Potential substitution of mineral fertilizer by manure: EPIC development and implementation

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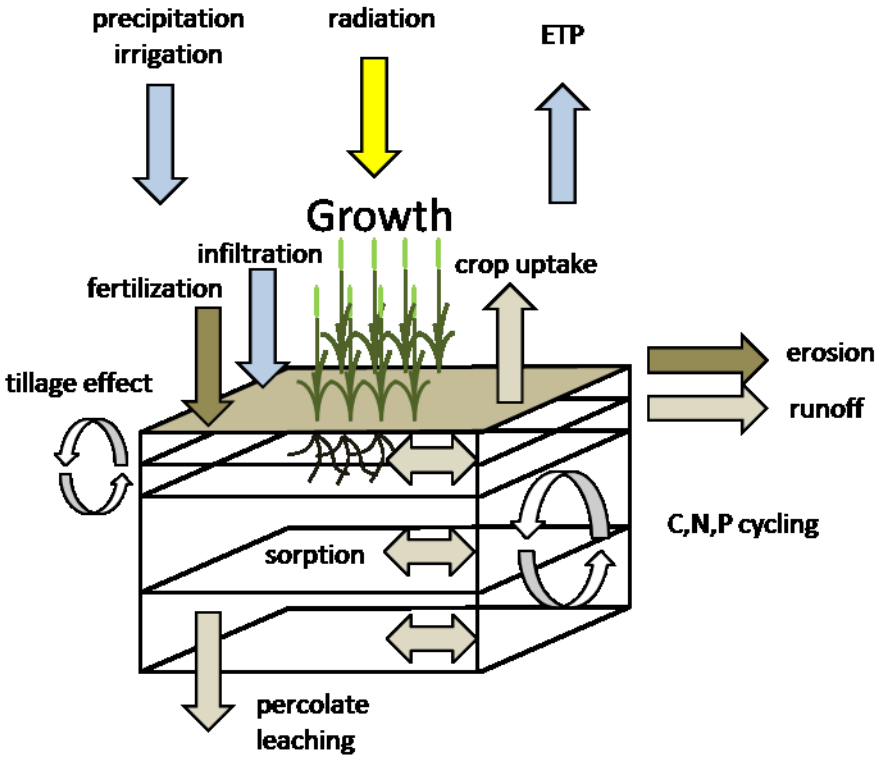
The phosphorus problem

- Non-renewable
- Politically sensitive
- Expensive
- Strong sorption in tropical soils
- Agricultural market pressure
- Environmental protection pressure
- Incompatible with a circular economy

Yearly mass flow of P

Fertilizers		17.5 MT
Animal manure		28.2 MT
Human excreta		2.2 MT
Food waste		0.8 MT

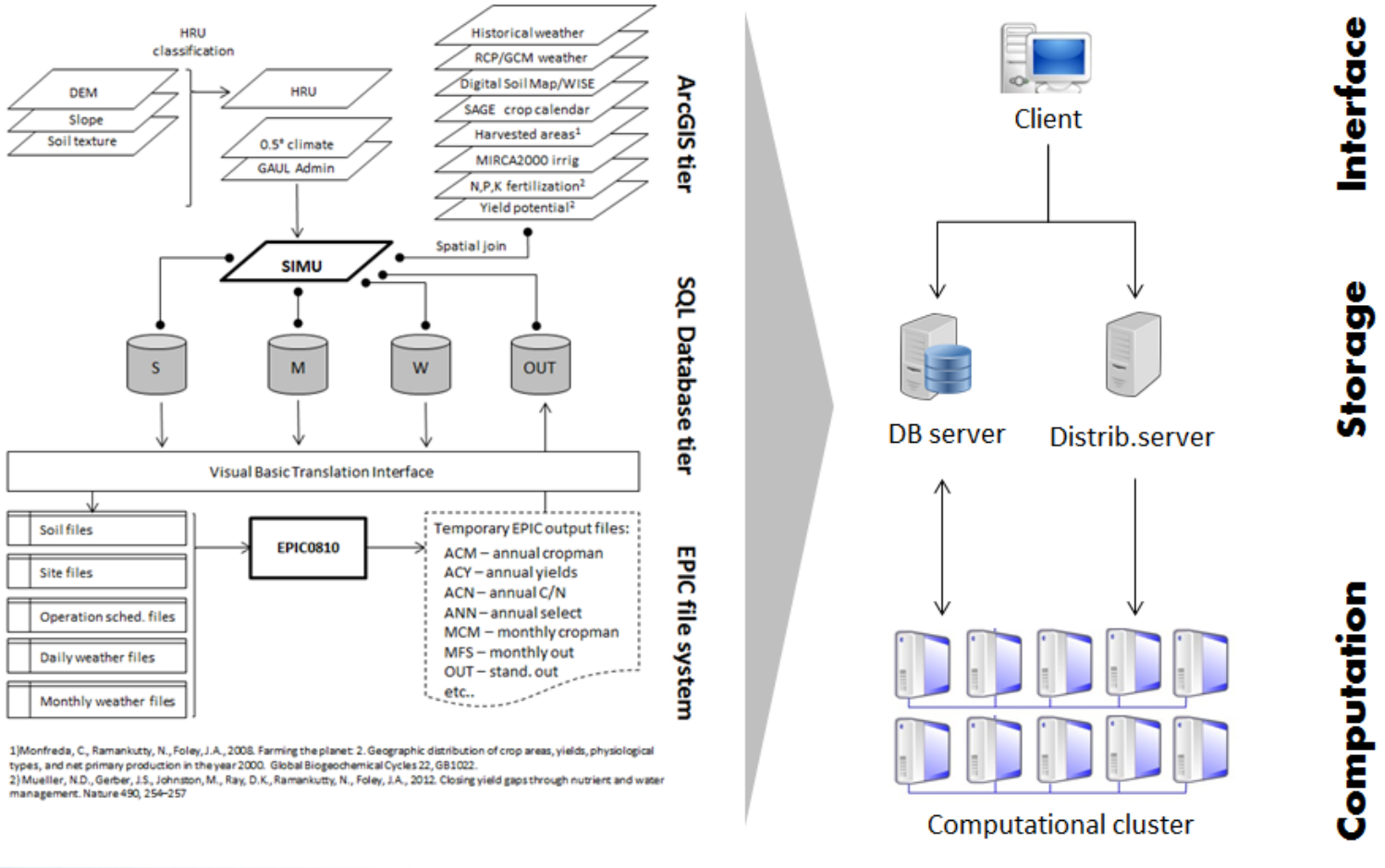
EPIC (Environmental Policy Integrated Climate)



EPIC overview

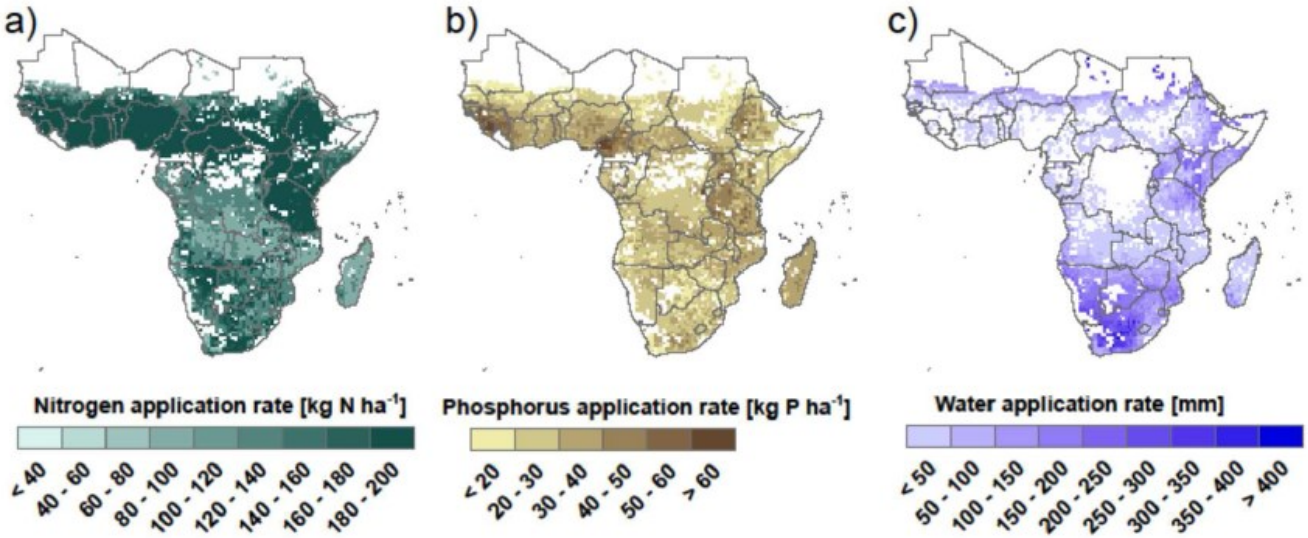
- **Process-based crop model, written in FORTRAN**
- **Plant growth limited by the most limiting factor (Liebig's Law of the Minimum)**
- **Time-step: daily**
- **INPUT: tillage, fertilization, irrigation, crop protection, liming, planting and harvesting dates, cultivar characteristics, historic (or projected) climate, soil information, landscape features**
- **OUTPUT: crop growth, yield, and competition, water and nutrient flows, pollution, various ecosystem services**

EPIC-IIASA

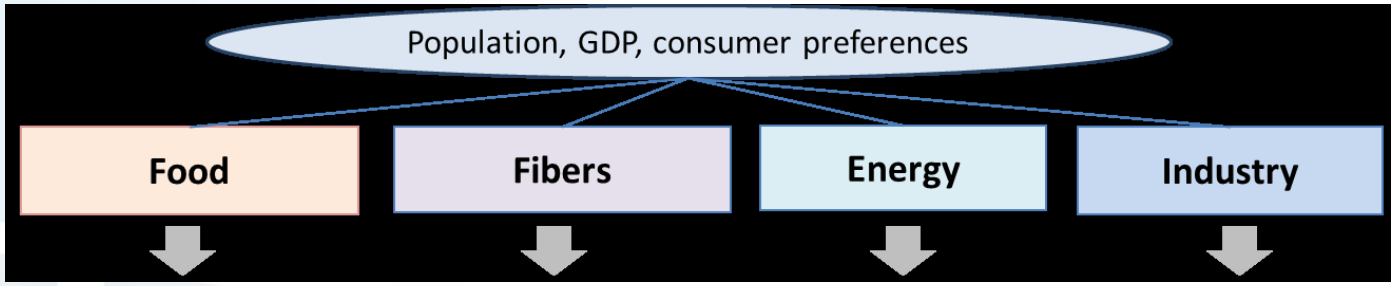


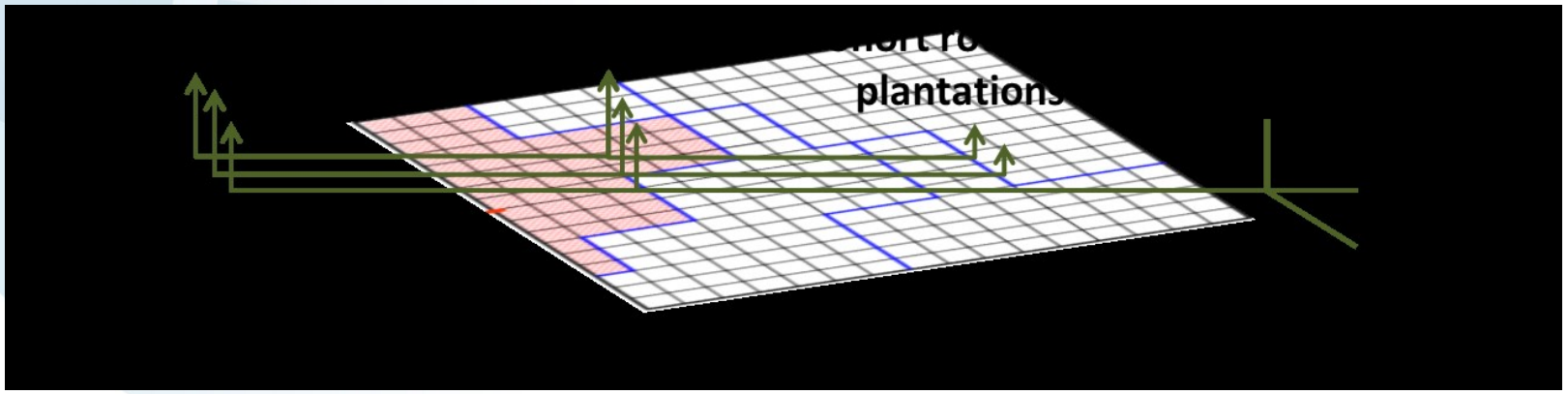
- Spatial resolution: 1 km (EU) to 5 min (global)
- Working version: 12 crops (EU), 17 crops (global)
- Bottom-up + top-down sources of input data

Application #1: Yield gap (food security)



Application #2: Land use optimization (agricultural intensification)





User-specified management

Tillage

Fertilization

Irrigation

Harvest

Research question

To which extend can animal waste substitute mineral sources of P?

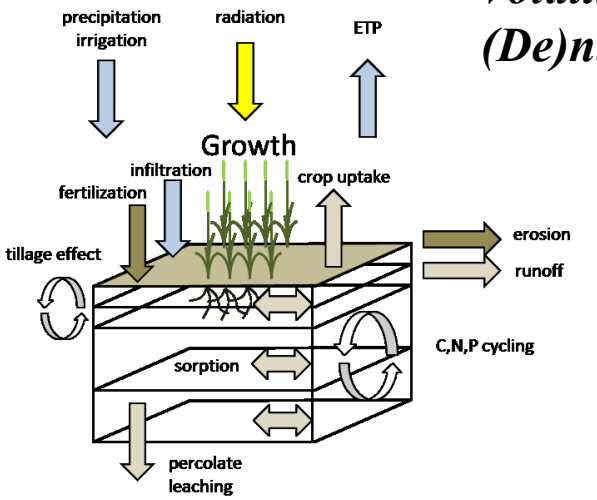
Improvement of the EPIC model

SurPhos

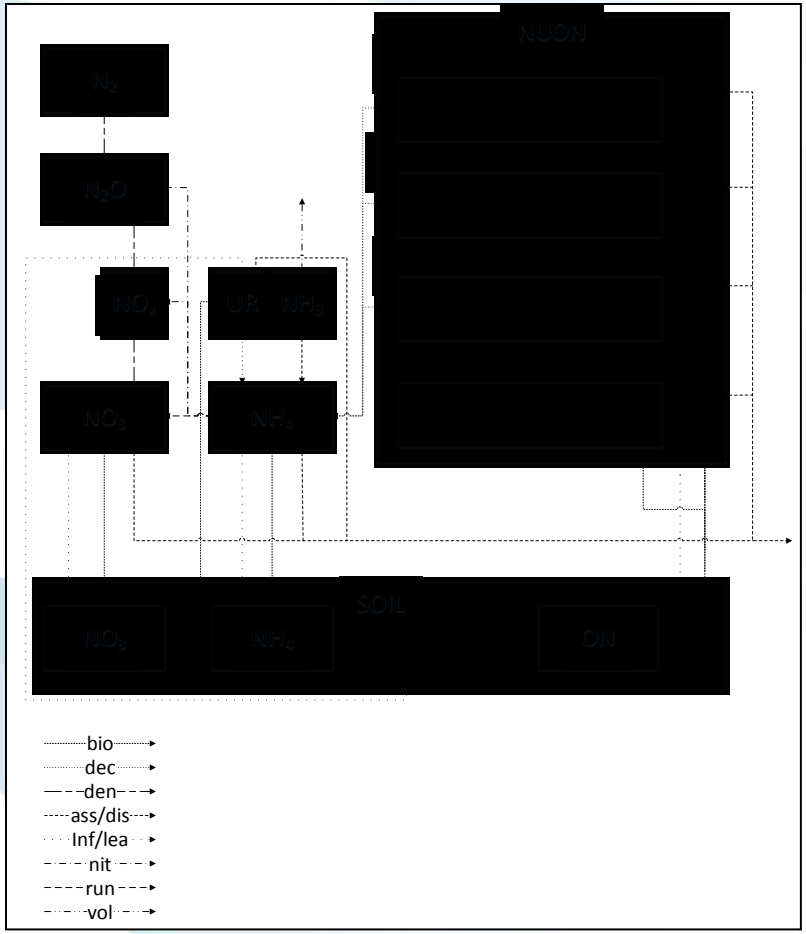
Runoff
Leaching
Bioturbation
Mineralization
Immobilization

Runoff
Leaching
Bioturbation
Mineralization
Immobilization
Hydrolysis
Volatilization
(De)nitrification

Manure DNDC



Processes


NUON
N_2
N_2O
NO_3
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NH_4
SOIL
NO_3
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bio
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Inf/lea
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run
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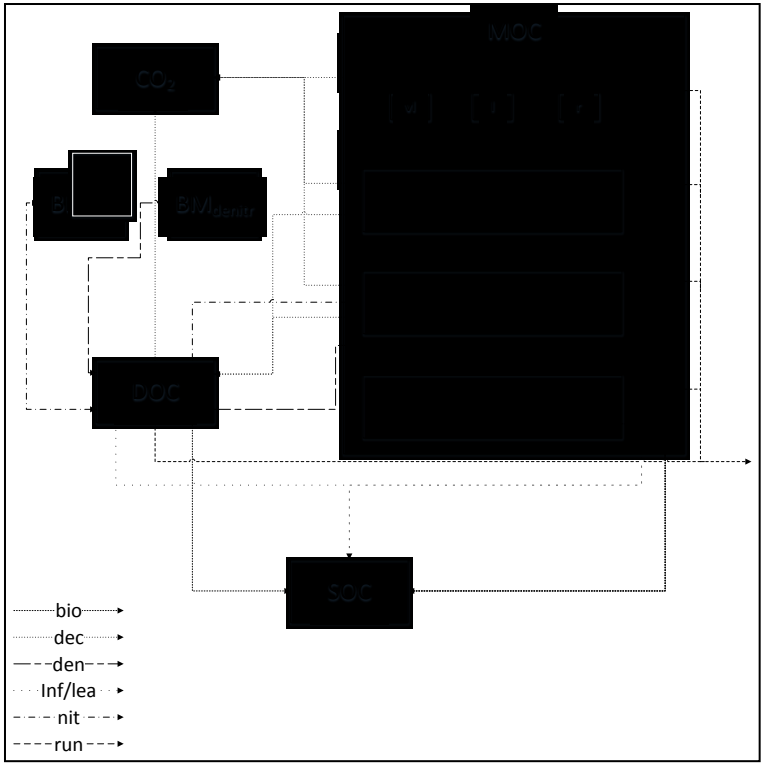
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bio
dec
den
Inf/lea
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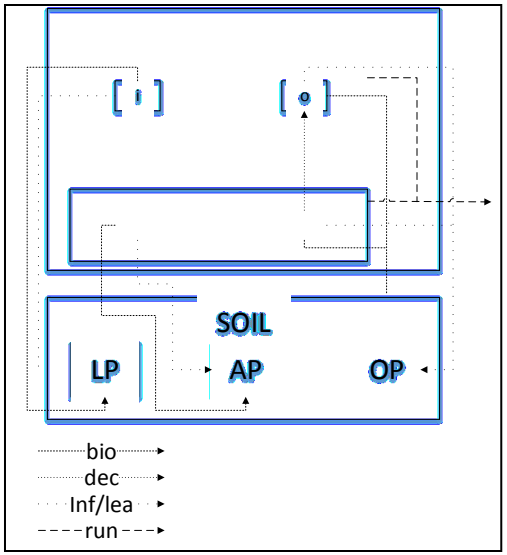

SOIL
LP
AP
OP
bio
dec
Inf/lea
run

Example of processes

- Mineralization (N, P, C) ~ Temp, Moist, Concentration, substrate quality (C/N, recalcitrance), decomposition rate

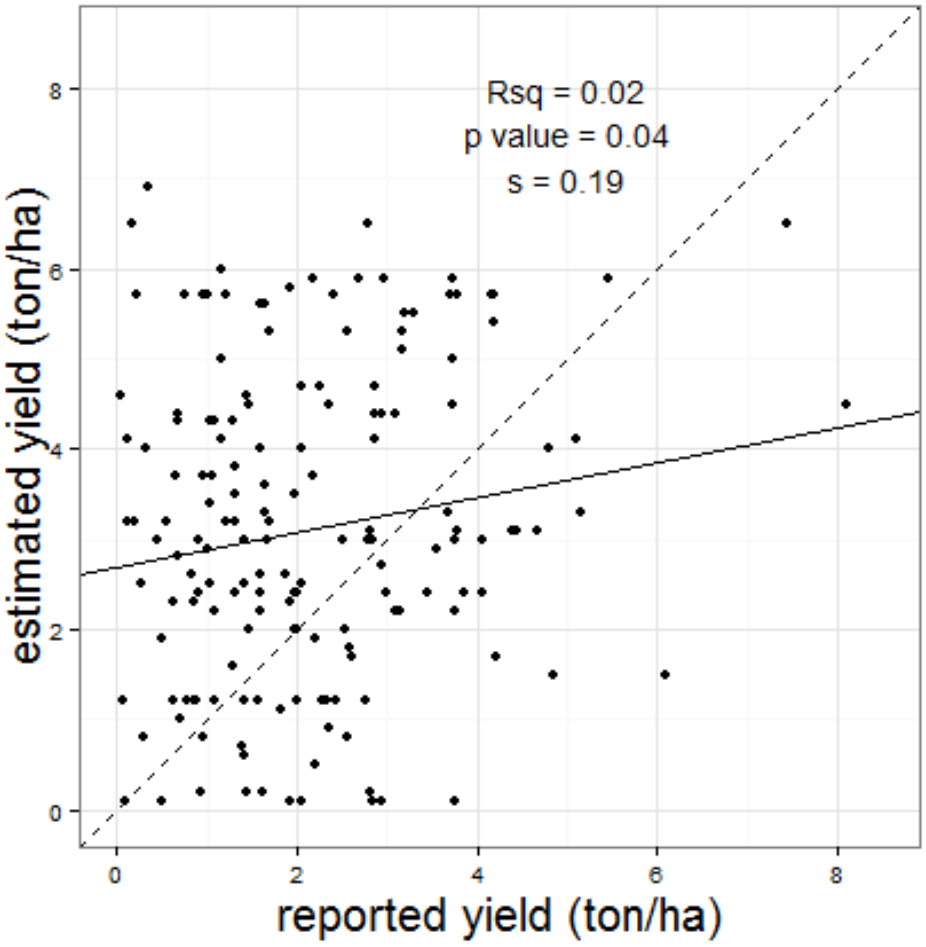
- Nitrification ~ Temp, substrate quality (NH_4), DOC, microbial biomass

Experimental field data (FERTIBASE – FAO)

- Crop yield (ton/ha)
- Soil order
- Geographic coordinate
- Mineral N, P, and K (kg/ha)
- Manure (ton/ha)

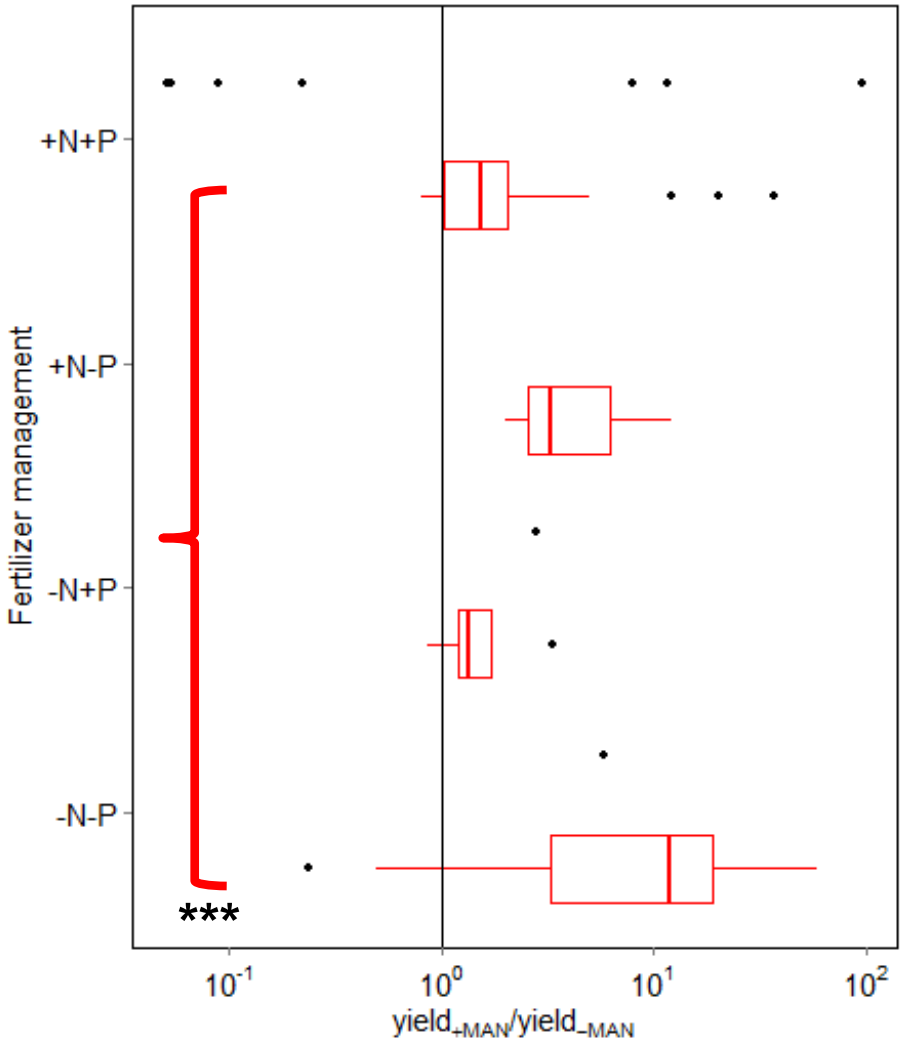
Finding #1: EPIC vs. FAO yields are correlated, but explained variance in very small

EPIC

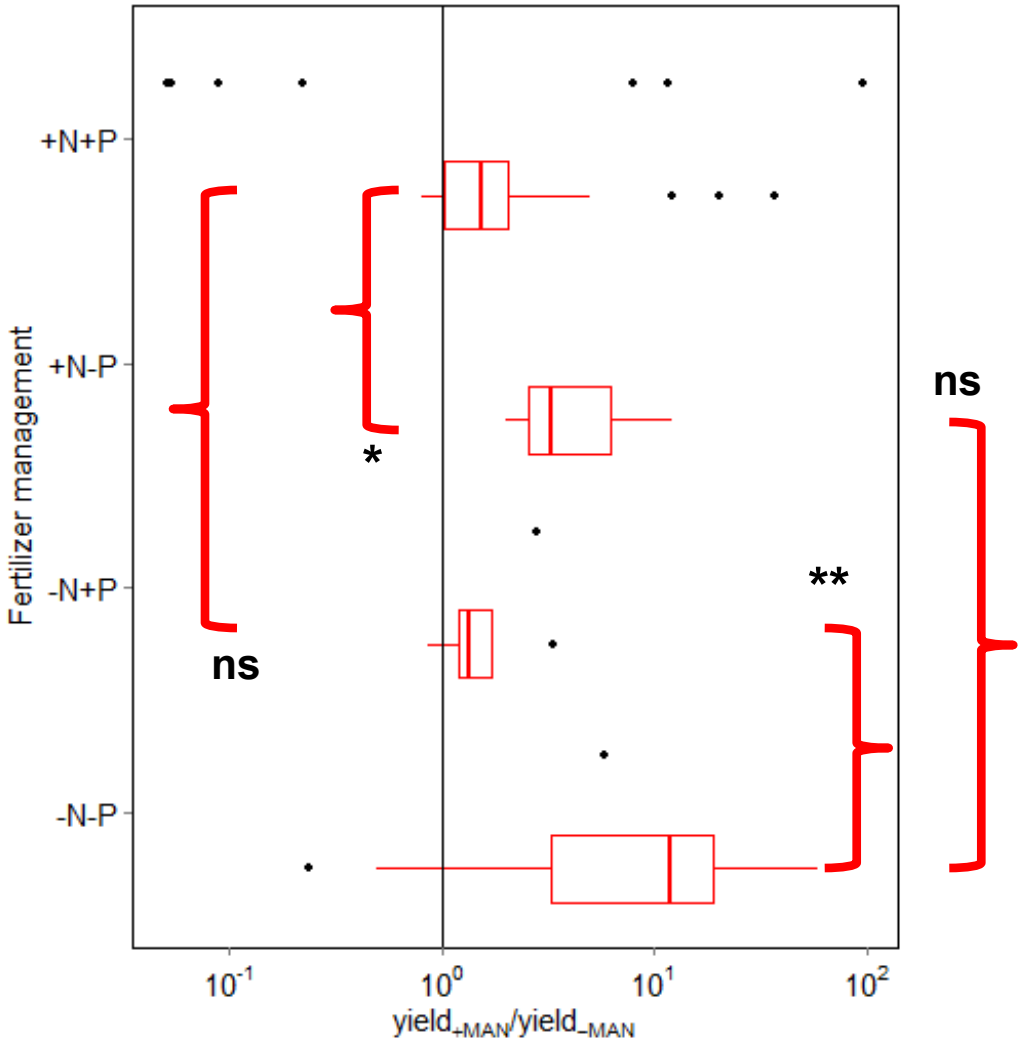


FAO

Finding #2: Manure benefits are higher in low mineral input plots



Finding #3: Higher manure benefits seem to be attributed to low P, not low N inputs



Applications of modified EPIC version

- Identifying regions of high relative yield increases

- Better coupling between animal and crop system

- Optimization of farm income considering transportation costs

Global initiative on long term experimental field data sharing

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