Regional Characterization of Alfalfa and Manure Legacy Impacts on Soil Quality in Crop Rotations

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OBJECTIVES

Evaluate the impact of a one-time dairy manure application on alfalfa and corn yield, soil microbial community structure, and soil chemical properties in a five-year alfalfa-corn rotation (AAACC).

Evaluate the impact of alfalfa on microbial community structure and on subsequent corn yield.

STUDY DESCRIPTION

Plot Layout:

Split-plot arrangement in a randomized complete block design.

Locations:

Grand Rapids, Lamberton, and Waseca, MN (Figure 1).

Factors:

Site: Grand Rapids, Lamberton, Waseca.

Crop phase: Corn (year 1, year 2), alfalfa (year 1, year 3).

Fertility: High manure rate, Low manure rate, Mineral fertilizer only, Control (no amendments).

Analysis:

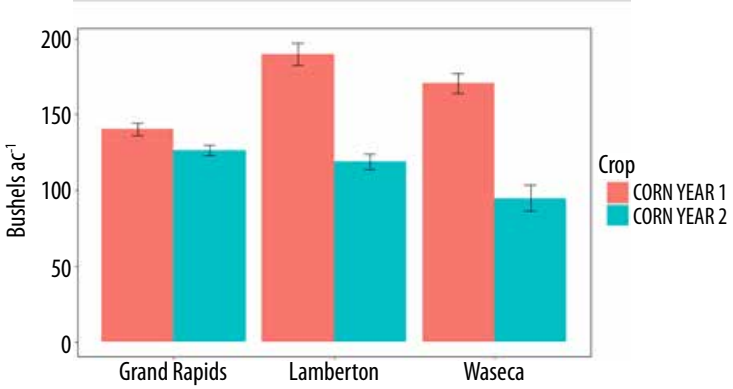
Corn and alfalfa yield were determined by hand harvesting a subsample of plants in each plot. Soil samples were collected to 6-inches depth in the spring prior to planting and manure applications and again in the fall after corn harvest. Genomic DNA was extracted from the soil and microbial composition and diversity were evaluated using high-throughput Illumina amplicon sequencing at the University of Minnesota Genomics Center. Soil samples for chemical analysis were sent to the University of Minnesota Research Analytical Laboratory and analyzed for NO_3-N, Bray P, Exchangeable K, Mg, Ca, Na and organic C.

Figure 1. University of Minnesota Long-Term Agricultural Research Network (LTARN) locations where the study was conducted.

RESULTS

- First-year corn following alfalfa (corn 1) yielded 14 bu ac^{-1} (11%), 71 bu ac^{-1} (59%), and 76 bu ac^{-1} (80%) more grain than second year corn at Grand Rapids, Lamberton, and Waseca, respectively (Figure 2). This pattern was repeated for overall corn stover production.

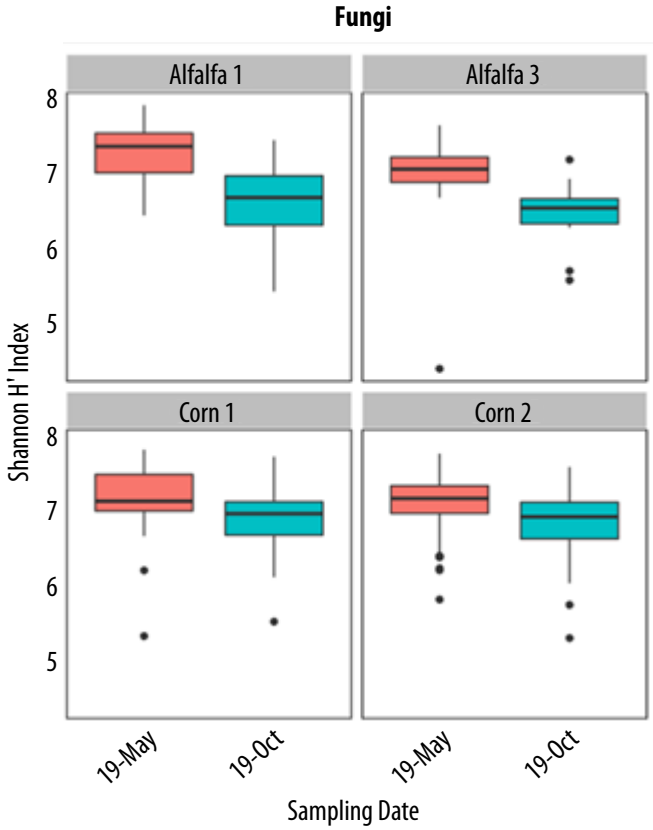
Figure 2. Corn grain yield by crop (1st vs 2nd year following alfalfa) and site.



- Manure treatments only impacted yield of first-year corn and first-year alfalfa. Across sites, first year corn with the high manure rate yielded more than the control. The high manure rate also resulted in higher first-year alfalfa yields compared to the mineral fertilizer and control treatments.

- Bacterial community diversity varied with sampling date. Bacterial diversity was greatest following the fall harvest. Fungal diversity also varied significantly by sampling date and seasonal differences were greater in alfalfa than corn (Figure 3).

Figure 3. Soil fungal local diversity (Shannon H' Diversity) varied by sampling date such that diversity was greater at spring than fall sampling, however, seasonal differences were greater for alfalfa than corn plots. Seasonal differences were observed regardless of manure and fertilizer applications.



- Overall, microbial community structure differed significantly among study site, sampling date, and crop phase.
- High manure rates significantly impacted soil fungal, but not bacterial, community compositions.
- Fungal communities were consistently correlated with available soil K across all sites, and correlations with other soil chemical measurements were site specific.

CONCLUSIONS

- Impacts of a spring manure application on the overall composition and diversity of microbial communities is limited.
- The "alfalfa rotation effect" resulted in an average yield boost of 54 bu. ac^{-1} in first year corn; this effect was not correlated with soil nutrient status and could be related to alfalfa's impact on soil biota.
- These results represent only a single season of data for this on-going study; more research is needed to explore the impacts of manure application and alfalfa on the overall composition and diversity of soil microbial communities.

Alfalfa
U.S. Alfalfa Farmer Research Initiative

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