Linked Crop Production and Soil Organic Matter Impacts of Winter Annual Legumes in Upper Midwest Organic Agroecosystems

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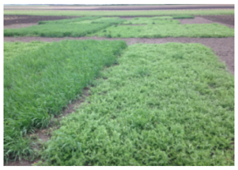
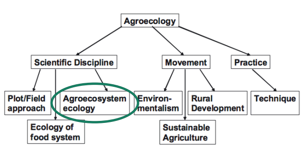




Introduction

Upper Midwest agroecosystems face a series of 'wicked problems', characterized by complexity, uncertainty, and interdependence, in the face of climate volatility, rising demand for agricultural products, and environmental externalities (Davies et al. 2015). Agroecology, the application of ecological concepts to design and management of agroecosystems, can play a role in addressing these complex issues. Cover crops, non-harvestable crops grown between cash crop production, are an agroecological practice that can increase a suite of ecosystem services in agricultural production. Cover crops provide benefits including reduced erosion, pollinator habitat, spatial and temporal biotic diversification, nutrient additions, and increased soil organic matter (SOM) (Dabney et al., 2007). SOM is any material produced by living organisms (plant or animal) returned to soils and decomposed. SOM influences soil structure, water retention, and nitrogen availability through microbial mineralization. Leguminous cover crops increase soil nitrogen by converting atmospheric nitrogen into plant soluble nitrogen forms through symbiosis with rhizobia, while also increasing organic carbon levels (Drinkwater and Snapp 2007). Landscape implementation of cover crops is limited by short growing seasons and lack of growing degree days for adequate biomass production and harsh winters with highly variable temperatures and snowfall. Additionally, low yields following cover crops in upper Midwest remain a significant challenge (Leavitt 2011). This project seeks to evaluate the viability of a fall-planted, winter annual legume cover crop, hairy vetch, and its effects on labile soil C and N pools before a succeeding sweet corn crop.



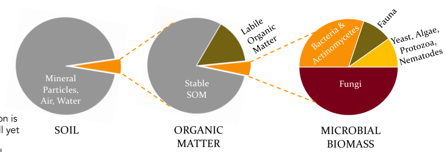
Experimentation is embedded within and closely linked to agrarian and environmental social movements and site/regionally specific farming practices (Wezel 2009)

Objectives

I. Assess viability of fall-planted, winter annual legumes cover crops for upper Midwest climates
II. Quantify contribution of select cover crops to soil carbon pools
III. Improve understanding of carbon and nitrogen coupling in agroecosystems

Hypotheses

I. Winter annual legumes increase labile soil C and N levels compared to no cover crop control and rye cover crops
II. Legume cover crop biomass N will provide significant N for crop production
III. **Increased** labile soil C will be correlated with mineralization of organic N
IV. Legumes reduce crop yield drag compared to rye cover crops



Labile soil carbon is a relatively small yet highly active, nutrient-rich soil organic matter fraction

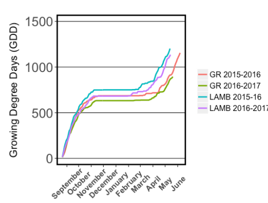
Methods

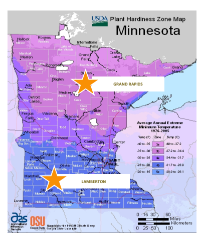
- Two sites x two years (southwest and northern Minnesota)
- Randomized 4-block design
- Organic production following USDA NOP Standards

Timeline

- Cover crops planted late August/early September
- Cover crop and weed biomass, 1st soil samples (*pre-termination*) collected early June at termination
- 2nd soil samples (*post-termination*) collected within two weeks of cover crop termination
- Corn cultivated and hand-weeded throughout season
- Mid-September harvest

Cumulative growing degree days





Crop	Species ID	Cultivar and Source	Rate (#/acre)
Vetch (*Vicia villosa*)	VET	VNS, Albert Lea MN 2014 #23 and Buckwheat Growers 2014 #25	25
Red Clover (*Trifolium pretense*)	CLO	Red Clover, Albert Lea 2014	12
Winter rye (*Secale cereale*)	RYE	Winter rye, Albert Lea 2014	105
Vetch/rye mix	MIX	VNS Buckwheat Growers 2014 #25 & Winter rye, Albert Lea 2014	25, 75
Sweet corn (*Zea mays*)	---------	Luscious, Johnny's Seeds	35,000 (seeds)

Data Collection

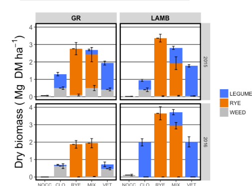
Soil Carbon
- Microbial biomass carbon
- Permanganate oxidizable carbon (POX-C) (Culman et al. 2012)
- Particulate organic matter (size fractionation) (Wander 2004)

Soil Nitrogen
- Extractable KCl nitrogen
- Potentially mineralizable nitrogen (7-day anaerobic)

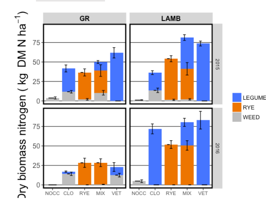
Agronomic Data
- Cover crop and weed biomass
- Marketable sweet corn yield (> 17 cm)

Results

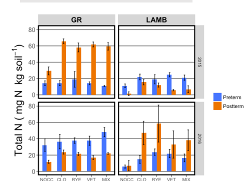
Cover crop and weed biomass



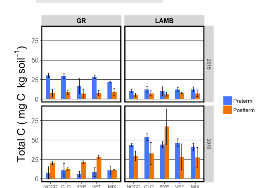
Biomass N



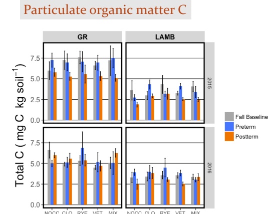
Potentially mineralizable N



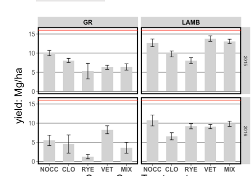
Microbial biomass C



Particulate organic matter C



Corn Yield



Conclusion

- Winter annual legume cover-crops may increase soil cover, labile SOM, and available N
  - Labile SOM can inform management effects, broadening parameters evaluation of cover crop effectiveness. Despite low CC biomass, high quality legume inputs may counteract SOM declines due to tillage and land-use change while providing significant N.
  - Increased PMN levels in cover crop treatments compared to NOCC in GR 2015 and LAMB 2016
- Effect of cover crop highly dependent on site and year differences
  - LT fallow site history influences background organic C and N levels
- Promising agronomic results: LAMB 2015 yielded close to conventional state average in NOCC, VET, and MIX treatments
- **Future research directions**
  - **Additional carbon input sources:** Priming, root-derived C, oxidation of protected/occluded C
  - Laboratory C respiration or in-field soil respiration and relationship to N mineralization
  - Identify minimum biomass production required for effect on soil C and N parameters

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Sweet corn (Zea mays)	-------------	Luscious, Johnny's Seeds	35,000 (seeds)

Crop	Species ID	Source & Cultivar	Rate (#/acre)
Vetch	V1	Albert Lea MN 2014 #23	25
Vetch	V2	Buckwheat Growers 2014 #25	25
Clover	Clo	Red Clover Albert Lea 2014	12
Rye	Rye	Winter Rye	105
Vetch 2/Rye	V2 Mix	Buckwheat Growers 2014 #25, Winter Rye	25:75

Crop	Species ID	Source & Cultivar	Rate (seed/acre)
Sweet Corn	-------	Organic Luscious, Johnny's Seeds	35,000

Activity	Lamberton	Grand Rapids
2015		
CC Planting	9/1	8/21
2016		
Soil and Biomass Sampling	5/23 – 5/24	6/5 – 6/6
CC Termination and primary tillage	5/24, 5/27	6/7
Secondary Tillage	6/7	6/15
Second soil sampling	6/7	6/15
Corn planting	6/9	6/16
Tractor cultivation	7/6, 7/29	7/5
Fertilization	7/29	7/27
Corn Harvest	8/22	9/6