The Effect of Intensification on Nitrogen Losses from Diversified Vegetable Farms

Debendra Shrestha¹, Krista Jacobsen¹, Ole Wendroth¹ and John Schramski²

(1) University of Kentucky, Lexington, KY, (2) University of Georgia, Athens, GA

Introduction

Nitrogen (N) is a major agricultural input that is critical for crop production. Human induced production and release of reactive nitrogen has greatly affected the natural balance of N, contributing to changes in ecosystems, over-enrichment of aquatic ecosystems, biodiversity losses, and global climate change (e.g. Ribaudo et al., 2011).

Agricultural soil management practices such as fertilizer application and other cropping practices were the largest source of nitrous oxide (N₂O) emission in the United States, accounting for 74.2% of total N₂O emission (EPA, 2015). Other key loss pathways include nitrate (NO₃⁻) leaching losses to the soil and water environment, with well documented subsequent effects on surface and ground waters.

The effect of N losses from agricultural management practices via greenhouse gas emissions and leaching losses have been broadly characterized in agronomic crop production. They have been studied to a much lesser extent in horticultural systems, perhaps due in part to the variability in the intensity of horticultural production practices. Given the intensity inputs, tillage and other resources, be they conventional or organic, and the growing interest in the sustainability of these systems, further investigation of these key loss pathways to the environment is warranted.

Objectives

The goal of this work is to improve our understanding of the N and carbon (C) inputs, outputs, and the key pathways driving agroecosystem sustainability in horticulture-based systems along a gradient of intensification. Specifically, this project aims to quantify greenhouse gas emissions (N₂O, NH₃, CO₂, and CH₄) and other cropping practices were the largest source of nitrous oxide (N₂O) emission in the United States, accounting for 74.2% of total N₂O emission (EPA, 2015). Other key loss pathways include nitrate (NO₃⁻) leaching losses to the soil and water environment, with well documented subsequent effects on surface and ground waters.

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Materials and Methods

The field experiment was initiated in 2014 at the Horticulture Research Farm, University of Kentucky, Lexington, KY, and a cooperating farm in Georgetown, Kentucky. The three systems presented in this work are 1) a pasture-based Extensive Organic system, 2) an Organic High Tunnel and 3) a Conventional system (Fig 1).

Fig 1: A subset of the systems in this study representing different level of intensification and parameters for characterizing the intensification gradient.

Results

Trace gas flux rates

Preliminary CO₂ and N₂O fluxes measured during the 2014 main growing season (Figs 4 and 5) indicate consistently higher N₂O and CO₂ fluxes in the Extensive Organic system. The Organic High Tunnel system had intermediate CO₂ flux levels, and the lowest N₂O fluxes of the three systems. The Conventional system had the lowest CO₂ flux levels, with intermediate N₂O fluxes. Fluxes peaked in all systems in June with declining rates through late summer and fall.

Fig 4: N₂O flux (µmol m⁻² s⁻¹) in three of the study systems during the 2014 main growing season.

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Fig 5: CO₂ flux (mg m⁻² hr⁻¹) in three of the study systems during the 2014 main growing season (Figs 4 and 5) indicate consistently higher N₂O and CO₂ fluxes in the Extensive Organic system.

Whole system energy input:output

Preliminary results for the 2014 calendar year indicate that the Extensive Organic system has a far lower total energy usage per unit output than other systems. At the time of this writing, data were available for the Extensive system and a commercial, mechanized organic system also used in the study (a “Medium Scale Organic” system). The cumulative ratio for the Extensive Organic system is approximately 10 (Fig 7). The cumulative ratio for the Medium Scale Organic system, is approximately 48 (Fig 8).

Fig 7: Energy input and output contributions for the Medium Scale Organic system for 2014.

Fig 8: Energy input and output contributions for the Extensive Organic system for 2014.

Conclusions

Preliminary results indicate that the level of intensification as characterized by this study may influence N losses to the environment via trace gases and leaching. However, it is important to view these field-scale results in the context of whole farming system metrics when assessing environmental sustainability of such systems. Future work will include two additional years of field data, and include other soil- and plant-based parameters to characterize labile N and C cycling in these systems.

References


Thompson, Dr. Mark Williams, Matthew Deason, and Savannah McGuire.