Soil Microbial Diversity and Corn Grain Yield as Affected by Cover Crop and Nitrogen Combinations

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Introduction

- Increased weather variability and inconsistent corn yields require improved nitrogen (N) management strategies with greater emphasis towards resilient cropping systems.
- Plants, soils, and soil microbiota function simultaneously to influence each other and affect plant productivity (Chaparro et al., 2012).
- Living ground covers can provide opportunities to influence soil microbiota through organic carbon substrates and root morphology.
- Michigan corn growers utilize spring pre-plant incorporated (PPI) N and starter + delayed N applications as strategies to supply N at planting and reduce probabilities for N loss due to volatile early-season weather.
- Crop production relies on microbial activity for nutrient cycling yet little data exist regarding how nutrient management and cultural factors impact microbial communities.
- Critical need to investigate alternative strategies that maximize plant genetic potential through incremental changes in soil health.

Objective

Determine the effect of cover crops individually and in combination with 4R Nutrient Stewardship on temporal changes in soil health, soil and rhizosphere microbial community composition (soil biology), and corn yield.

Materials and Methods

- Field studies initiated in 2014 on a Capac loam soil (fine-loamy, mixed, active, mesic Aquic Glossudalf) with 0-3% slopes in Lansing, Michigan.
- Conventional tillage following wheat, 2.5% OM, 6.1 cmol(+) kg^{-1} CEC; 57 mg kg^{-1} P; 101 mg kg^{-1} K; 6.1 pH.
- Study arranged as a split-plot randomized complete block design with four replications containing 18 experimental units each measuring 4.6 m x 12.2 m.
- Treatments are combinations of cover x N management strategy
  - Main plot factor was cover treatment: 1) no cover, 2) "The Buster" daikon radish (seeded 11.2 kg ha^{-1}), or 3) "Magnum" forage oats (seeded 28.0 kg ha^{-1}).
  - Subplot factor was N management strategy equalized to the site-specific maximum return to nitrogen rate (MRTN) of 179 kg N ha^{-1}, and a zero N check:
    1. Zero N control
    2. Urea pre-plant incorporated (PPI)
    3. Poultry manure (4-3-2) (2.2 Mg ha^{-1}) followed by sidedress (SD) urea ammonium nitrate (28% UAN) at corn growth stage V10-12
    4. Starter N (subsurface banded [SS band] 28% UAN applied at 44.8 kg N ha^{-1}) placed 5-cm to the side and 5-cm below seed furrow followed by SD 28% UAN at V4-6 corn
    5. Starter N followed by SD 28% UAN at V10-12 corn
    6. Starter N followed by SD 28% UAN split 50/50 at V4-6 and V10-12 corn
- Corn (98-d relative maturity) was seeded in 0.76-m rows at 84,510 seeds ha^{-1}.
- Soil data measurements included:
  - 0-10 cm soil samples to determine microbial taxonomy
  - 0-15 cm soil samples to determine microbial activity
  - 0-20 cm soil samples to determine soil nutrient fluctuations
  - 0-30 cm soil samples to determine total N fluctuations
- Corn data measurements included:
  - V2 and R6 stand counts
  - V6 and V10 NDVI readings
  - V7, V15, R2 corn canopy heights
  - R1 ear leaf tissue total N content and dry weight

Table 1. Corn grain yield by cover crop and N management strategy, Lansing, MI 2015.

Treatment	Grain Yield (Mg/ha)	Moisture (%)	Test Weight (Kg/hl)
Cover Crop	--	--	--
No Cover	15.8	22.2 a*	66.5 b
Radish	15.4	20.4 b	67.3 a
Oat	15.5	20.3 b	67.4 a
N Strategy	--	--	--
Unfertilized	12.4	20.5 b	66.5 a
Urea PPI	15.9	20.6 b	67.2 a
Poultry manure + V10 SD	16.4	20.2 b	67.6 a
2x2 starter + V4 SD	16.2	20.6 b	67.3 a
2x2 starter + V10 SD	16.4	21.8 a	66.9 a
2x2 starter + V4/V10 SD	16.3	21.9 a	66.9 a
Multiple *df* contrasts - SS band + SD timings	--	--	--
No Cover	16.3 a	22.4 a	66.7 a
Radish	16.2 a	21.0 b	67.2 a
Oat	16.2 a	21.0 b	67.3 a
Source of Variation (*P*>F)			
Cover Treatment (C)	0.1958	0.0067	0.0216
N Strategy (N)	<.0001	0.0200	0.1197
C x N	0.0256§	0.1583	0.6346
SS band + timings	0.9087	0.0267	0.1545

*Column values with the same lower case letter are not significantly different (α=0.1).
§Significant cover x N strategy interaction due to cover x unfertilized strategy (*P*<.0001).
Significant grain yield means contrasting cover x unfertilized strategy presented below.

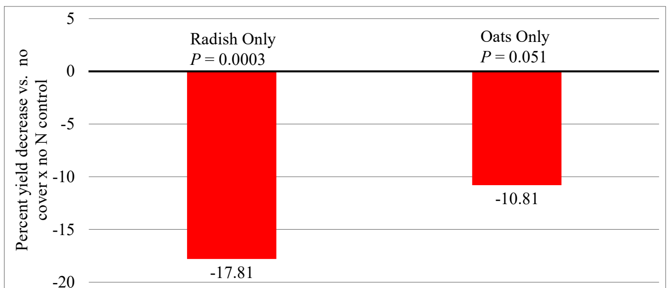

Figure 1. Impact of cover crop on percent change in mean grain yield as compared to the no cover x zero N check using single *df* contrasts applying Dunnett's test to control Type I error rate, Lansing, MI, 2015.

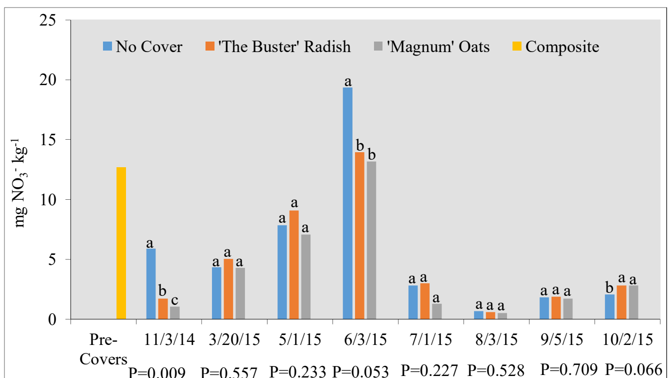

Figure 2. Impact of cover treatment only on monthly soil nitrate levels (0-30 cm depth), Lansing, MI, 2014-15. Bar clusters followed by the same letter are not significantly different.

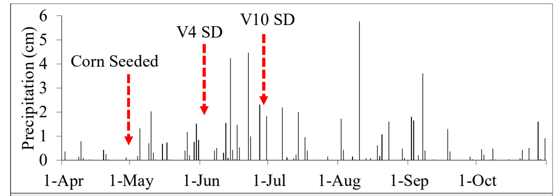

Figure 3. Rainfall frequency for 2015 Lansing, MI research site.

Table 2. Impact of cover crop* on biomass production and total N uptake at two sampling timings.

	03-November, 2014		20-March, 2015	
	Biomass	N Uptake	Biomass	N Uptake
	kg ha^{-1}			
Radish	10,582 a	230 a	--	--
Oat	7,614 b	141 b	2432	36
P>F	0.0713	0.0550	--	--

**Radish canopy and root combined. Oat cover sampling was canopy only.*

Table 3. Cover crop and soil sampling timing on inverse Simpson's diversity values (0-10 cm at two soil sampling locations, 2015, Lansing, Michigan*

	R1	Harvest	*P>F*
Bulk Soil			
No Cover	338 a	317 b	0.1098
Radish	342 a	366 a	0.0832
Oat	341 a	357 a	0.2624
P>F	0.9810	0.0338	--
Corn rhizosphere			
No Cover	335 a	370 ab	0.0094
Radish	355 a	352 b	0.8199
Oat	344 a	381 a	0.0068
P>F	0.3308	0.1044	--

**Significant cover x soil sampling location x timing interaction (P=0.0122).*
Means followed by the same letter are not significantly different at α=0.10.

Preliminary Results and Discussion

Lansing, Michigan

- June rainfall was 116% above avg. monthly mean with 3 events > 2.0 cm. (Fig. 3). Total rainfall between at-plant N applications and V4-6 sidedress was 11 cm while rainfall between at-plant and V10-12 sidedress was 28 cm.
- The radish cover produced 39% more biomass than an oat cover corresponding to a 63% increase of total N uptake. Fall radish and oat covers reduced soil nitrate levels 71% and 82%, respectively, after 81 days of growth before termination suggesting that a portion of total N taken up by oats remained in the roots as total N uptake observed was greater with radish (Table 2, Fig. 2).
- A significant C x N strategy for corn grain yield was observed due to the cover x unfertilized control combinations. Where no N was applied the radish and oat covers significantly reduced grain yield 17.8 and 10.8% respectively from the no cover x no N control. This indicates that N removed from the soil by the covers in the fall may not have been available for corn N uptake as evidenced by June and October NO_3^- levels (Table 1, Fig. 1).
- A cover x soil sampling location x sampling timing interaction occurred for inverse Simpson's diversity index (Table 3). Overall community diversity did not correlate with yield (data not shown) suggesting bacteria relative abundance may be more important than diversity for crop yield.