Multi-Species Cover Crop Effects on Nitrogen Availability in Corn

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Abstract

Virginia farmers were among the pioneers in no-tillage crop production and the early recipe for successful no-till production always included cover crops. The reasons include soil conservation, nutrient retention, and weed suppression, among others. Based on past farmer adoption of no-tillage production systems, we know that producers will adopt and maintain systems that noticeably improve soil quality and crop productivity. In the case of no-till, farmers have experienced the effects of increased soil quality (organic matter) and the concurrent increase in crop productivity. Adoption of diverse cover crop species mixtures and planting these cover crops in current gaps in crop rotations (e.g., in the typical fallow period after soybean) can result in further measurable improvements in soil quality. Understanding the potential nitrogen contribution of multi-species cover crop (MSCC) mixtures to the following corn (Zea mays L.) crop will be essential in order to better integrate mixtures into current cropping systems. A total of 10 on-farm studies were conducted over two years in the Shenandoah Valley and Northern Piedmont regions of Virginia. Mixtures of winter-hardy grass and legume cover crops were planted in the fall with aboveground biomass measured in December (fall growth) and at in spring at the time of cover crop termination. Corn was planted directly into cover crop residue following standard agronomic practices. At the V6 growth stage corn was sidedressed with either 0, 56, or 112 kg N ha^{-1}. Corn was harvested with commercial equipment for either grain or silage, depending on site and the effect of N rate determined. Overall, MSCC contributed up to 80 kg N ha^{-1} but the contribution was highly dependent on the timing of spring termination and cover crop biomass.

Materials and Methods

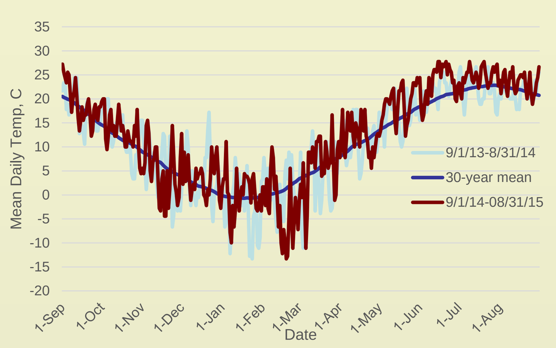
- Prior to cover crop establishment, preliminary soil samples were collected from the entire experimental area and basic chemical properties determined for each site.
- At each site, whole fields of winter cover crops were planted in fall using a commercial grain drill. Species consisted of barley (*Hordeum vulgare* L.), wheat (*Triticum aestivum* L.), Rye (*Secale cereale* L.), forage radish (*Raphanus sativa* L.), hairy vetch (*Vicia villosa* L.), crimson clover (*Trifolium incarnatum* L.), and Austrian winter pea (*Pisum sativum* L.).
- Aboveground biomass was hand clipped from a 0.5 m-2 area in each treatment in early December and in spring, just prior to killing the cover crop to estimate fall and total biomass, respectively.
- Crop samples were dried in a forced air oven at 60°C for 48 hr and then ground to pass a 2 mm screen using a Wiley (Thomas Scientific, Swedesboro, NJ) sample mill and total carbon (C) and nitrogen (N) determined by dry combustion (Elementar, Hanau, Germany).
- At the same time as the cover crop biomass sampling, four representative soil samples (1.9 cm diameter cores), each representing 8-10 composited cores were collected at 0-15, 15-30, and 30-60 cm depths.
- Cover crop nitrogen uptake was determined as the product of dry matter yield and tissue N concentration.
- At the V6 corn growth stage core was sidedressed with either 0, 56, or 112 kg N ha^{-1} as UAN in replicated strips (3) that were 60 to 90 m in length.
- Corn was harvested from each of the strips individually with commercial equipment for either grain or silage, depending on site. and yield determined.
- After harvest, soil samples (1.9 cm diameter cores), each representing 8-10 composited cores were collected at 0-15, 15-30, and 30-60 cm depths form each plot.
- Soil ammonium and nitrate were determined via extraction with 2M KCl and automated colorimetric analysis.
- Analysis of variance was conducted using PROC GLM available in SAS, and mean separations performed using a protected LSD test.

Materials and Methods (cont.)

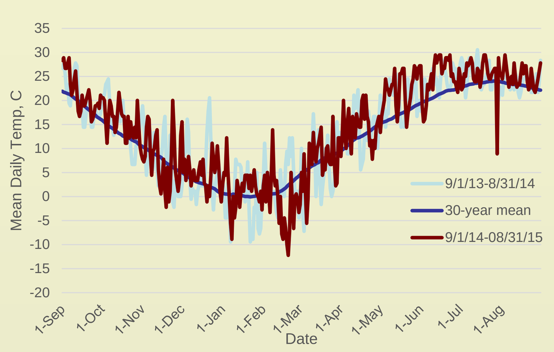
Year	Site Code	Cover Crop Mixture	Cover Crop Planting Date	Cover Crop Termination Date	Starter Fertilizer, kg N, P2O5, K2O ha-1	Corn Hybrid	Corn Planting Date	Corn Harvest Date
2014	1	Barley, forage radish and hairy vetch	10/4/2013	4/25/2014	101-54-161	Pioneer Brand P1498CHR	5/7/2014	8/29/2014
	2	Wheat, austrian winter pea and hairy vetch	10/25/2013	4/25/2014	90-0-0	Pioneer Brand P1498CHR	4/18/2014	9/16/2014
	3	Rye and forage radish	10/10/2013	5/5/2014	21-35-136	Pioneer Brand P1498CHR	5/1/2014	10/12/2014
	4	Barley and forage radish	9/7/2013	4/30/2014	45-77-119	NK-74R	5/3/2014	10/23/2014
	5	Barley, crimson clover and forage radish	10/10/2013	5/12/2014	90-93-95	DynaGro D54DC94	5/14/2014	10/25/2014
2015	6	Rye and hairy vetch	9/17/2014	5/5/2015	116-44-121	Pioneer Brand P2088AMX	5/12/2015	9/4/2015
	7	Barley and hairy vetch	10/16/2014	4/13/2015	90-45-67	Pioneer Brand P1498AMX	4/17/2015	10/11/2015
	8	Barley and crimson clover	10/22/2014	5/5/2015	28-44-101	Pioneer Brand P1105AM	5/11/2015	10/26/2015
	9	Barley and hairy vetch	10/7/2014	4/10/2015	38-90-98	NK-74R	4/25/2015	10/14/2015
	10	Barley and austrian winter pea	3/18/2015	6/4/2015	90-93-95	DynaGro D54DC94	6/4/2015	11/18/2015

2013-14 and 2014-15 Temperatures

Sites - 1,3,4,5

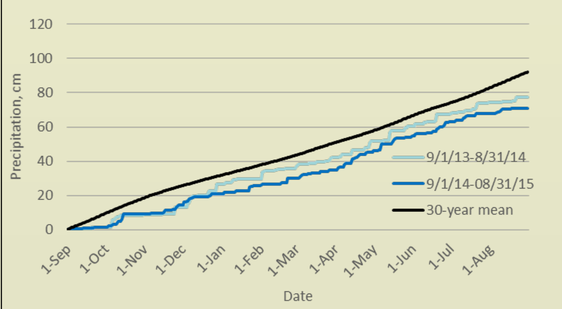


Site 2

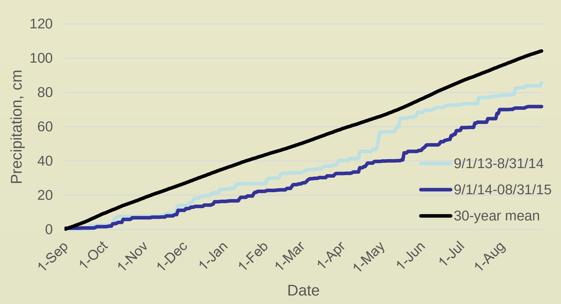


2013-14 and 2014-15 Precipitation

Sites - 1,3,4,5



Site 2

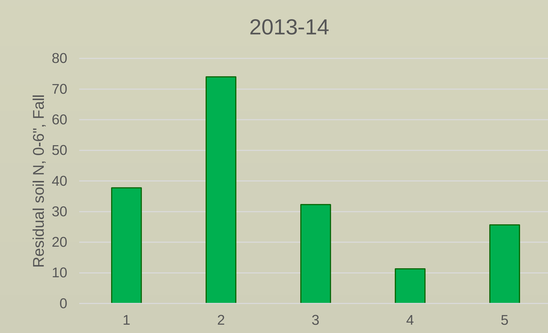


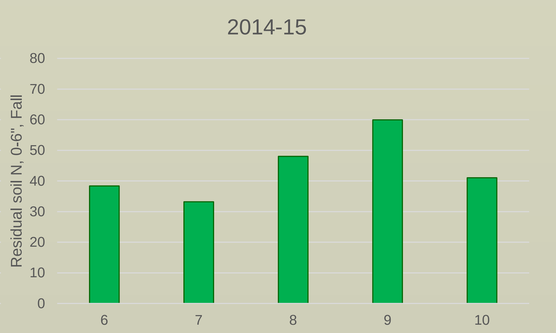
Initial Fall Soil Chemical Parameters

Site	pH†	P‡	K	Ca	Mg	Zn	Mn	Cu	Fe	B	CEC
			----------	----------	----------	mg kg^{-1}	----------	----------	----------		meq 100g^{-1}
1	6.8	94	78	1569	145	8.1	17.1	1.3	3.0	1.2	9.3
2	6.3	219	124	1344	103	2.0	16.8	0.9	37.0	0.4	8.0
3	6.7	105	146	2087	220	12.5	27.5	1.5	6.2	1.2	9.3
4	7.2	44	146	908	108	6.3	15.6	1.3	9.4	0.4	12.6
5	6.0	93	178	1518	126	7.3	25.3	2.0	5.0	0.8	7.0
6	7.0	79	141	1343	163	8.0	15.5	1.4	4.5	1.1	8.4
7	6.6	25	136	996	37	1.8	20.6	1.3	38.9	0.3	5.8
8	6.4	93	225	1205	115	7.5	15.8	2.2	6.0	0.7	7.8
9	6.2	91	106	1167	141	5.7	8.3	3.5	6.2	0.5	8.5
10	6.2	58	135	793	105	4.7	8.9	1.5	7.2	0.3	6.2

†pH: 1:1 Soil: Water
‡: Mehlich III extraction

Residual Fall N





Results

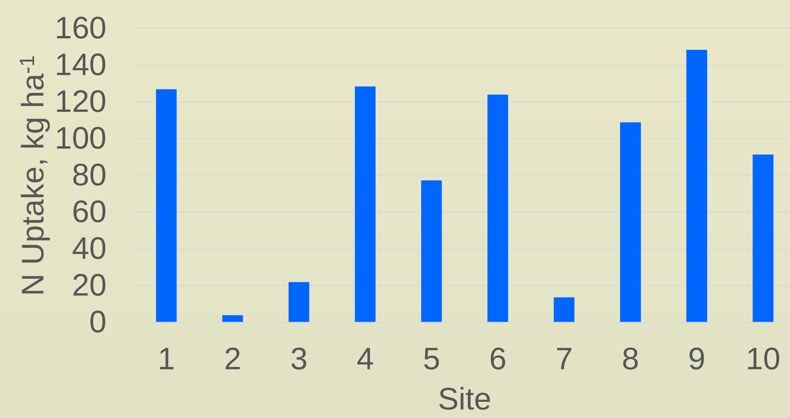
Early winter cover crop biomass, N uptake, and CN ratio, 2014-15

Site	Cover Crop Biomass	Cover Crop N Uptake	Cover Crop C:N Ratio
	---------kg ha^{-1}---------		
6	970	65.0	10.4
7	829	41.2	15.4
8	99	6.0	10.2
9	934	70.2	9.5

Spring cover crop biomass and CN ratio

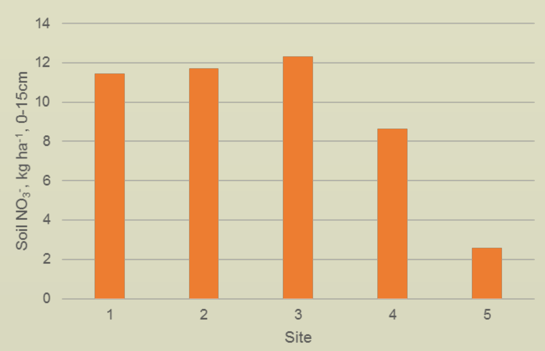
Site	Cover Crop Biomass kg ha^{-1}	Cover Crop C:N Ratio
1	1668	10.2
2	90	16.2
3	700	24.4
4	3891	23.9
5	1449	14.1
6	3800	24.3
7	387	22.4
8	3201	23.8
9	2832	15.9
10	2920	23.2

Cover crop N uptake, spring termination

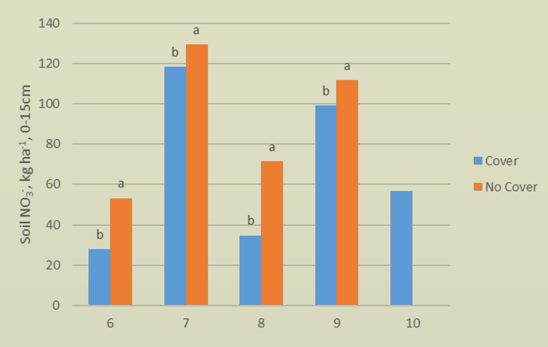


Residual soil nitrate-N, spring

2014



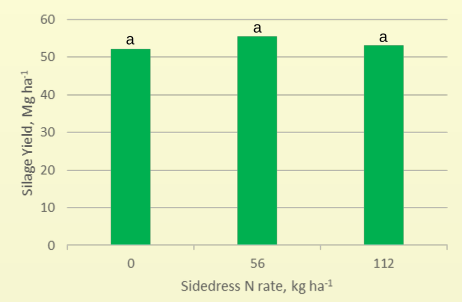
2015



Results (cont.)

Corn silage yield

Site 1

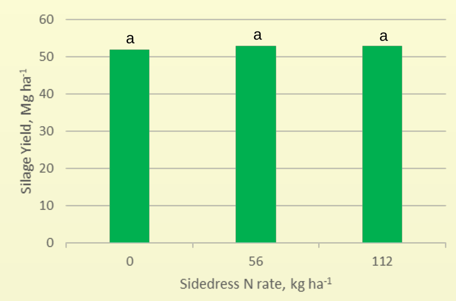


Baseline N†, kg ha^{-1}	188
PSNT, mg kg^{-1}	14
Cover DM, kg ha^{-1}	3384
Cover C:N ratio	10.2
Cover N up, kg ha^{-1}	127

† - sum of PAN from manure and preplant N

Columns labeled with similar letters are not different, p<0.10

Site 6

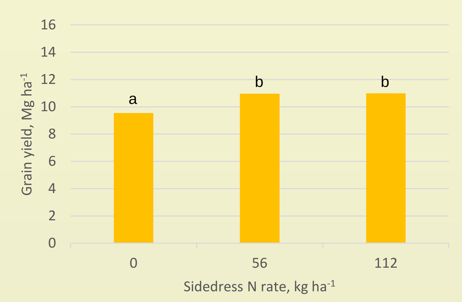


Baseline N†, kg ha^{-1}	183
PSNT, mg kg^{-1}	81
Cover DM, kg ha^{-1}	7741
Cover C:N ratio	10.2
Cover N up, kg ha^{-1}	124

† - sum of PAN from manure and preplant N

Corn grain yield

Site 2



Baseline N†, kg ha^{-1}	56
PSNT, mg kg^{-1}	16
Cover DM, kg ha^{-1}	179
Cover C:N ratio	16.2
Cover N up, kg ha^{-1}	4

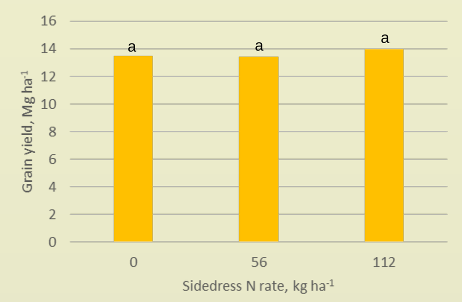
† - sum of PAN from manure and preplant N

Site 7

Baseline N†, kg ha^{-1}	34
PSNT, mg kg^{-1}	14
Cover DM, kg ha^{-1}	788
Cover C:N ratio	22.4
Cover N up, kg ha^{-1}	14

† - sum of PAN from manure and preplant N

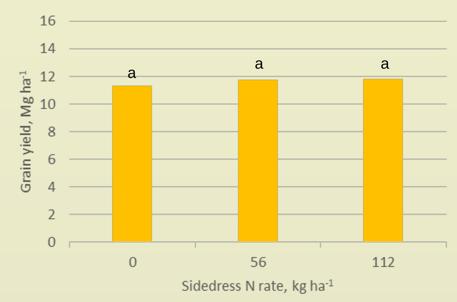
Site 3



Baseline N†, kg ha^{-1}	80
PSNT, mg kg^{-1}	32
Cover DM, kg ha^{-1}	1434
Cover C:N ratio	24.4
Cover N up, kg ha^{-1}	22

† - sum of PAN from manure and preplant N

Site 8



Baseline N†, kg ha^{-1}	73
PSNT, mg kg^{-1}	31
Cover DM, kg ha^{-1}	6522
Cover C:N ratio	23.8
Cover N up, kg ha^{-1}	109

† - sum of PAN from manure and preplant N

Site 4

Baseline N†, kg ha^{-1}	124
PSNT, mg kg^{-1}	20
Cover DM, kg ha^{-1}	36
Cover C:N ratio	24.4
Cover N up, kg ha^{-1}	129

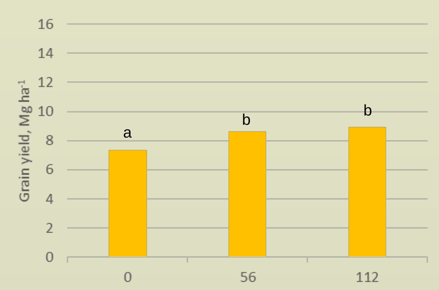
† - sum of PAN from manure and preplant N

Site 9

Baseline N†, kg ha^{-1}	67
PSNT, mg kg^{-1}	18
Cover DM, kg ha^{-1}	5770
Cover C:N ratio	15.9
Cover N up, kg ha^{-1}	148

† - sum of PAN from manure and preplant N

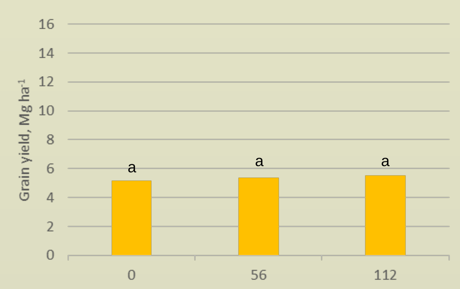
Site 5



Baseline N†, kg ha^{-1}	90
PSNT, mg kg^{-1}	31
Cover DM, kg ha^{-1}	2958
Cover C:N ratio	14.0
Cover N up, kg ha^{-1}	77

† - sum of PAN from manure and preplant N

Site 10



Baseline N†, kg ha^{-1}	90
PSNT, mg kg^{-1}	22
Cover DM, kg ha^{-1}	5949
Cover C:N ratio	23.2
Cover N up, kg ha^{-1}	91

† - sum of PAN from manure and preplant N

Conclusions

- Initial soil residual N in the fall varied from 12 to over 70 kg N ha^{-1} among sites, likely due to differences in soil and previous management.
- Winter and spring biomass varied among sites as well. This is likely due to differences in planting date, in the case of the winter measurements and differences in cover crop termination timing in the case of spring measurements.
- Cover crop N uptake mirrored dry matter accumulation
- Cover crop C:N ratio was affected by timing of cover crop termination with earlier termination resulting in more narrow ratios.
- Soil residual nitrate-N prior to corn planting was significantly reduced at all sites when cover crops were planted
- A sidedress N response was observed at five of ten experimental sites.
- Sites with high levels of baseline N (estimated PAN from previous manure application and preplant N) and with high PSNT values (>30) were typically, and predictably nonresponsive to sidedress N.
- Cover crops can contribute toward current season corn N need, but mineralization is dependent on weather and cover crop composition.