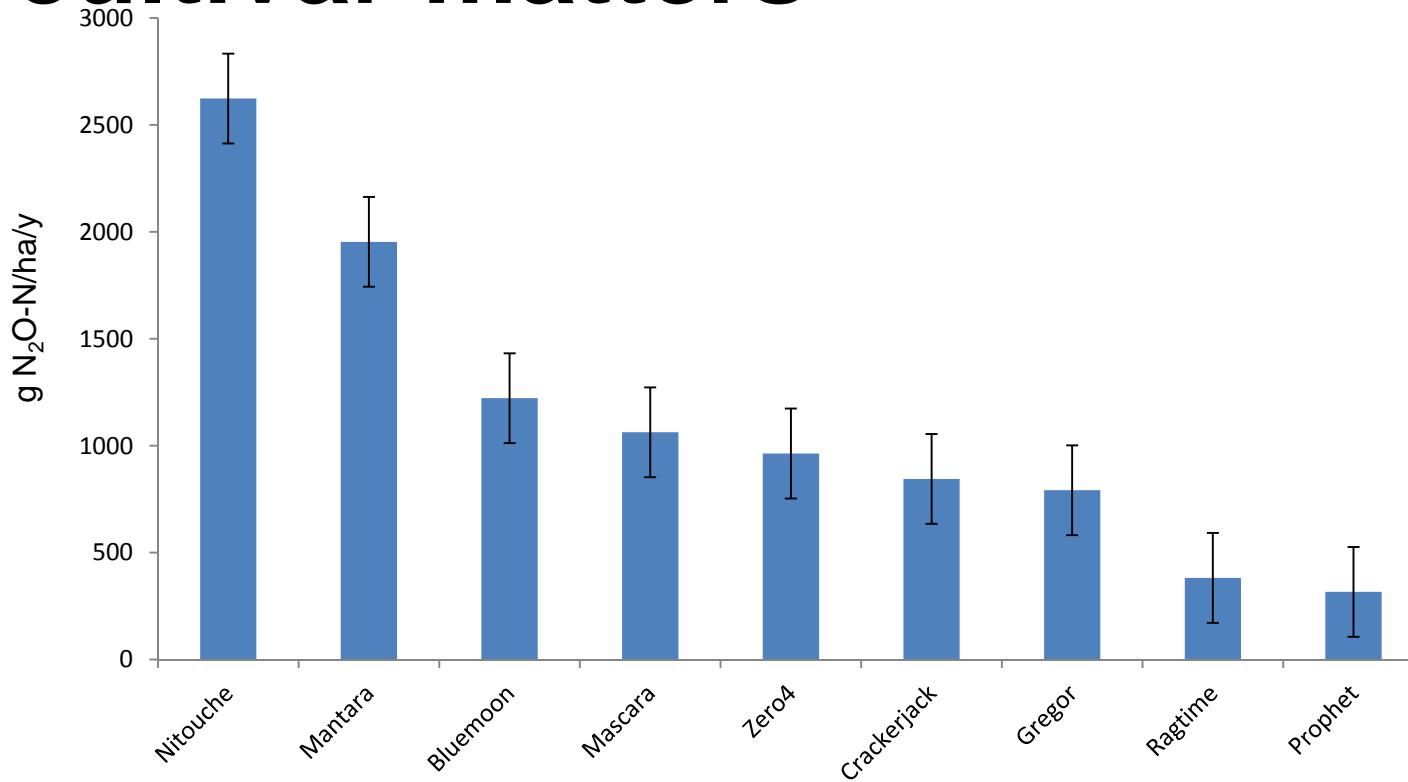


Comparison of N₂O emissions from legume and non-legume crops

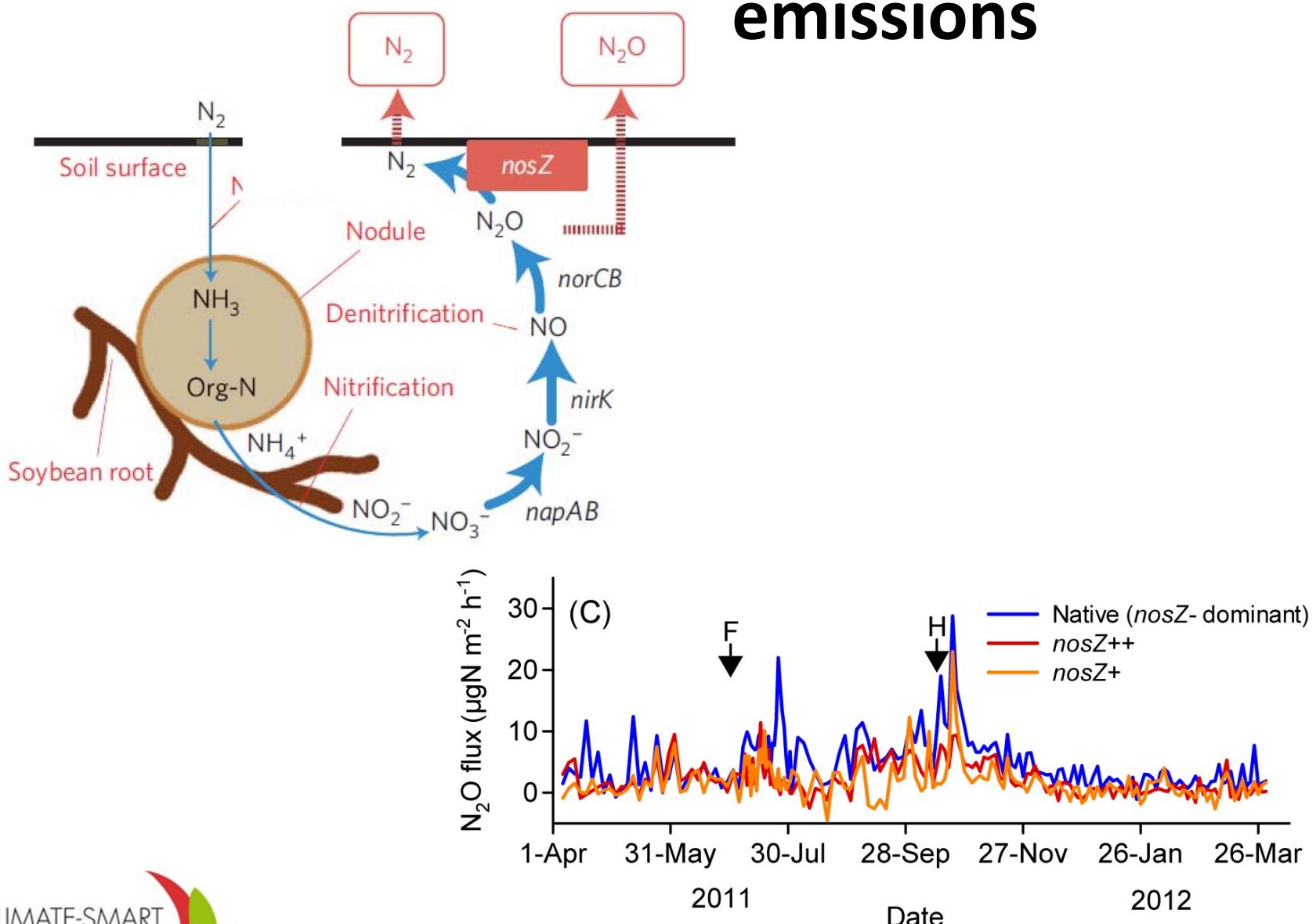
| Category and Species | Site Years | Total N ₂ O emissions per growing season or year (kg N ₂ O-N ha ⁻¹) | |
|----------------------------|------------|---|-------------|
| | | Range | Mean |
| Pure legume stands | | | |
| Alfalfa | 14 | 0.67-4.57 | 1.99 |
| White clover | 3 | 0.50 – 0.90 | 0.79 |
| Mixed pasture sward | | | |
| Grass-clover | 8 | 0.10 – 1.30 | 0.54 |
| Legume Crops | | | |
| Faba bean | 1 | - | 0.41 |
| Lupin | 1 | - | 0.05 |
| Chickpea | 5 | 0.03 – 0.16 | 0.06 |
| Field pea | 6 | 0.38 – 1.73 | 0.65 |
| Soybean | 33 | 0.29 – 7.09 | 1.58 |
| Mean of all legumes | | | 1.29 |

Nitrous oxide emissions

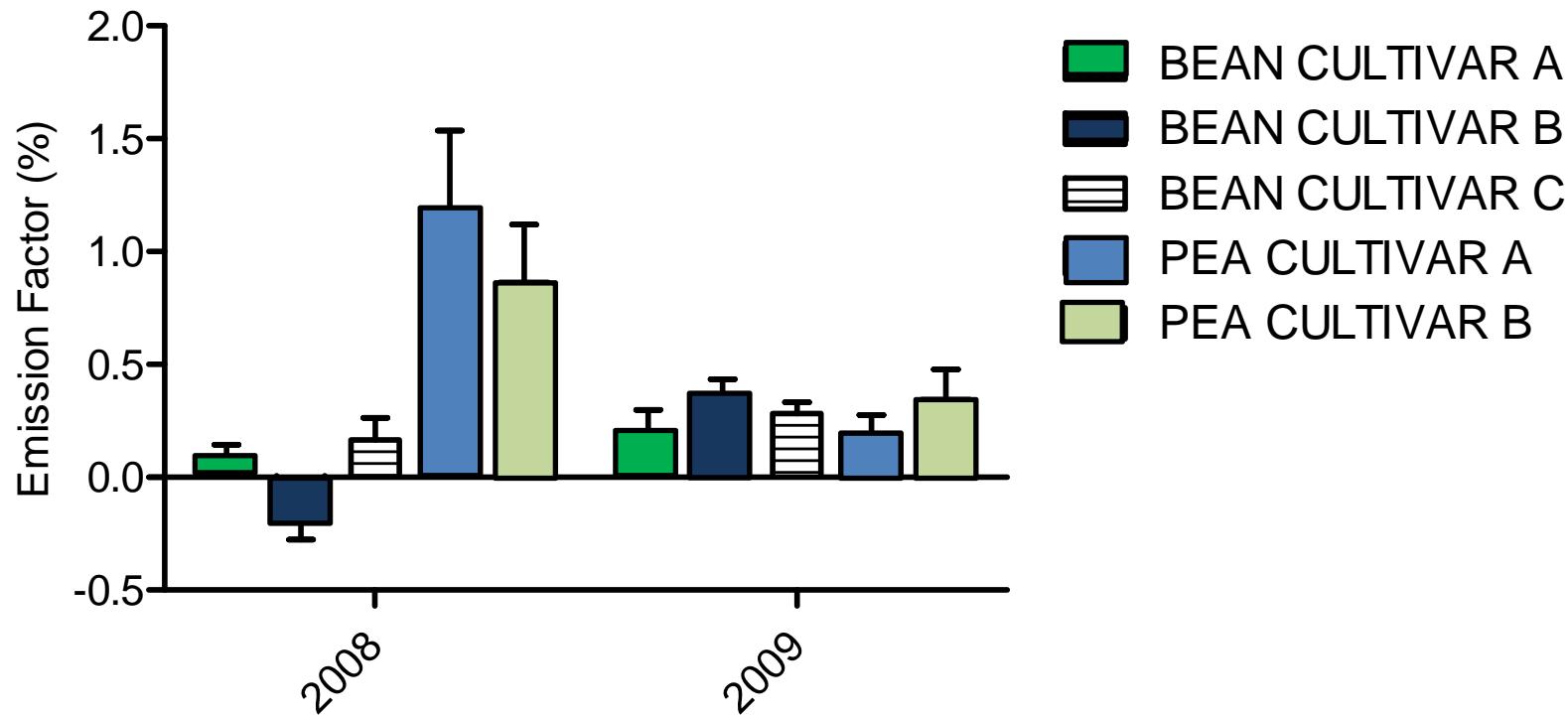
Pea cultivar matters



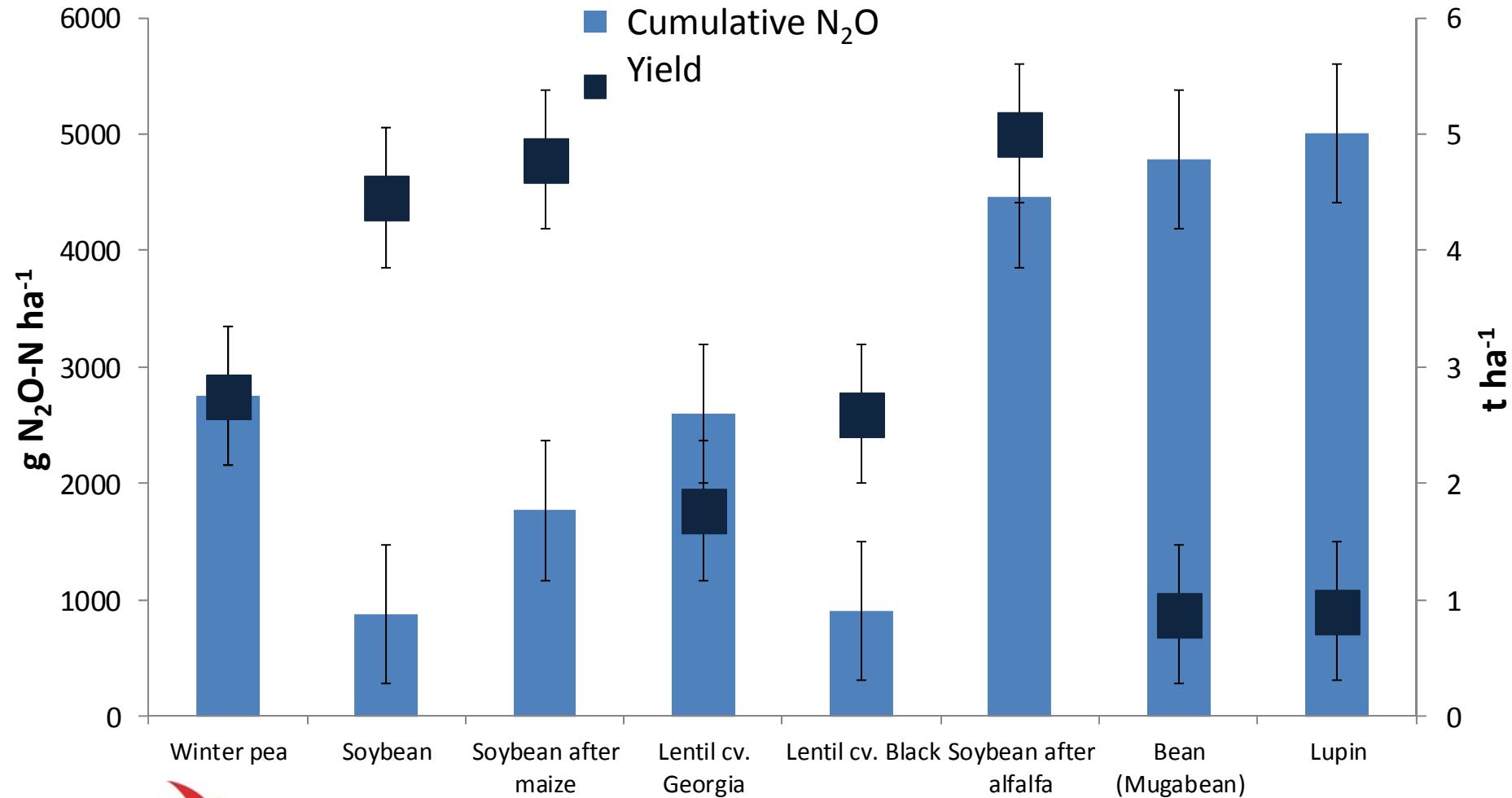
Affects of *Rhizobium* species on N_2O emissions



Emission factors are sensitive to cultivar and climate

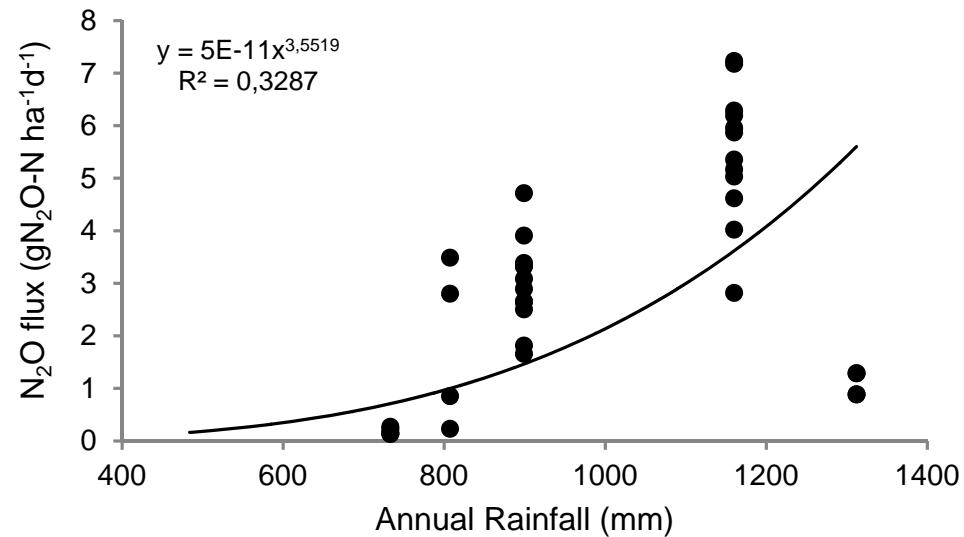


Nitrous oxide emissions- Species and rotations matter – Romania 2011

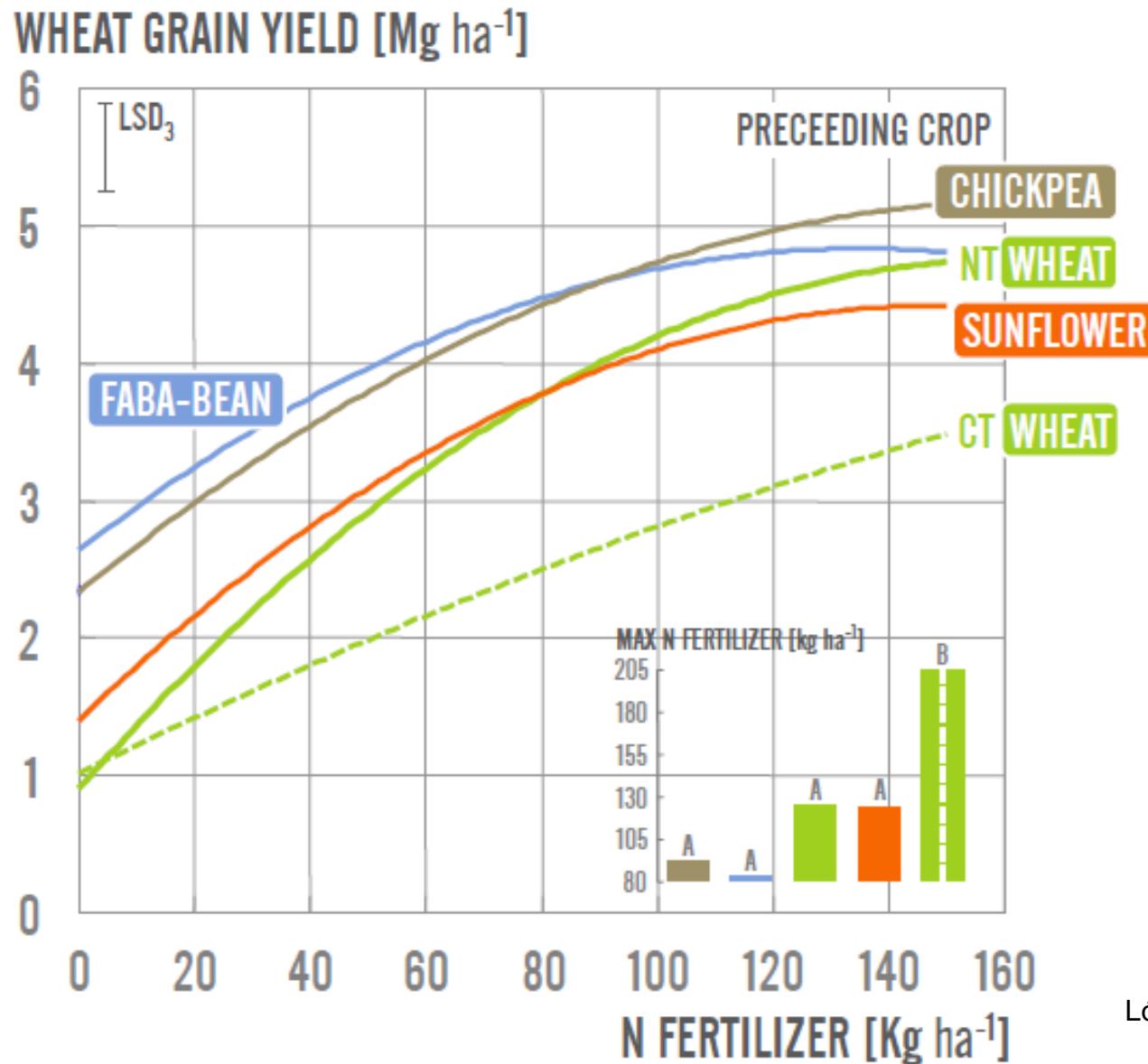


Environmental controls

N_2O emissions more sensitive to rainfall than BNF



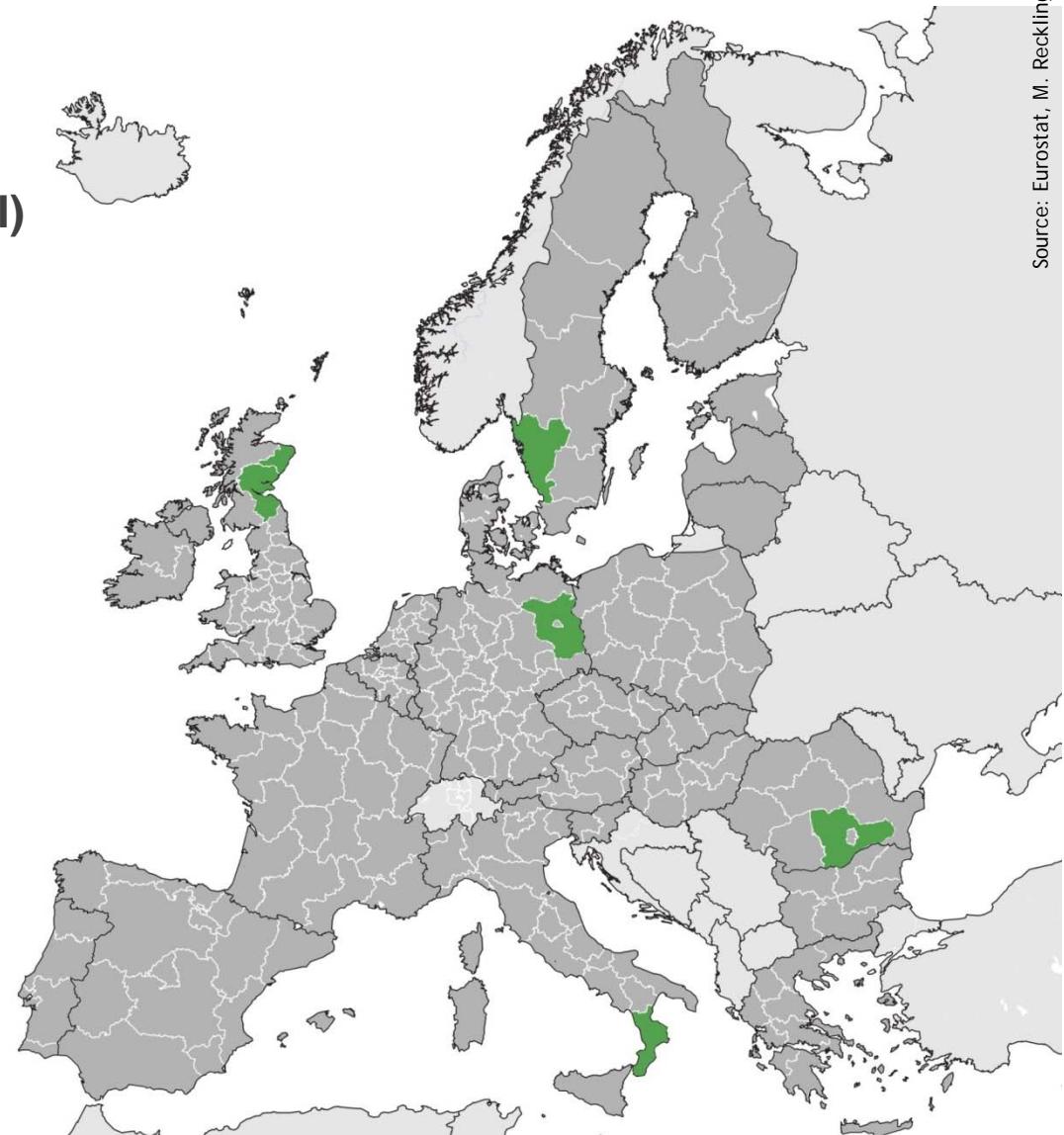
Pre-crop effects



López-Bellido et al, 2011

Farming systems Case study areas

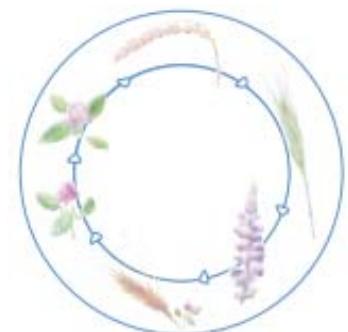
- Sud-Muntenia, Romania (NARDI)
- Calabria, Italy (UDM)
- North-Eastern Scotland (SRUC)
- Western Sweden (SLU)
- Brandenburg, Germany (ZALF)



Generation and evaluation of crop rotations

Generation takes all agronomic suitable options into account

- Crop rotation model used to generate a series of crop rotations
- Evaluated by local agronomists
- **Evaluation of whole crop rotations**
- Nitrogen assessment: N balance, nitrate-N leaching and N₂O emissions
- Infestation risk assessment: Pests, diseases and weeds
- Gross margin assessment: Revenues and costs



Crop rotation comparisons (selection)

| Country, Region | Non-legume rotation | Gross margin (Euro) | N leaching (kg/ha) | N ₂ O (kg/ha) | Legume rotation | Gross margin change | Leaching change | N ₂ O change |
|-----------------|---|---------------------|--------------------|--------------------------|--|---------------------|-----------------|-------------------------|
| Romania | Rapeseed Maize Wheat | 432 | 13 | 3.5 | Soybean Maize Wheat Rapeseed | +86 | +1 | -0.7 |
| Sweden | Rapeseed Wheat Linseed Wheat S barley | 644 | 34 | 3.7 | Rapeseed Wheat Fababean Wheat S barley | -51 | 0 | -1.3 |
| Germany | Rapeseed Wheat S barley | 130 | 28 | 4.7 | Rapeseed Wheat Rye Rye Pea | -19 | -8 | -1.2 |

Scotland

Generated rotations

| | | | | | GM without all pre-crop effects | add. revenue pre crop effect | | GM with all pre- crop effects |
|-----------------|---|------------------|---|------------------|---------------------------------------|---------------------------------|--------|--|
| | | | | | | winter rape | legume | |
| | | | | | [€/ha] | [€/ha] | [€/ha] | [€/ha] |
| winter rape | - | winter wheat | - | spring barley | 390 | 38 | | 428 |
| winter rape | - | winter wheat | - | spring oat | 380 | 38 | | 417 |
| winter wheat | - | spring barley | - | spring oat | 285 | | | 285 |
| winter rape | - | winter wheat | - | faba bean | 355 | 38 | 38 | 430 |
| winter rape | - | winter wheat | - | spring barley | 350 | 31 | 31 | 413 |

Conclusions

- Legumes contribute 839 kt N to European agriculture (<10% Fertiliser N)
- Legumes benefit following crops in rotations
- They can reduce N losses particularly in the form of N_2O
- Economics barriers to legume production remain, however some of the benefits are undervalued
- A climate smart contribution!

Acknowledgements

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