Agricultural Greenhouse Gases Program (AGGP2)

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# Forested Land-use Decreases $N_2O$ and $CH_4$ Emissions but Increases $CO_2$ Emissions as Compared to Croplands in Hedgerow and Shelterbelt Systems

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## Introduction

The effect of different land-use systems on greenhouse gas (GHG) emissions is often inconsistent among studies. Such effects are often site-specific and thus more research is needed to understand the source-sink relationship of different agroforestry systems. The emission of GHG depends on soil microbial activities, which are dependent on the quantity and quality of available substrate. Both the availability and quality of substrates supporting microbial activity are affected by land-use type/change. Regarding microbial activities, the gross rates of nitrogen (N) transformations are a good surrogate of the rate of microbial activities and there maybe close relationships between gross N transformation rates and GHG emissions. We conducted a laboratory experiment to study the above relationships.

## Methods

Soil samples (0-20 cm) were collected from the forested and cropland areas of two agroforestry systems, hedgerow and shelterbelt systems, in 2015. A laboratory incubation experiment (incubated at 20 °C) was set up to allow GHG (including $CO_2$, $N_2O$ and $CH_4$) emission rates to be quantified (with GHG concentrations measured on a gas chromatograph). Gross rates of N transformation were determined using an $^{15}N$ pool dilution method.

## The Result

Soils from forestland had a lower $N_2O$ emission rate than those from cropland and the forest soils were a sink for $CH_4$ (oxidation of $CH_4$ occurs in the soil, rather than emissions) as compared with being a $CH_4$ source of the cropland soil. Forest soils, however, had a greater rate of $CO_2$ emissions, which dominate the contribution to the global warming potential of the different land-uses and agroforestry systems. Between the two agroforestry systems, hedgerow soils had greater $CH_4$ oxidation rates and lower $N_2O$ emission rates but greater $CO_2$ emission rates. Emissions of $N_2O$ were related positively with gross nitrification rates and soil pH, and negatively with gross N immobilization rates. The $CO_2$ emission rates were positively related with water-soluble organic C content, while $CH_4$ emission rates were related positively with clay content, but negatively with gross N immobilization rates and soil organic C content. Our result suggests that $N_2O$ emissions were driven by gross nitrification while $CO_2$ emissions were fueled by labile C availability in the studied systems.

Photo credit: Farrah Fatemi

## Implications

Since there was more C sequestered in forest than in cropland soils as reported in our other studies in the same project, this study suggests that forest soils received more C input, and after the C loss through microbial respiration, more soil organic C was stored in forest soils to achieve C sequestration. The lower $N_2O$ and $CH_4$ emissions from forest soils further support the benefit in including trees in the agricultural landscape for mitigating climate change. Emissions of different GHGs need to be assessed collectively to understand the total impact of land use activities on climate change.

## Further Reading

Li, P., Lang, M., Zhu, S.X., Bork, E. W., Carlyle, C.N. and Chang, S.X. 2020. Greenhouse gas emissions are affected by land use type in two agroforestry systems: results from an incubation experiment. Ecological Research 35:1073–1086.

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