



Does temperate agroforestry reduce nutrient leaching losses compared to cropland monocultures?

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General background

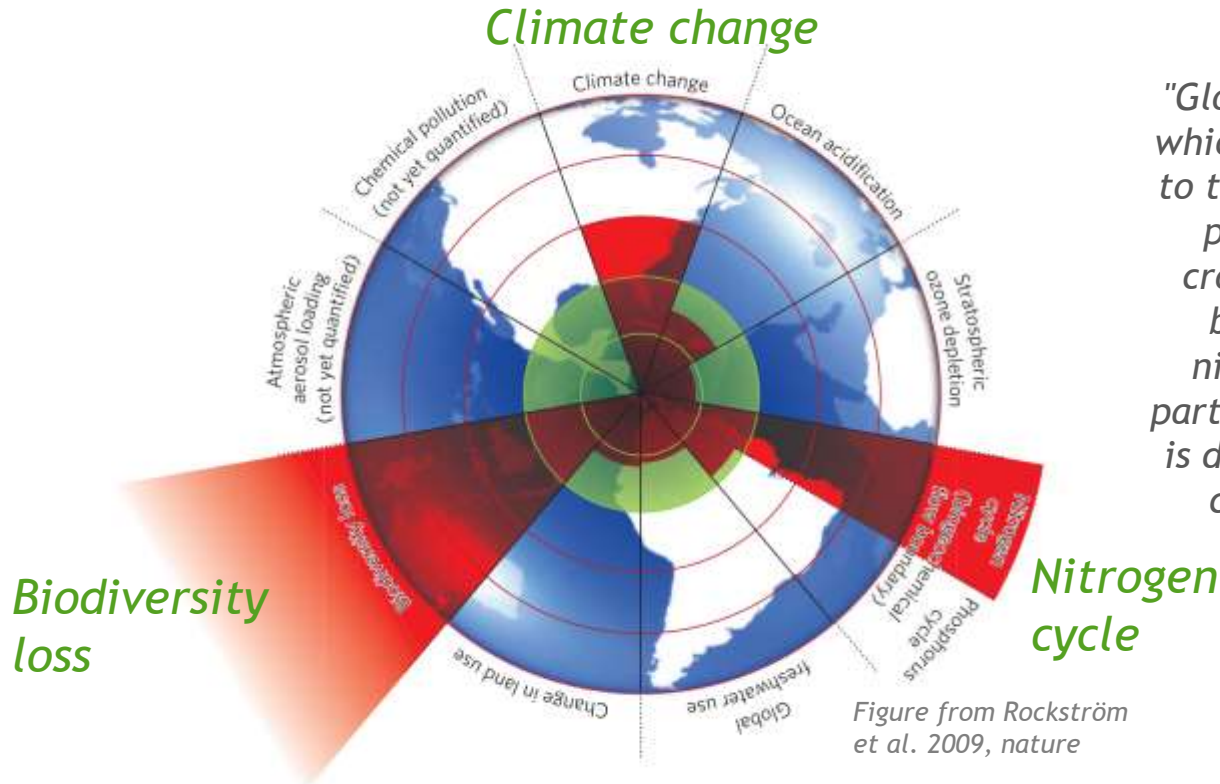
Interactions in agroforestry

Results: Leaching losses and nutrient response efficiency

Reducing fertilization

Conclusions

Humans have crossed global boundaries for climate change, biodiversity loss and the nitrogen cycle



"Global boundaries are limits, which, when reached, a return to the conditions before is not possible. They have been crossed for climate change, biodiversity loss and the nitrogen cycle. For a large part, crossing these boundaries is due to intensively managed cropland monocultures."

Figure from Rockström et al. 2009, nature

Agriculture is under pressure to produce sustainable in the light of global change

"Voices for a more sustainable food production are getting louder and the EU is suing Germany because of high nitrate concentrations in the ground water."



https://ec.europa.eu/germany/news/nitratbelastung-gew%C3%A4ssern-eu-kommission-verklagt-deutschland_de

„Nitrate pollution in ground water:
EU commission sues Germany“

Agroforestry provides interactions typical for natural ecosystems



Competition for
nutrients, water & light^{1,2}

Complementary resource use
& nutrient redistribution^{1,3}

Picture: Guodong Shao

¹Jose et al 2000, *Methods of Ecology and Evolution*; Jose 2008 in *Ecological Basis of Agroforestry*

²Pardon et al. 2018, *Agricultural Systems* ³Cardinael et al. 2015, *Geoderma*

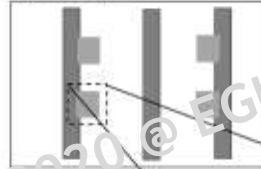
Study design

Three sites:

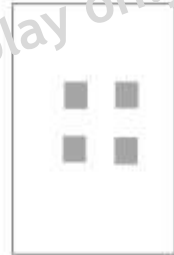


At each site:

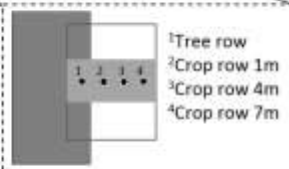
Agroforestry



Monoculture



Each replicate plot



"At three sites of cropland agroforestry (alley cropping) and cropland monocultures, we set up four plots in each land use.

In agroforestry, we sampled within the tree row as well as in three distances from the tree row - inside the crop row."

Study design



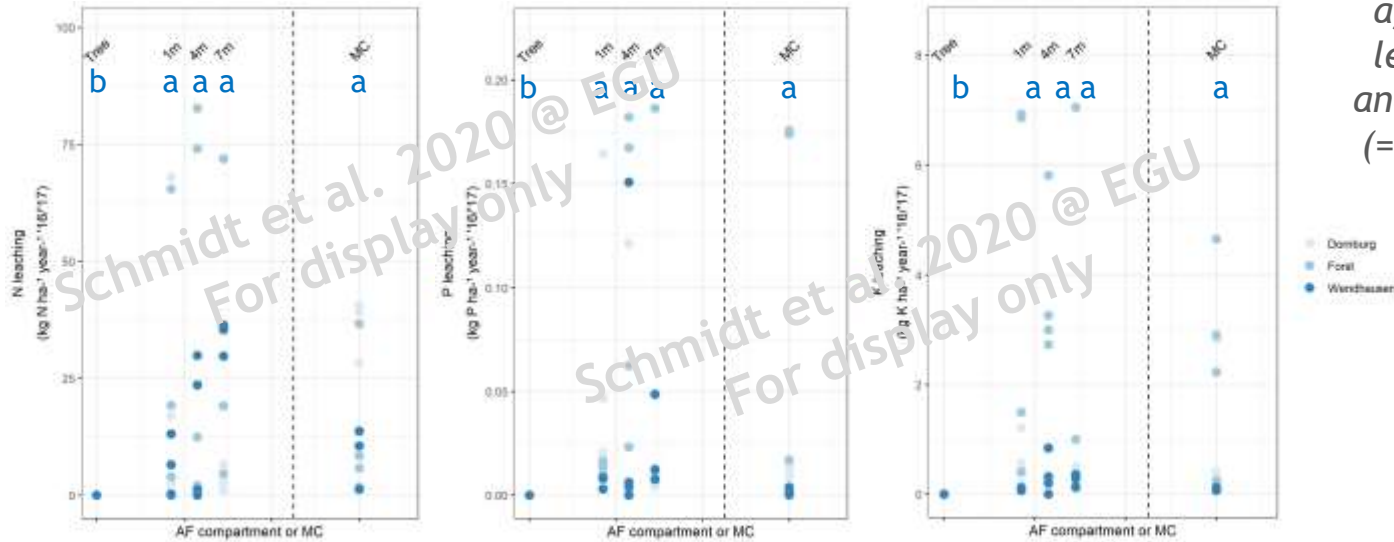
"We used suction cup lysimeters to sample soil water underneath the rooting zone monthly from April 2016 to April 2017."



"Soil water fluxes were modeled using the plant-soil-atmosphere model Expert-N."

"Total dissolved nitrogen in soil water was analyzed by continuous flow injection colorimetry. For concentrations of total P as well as K cations, we used an inductively coupled plasma-atomic emission spectrometer."

Results pt 1: Nutrient leaching

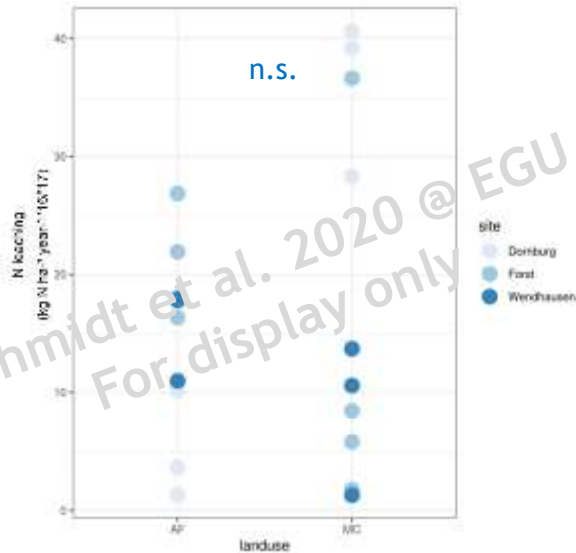


"These graphs shows leaching losses in different distances of agroforestry (= AF, left in each graph) and the monoculture (=MC" right in reach graph)."

Stats: Multiple comparison test after Kruskal Wallis at $p < 0.05$

"What sticks out is that there is virtually no nutrient leaching under the tree row. We believe that some of the relatively high leaching close to the tree row is due to less productive plants not taking up as many nutrients."

Results pt 2: Nutrient leaching per landuse



"For this graph, the values for tree row and crop row in agroforestry ("AF", left) were area-weighted to represent the actual area in the field and compared to the monoculture ("MC", right). "

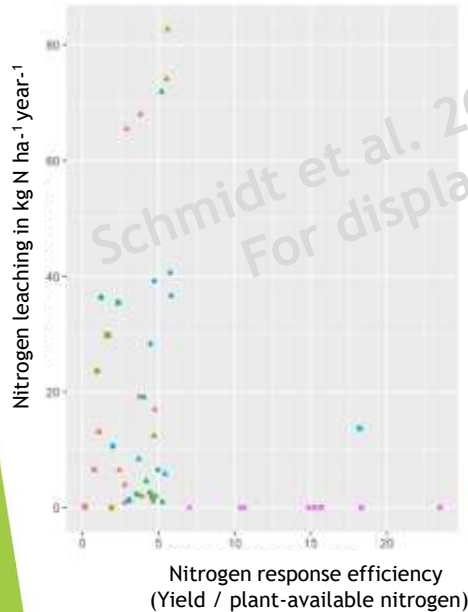
Total dissolved nitrogen contained:

- 61% Nitrate ($\pm 2\%$) &
- 6% Ammonium ($\pm 1\%$)

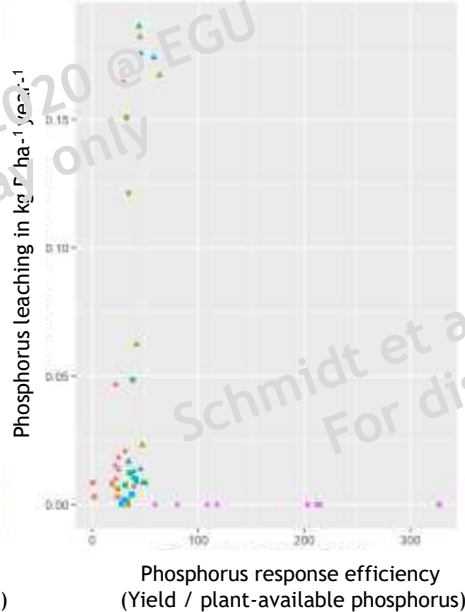
Stats: Two Sample t-test

"Some of the highest values of leaching were found in the monoculture, though there was no overall significant difference. The same was true for P and K."

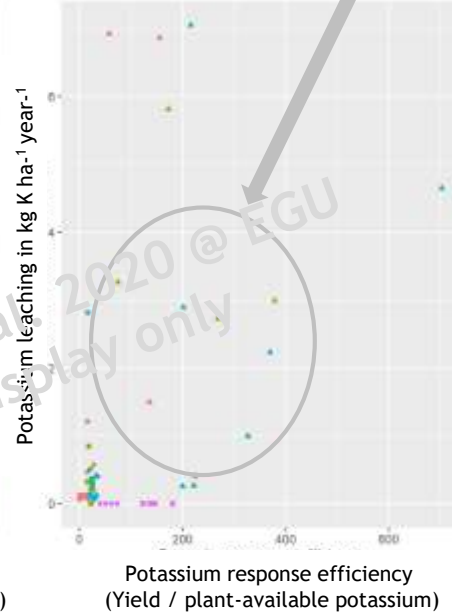
Results pt 3: Leaching losses and nutrient response efficiencies (NRE)



Nitrogen



Phosphorus



Potassium

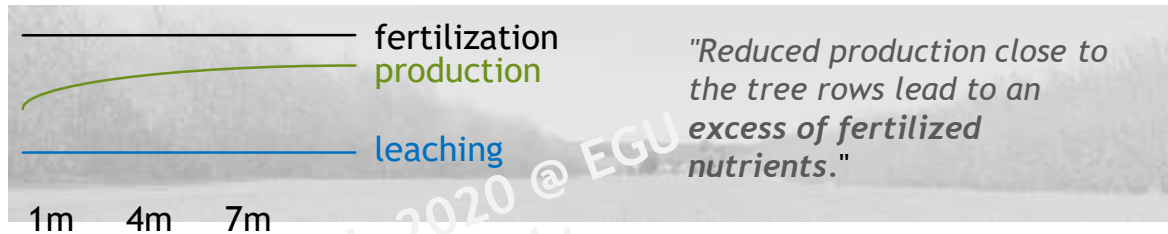
"The cluster of triangles is due to high K leaching through the sandy soils at the Forst site"

"NRE (x-axis) is an indirect indicator of nutrient retention (Bridgham et al. 1995, The American Naturalist). Our graph show that this holds true for our system. Where nutrient response efficiency is high (in the tree row), leaching losses (y-axis) are mostly reduced to zero."

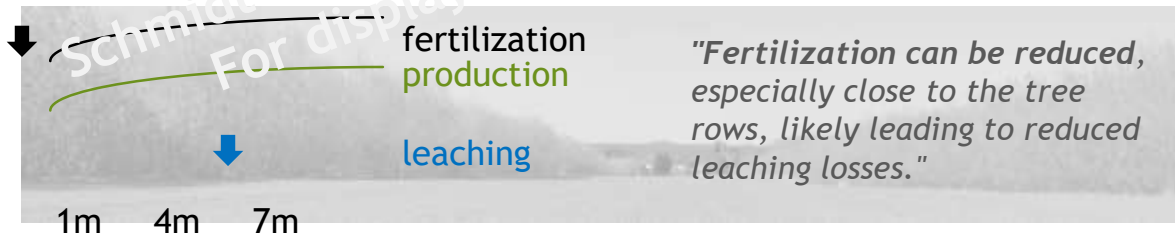
Reducing fertilization



Current management



Proposed management



"Our previous studies on NRE showed that these sites are largely nutrient-saturated. While fertilization of the crops can be reduced in general, this is especially recommended for the crops close to the tree row, which produce less. However, this is countered by high production in the crop row centre."

Conclusions



Tree rows have the potential to reduce leaching losses in agricultural fields by introducing an area with virtually no leaching losses.

Adapted management will be key to reduce leaching losses close to the tree rows.