UNIVERSITY OF MINNESOTA

Nitrogen Contributions from Winter Annual Cover Crops in the Upper Midwest

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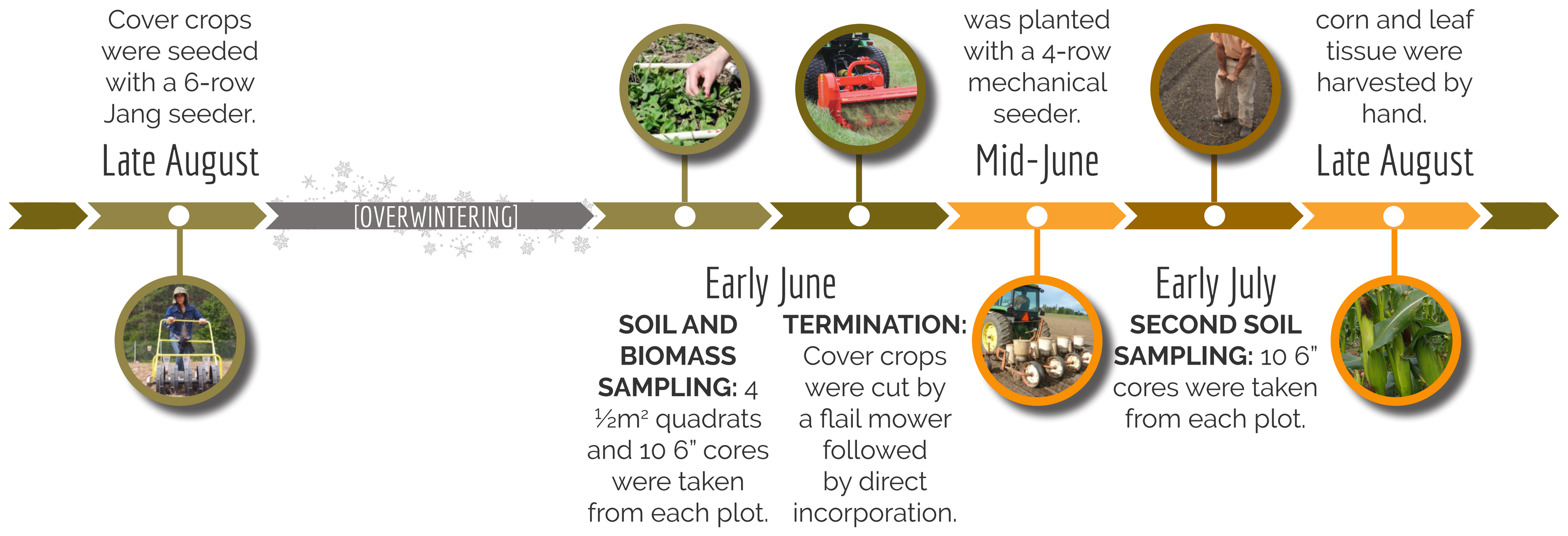
INTRODUCTION

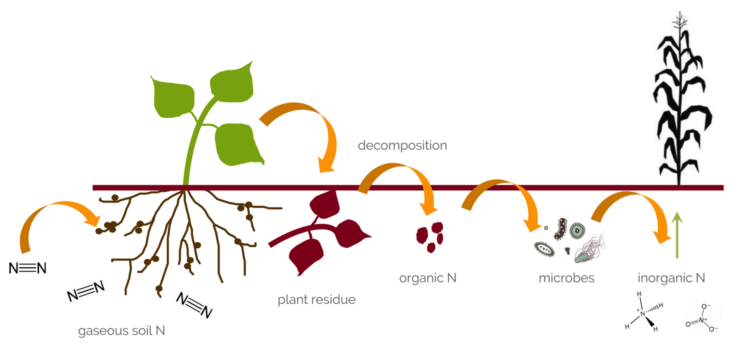
Nitrogen (N) management is of prime concern for farmers and land managers. Current N delivery through synthetic fertilizer can be inefficient and deleterious to the environment. Legumes, with the ability to fix atmospheric N into plant matter via rhizobial root colonization and symbiosis, present an alternate source and mechanism of N fertility that may help in "tightening" the nitrogen cycle to prevent losses to the environment. While legume cover crops may play a valuable role in maintaining and increasing soil quality and N availability for cash crops, they face unique challenges in the Upper Midwest, such as short growing seasons; cold, wet springs; and harsh winters. **This study was performed to assess the quantity and source of N contributions from winter annual legume species in two Minnesota plant hardiness zones that may address these challenges.**

EXPERIMENTAL DESIGN

Candidate legumes were planted with a non-legume control in a randomized complete block design in Fall 2015 (Y1) and 2016 (Y2) at Grand Rapids, MN (zone 3b, Menagha-Itasca complex) and Lamberton, MN (zone 4b, Webster-clay loam). Legumes were subdivided into rhizobia inoculated and non-inoculated treatments (Y1 only). Luscious variety organic sweet corn was planted as a cash crop at 35M/acre. Corn was fertilized with 50 lb/acre Sustane 8-2-4 composted turkey litter one month after planting.



SYSTEM MODEL



Treatment	ID	Source & Cultivar	Rate (lb/ac)
Hairy Vetch 1*	V1	Albert Lea MN 2014 #23	35
Hairy Vetch 2	V2	Buckwheat Grs 2014 #25	35
Red Clover	clo	Albert Lea 2014	12
Biculture	mix	rye + V2	60:20
Winter Rye	rye	rye	105
Bare Control	noCC	-	-

*V1 was not planted at Grand Rapids in Y2.

HYPOTHESES

H1. Differences in nodule number, nodule weight, biomass, and biomass N will be observed between inoculated and non-inoculated treatments.

H2. Vetch in biculture will fix a larger percentage of N from the atmosphere than vetch in monoculture.

H3. Sweet corn yield will be highest in treatments with high cover crop biomass and low C:N.

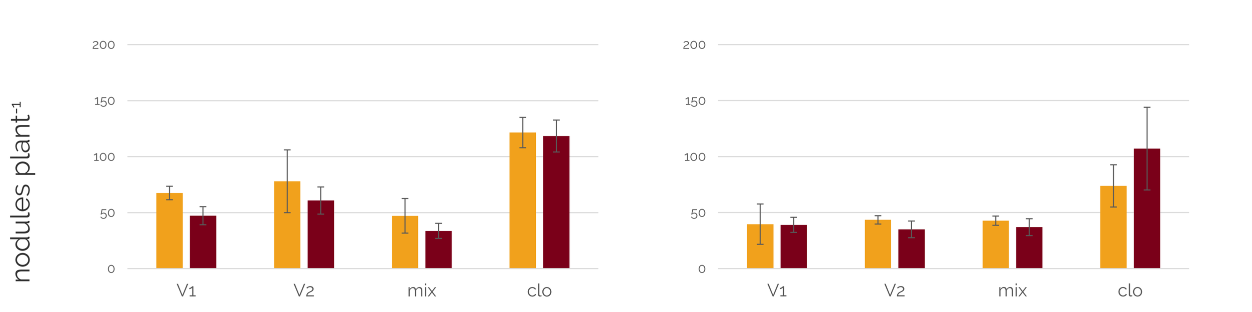
DATA COLLECTED

1. Nodule number and weight per plant
2. Total cover crop and weed biomass
3. Total cover crop and weed carbon + nitrogen
4. Nitrogen derived from the atmosphere
5. Sweet corn yield

*2-4 achieved through isotopic elemental analysis with Elementar's vario PYRO cube.

RESULTS

INOCULATION + NODULATION



Nodules per plant separated by cover crop and inoculation treatment in Y1.

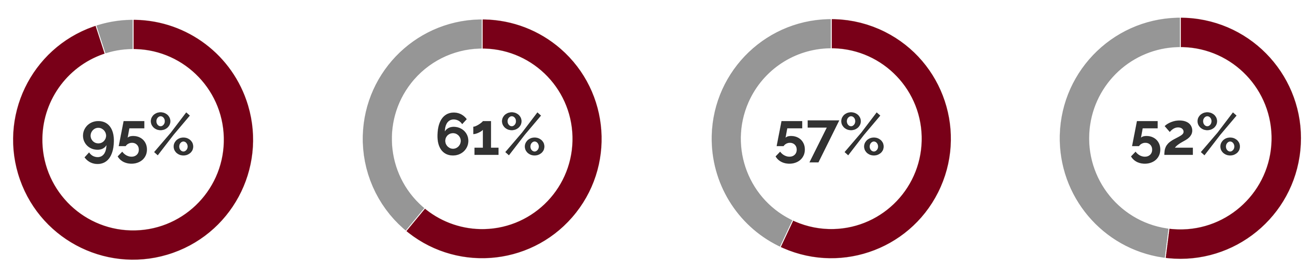
- » Inoculation did **not** have a significant effect on nodule number, nodule weight, cover crop biomass, cover crop N, or sweet corn yield.
- » Nodule number and nodule weight were **not** correlated with cover crop biomass, cover crop N, or sweet corn yield.

COVER CROP BIOMASS + NITROGEN

Treatment	Grand Rapids Biomass	Grand Rapids Biomass N	Lamberton Biomass	Lamberton Biomass N
Y1				
	--- Mg ha⁻¹ ---	--- kg ha⁻¹ ---	--- Mg ha⁻¹ ---	--- kg ha⁻¹ ---
V2	1.8 abc	**71 a**	1.9 b	**73 ab**
V1	1.5 bc	**52 ab**	2.0 b	**74 ab**
mix	2.5 ab	39 b	3.1 a	79 a
rye	3.0 a	35 b	3.7 a	53 b
clo	0.9 cd	30 b	0.6 c	23 c
Y2				
V2	0.3 b	**10 ab**	2.2 bc	**82 a**
V1	N/A	N/A	1.8 c	**85 a**
mix	1.9 a	29 a	3.7 a	80 a
rye	1.9 a	29 a	3.7 ab	52 a
clo	0.1 b	3 b	2.0 c	72 a

- » **Mix** and **rye** consistently yielded the **most cover crop biomass** across site-years.
- » **V1** and **V2** consistently yielded the **most cover crop biomass N** at all site-years.
- » **Mix** yielded **more biomass** than V1 and V2 at 3 of 4 site-years but **equivalent biomass N.**

NITROGEN DERIVED FROM THE ATMOSPHERE

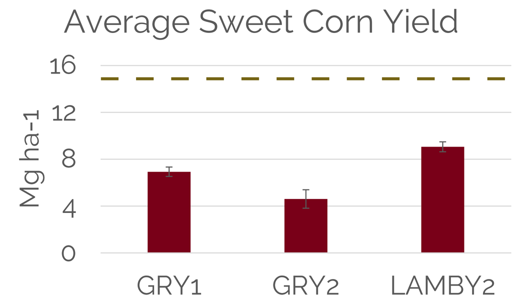


- » **Mix** yielded significantly **higher NDfA** than all other treatments, most notably its monoculture counterpart.

*Note: This is preliminary data from a representative site-year, Lamberton Y2. A growth chamber project is underway to determine more accurate isotopic references.

SWEET CORN YIELD

Average sweet corn yield in 3 of 4 site-years where treatments were not significant. Dashed line is 2016 Minnesota average, 15.5 Mg ha⁻¹.



- » Sweet corn yield was measured in marketable and total shucked weight per plot. Yield was highly variable among site-years.
- » There were **no differences among treatments** with the exception of Lamberton in Y1, where V2, V1, and mix outperformed clo and rye, and noCC outperformed rye.

SUMMARY + CONCLUSIONS

- » **(H1) Inoculation of legumes had no effects on any of the parameters investigated.** Both sites had native rhizobia that likely outcompeted the inoculant, negating any performance evaluations of the inoculant.
- » **Cold-hardy ecotypes of hairy vetch may provide significantly more or equal biomass nitrogen than rye or other legumes** under average climate conditions. This nitrogen may be more available for microbial metabolism than nitrogen in residue with a high C:N, such as rye.
- » **(H2) Growing a legume-grass biculture may increase the percentage of "free"-sourced nitrogen in legume biomass** by creating a nitrogen-scarce rhizosphere. However, growers should evaluate the tradeoffs, which include lower total legume biomass.
- » **(H3) Growing cover crops in a sweet corn cropping system can provide equal yields** to bare ground cropping while providing important soil health benefits.

Future research should evaluate the effects of residue decomposition from various cover crop inputs on soil health parameters and rapid nutrient cycling.

1. How do we predict and time peak nutrient availability with peak crop need, essentially "tightening" the N cycle?
2. How do roots contribute to nutrient cycling under cover cropping systems?
3. Can we harness rhizobia to enhance N fixation in legumes?

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