EGU22-3495
https://doi.org/10.5194/egusphere-egu22-3495
EGU General Assembly 2022

Does soil heterogeneity drive nitrogen transformation in agricultural landscapes? Towards an increased process understanding by quantification of N emissions and N transformation in soil

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Most often, yield variability can be associated with differences in topography, soil properties and other environmental factors across agricultural landscapes. Ensuring high yield levels while simultaneously minimizing the risk of N-losses through inadequate use of fertilizers is especially difficult due to the high spatial variability of N transformations originating from those heterogeneities. Thus, understanding of N transformation in heterogeneous agricultural landscapes is key to an efficient and sustainable crop management.

To assess the impact of soil heterogeneity on N transformation processes, a novel field design was established in Tempelberg, North-East Germany. The experimental area was categorized in high yield and low yield potential zones based on historic yield and soil textural maps with field sizes of half a hectare. To display the small-scale soil heterogeneity within the patches, measurements were done along transects of gradients of yield potential.

We hypothesized that low yield soils with sandy texture, low soil water holding capacity (WHC) and locations at lower elevations within the field are associated with low N_2O emissions and high N-leaching. In contrast, we expected high yield potential soils located at higher altitudes with a loamy texture to be characterized by high WHC, high N_2O emissions and low N-leaching. Additionally, we postulated that edge effects across the transects may play a role due to patch design. We present results of the monthly N_2O emission measurements done in fields cultivated with rape seed (*Brassica napus L.*), sunflower (*Helianthus annuus L.*) and maize (*Zea mays L.*), measured with NFT-NSS closed chambers, over a period of 6 months. ^{15}N balances were calculated in the same fields tilled with sunflower (*Helianthus annuus L.*) and maize (*Zea mays L.*), by ^{15}N tracer application and evaluation at three time points over growing season. Combination of N transformation processes and gaseous N fluxes in addition with WHC and topography allows for the identification of factors controlling soil N transformation and N availability in agricultural landscapes with high spatial variability of soil properties.

Soil dependent N_2O measurements were observed across each transect. Elevation, texture as well as soil water content (SWC) showed a clear influence on N_2O emissions. High emissions were measured in plots characterized by a loamy texture, high SWC and locations at higher elevations. In addition, lower emissions were measured at the edge point of the given transect, which could be described as an edge effect.

Evaluations of ^{15}N tracer application results showed significant higher ^{15}N leaching in low yield soils, which tend to have a higher sand content. High yield soils showed lower N-leaching. A strong dependence on soil texture and SWC was visible in the field cultivated with sunflower (*Helianthus annuus L.*): plots with higher sand content and lower SWC located at the center of the transect showed a higher N-leaching. This finding is in agreement with measured N_2O emissions, which were noticeably lower in these areas.

In conclusion, soil heterogeneity in agricultural fields originating from differences in soil texture, SWC and topography show a clear impact on N transformations and N emissions.