# The ecological yield gap in continuously grown maize

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# Abstract

*Context*

Even in high-input agricultural systems, ecological processes can provide significant contributions to agricultural productivity. These contributions can be difficult to quantify and are therefore not well understood, precluding our ability to fully leverage them. In this study we use the continuous maize penalty - wherein maize grown continuously on the same land requires more inputs and concomitantly produces lower maximum yields compared to maize grown in rotation with soybean (Glycine max) – to develop a framework for estimating and exploring ecological processes’ contributions to yield. The aims of the research were to (1) conceptually define agronomic and ecological yield gaps in maize, (2) couple the framework with experimental data to estimate them empirically, and (3) to compare the empirical results with model simulations to identify potential causal mechanisms for ecological yield gaps in maize.

*Methods*

To achieve our research objectives we conducted a literature review, used 157 site-years of experimental data from the US Corn Belt, and a processed-based simulation model (APSIM).

*Results*

Using the continuous maize penalty as a backdrop, we conceptually defined the agronomic yield gap (agroYG) as the differential between the continuous maize yield at the rotated maize agronomically optimum nitrogen rate (AONRrot) and the maximum yield obtained in the continuous maize (i.e., the yield increase resulting from additional fertilization above the AONRrot), representing ecological yield provisioning that can be replaced through additional inputs. The difference between the maximum yields in the two systems was defined as the ecological yield gap (ecoYG), representing ecological yield provisioning that cannot be replaced by inputs. We applied this concept to experimental data consisting of N response curves for maize yields from continuous maize and maize-soybean rotations in Iowa (7 sites) and Illinois (7 sites) conducted between 1999 and 2016. The mean ecoYG was steady over time at 1.0 (SE:0.2) Mg ha-1, corresponding to 10% of mean rotated maize yields. The ecoYG ranged from 0-4.8 Mg ha-1, and tended to be higher in colder environments; soil characteristics contributed to only 13% of the variation. The agroYG ranged from X-X Mg ha-1 and was not correlated with the ecoYG, suggesting they reflect distinct processes. Synthesizing these results with existing literature and a modeling exercise, we suggest compromised maize roots are a significant driver of the ecoYG in maize monocultures, but find little empirical evidence to support or refute this hypothesis. This study provides a framework for empirically quantifying ecological contributions to crop yields, opening the door for designing cropping systems that optimize both input use efficiency and ecological processes’ contributions to yield.

**A graph of a graph showing a graph of a yield

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