Increased nitrous oxide emissions by application of organic amendments may largely offset the carbon benefits

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Abstract

Application of organic amendments increases soil carbon (C) sequestration but also affects the emission of the powerful greenhouse gas (GHG) nitrous oxide (N_2O). However, effects of organic amendments on soil N_2O emissions remain uncertain as long-term, multi-year measurements are mostly missing. Here we report on six years of measurements in a long-term field experiment and a global meta-analysis of organic amendment effects on soil N2O emissions. Results showed the intra- and inter-annual variations in soil N_2O emissions were correlated positively ($P<0.01$) with the temporal dynamics of soil temperature, soil WFPS, soil NO_3^- and DOC contents. On the basis of global meta-analysis and the experiment of six years, application of organic amendments on average significantly increased soil N_2O emissions by over 30% compared with synthetic N fertilizer. Our studies indicate that increased soil N_2O emissions must be carefully considered when organic amendment practices are proposed to maximize the climate change mitigation potential of agricultural soils.

Keywords: N_2O, organic amendment, trade-offs

1. Background and motivation

How organic amendment application affects soil N_2O emissions is critical to evaluating the potentinal of organic amendment application to agricultural soils for climate change mitigation on a global scale. Although organic amendment can increase SOC stocks, the increases in labile organic C availability may enhance soil N_2O production and emission. However, the quantitative synthesis of the overall and long-term organic amendment effects on soil N_2O emissions relative to synthettic N fertilizer is still lacking.

2. Materials and Methods

A global meta-analysis and six-year field measurments have been conducted to evaluate the overall sign and magnitude of organic amendment (manure and crop residue) effects on N_2O emissions relative to synthetic N fertilizers in agricultural soils.

3. Results and conclusion

At the global scale, on average, manure application increased N_2O emissions by 33% relative to mineral N fertilizer application and the increases in N_2O emission by

manure application offset 37% of the benefit of increasing SOC stocks as GHG sinks. In the long-term perspective, our six-year continous field measurmeents showed that soil N_2O emissions increased by over 30% following incorporations of either manure or crop residue, as compared to synthetic N fertilizer application, from the subtropical agricultural soils.

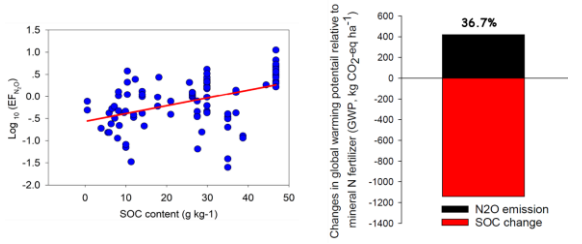

Fig. 1: Response of N_2O emissions to SOC content and the percentage of GWP for SOC change offset by increased N_2O emissions.

Overall, our global meta-analysis and multi-year field studies highlight that the increased soil N_2O emissions must be carefully considered when organic amendment practices are proposed to maximize the climate change mitigation potential of arable lands, particularly in subtropical climates.