Soil Nitrogen Tests for No-Till Corn Following Winter Cover Crops in the Mid-Atlantic Coastal Plain

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METHODS

- This study was conducted at four different locations from fall 2012 through fall 2013 in the Virginia coastal plain region in USDA hardiness zone 7b. Average annual temperature of the region is 14.5° C and precipitation is 106 cm yr^{-1}. All sites are in no-till corn–winter wheat–double-crop soybean rotation. All sites were planted with winter cover crops following double-crop soybeans either by intereseeeding into the soybean canopy or planted shortly after soybean harvest.
- The experimental sites employ a split plot design with four replications at each location. Main plots were winter rye (94 kg ha^{-1}), hairy vetch (24 kg ha^{-1}), and winter rye-hairy vetch mixture (63 kg ha^{-1} + 18 kg ha^{-1}) winter cover crops planted following double-crop soybeans. Subplots are ten fertilizer N rate combinations applied as liquid urea ammonium nitrate (UAN) dribble banded. Fertilizer N combinations were 2 starter N rates (0 or 45 kg N ha^{-1}) applied at planting and 5 sidedress N rates (0, 45, 90, 135, and 180 kg N ha^{-1}) applied at corn growth stage V5. Main plots were approximately 75 x 15 m; subplots were 9.1 m by 4 rows (3.1 m). Corn was planted using a no-till planter into winter cover crop residues at 76 cm row spacing.
- Soil samples were collected at corn planting and at corn growth stage V4-V5 from 0-15 cm depth and analyzed with the Solvita® CO_2-Burst Test (Haney, et al., 2008b), 28-day aerobic incubation (Haney, et al., 2008b), and according to PSNT methods used in Virginia (Evanylo and Alley, 1997). Soil samples were oven dried at 40° C for Solvita® CO_2-Burst test and 28-day incubation or air dried for PSNT. Dried soil samples were hand processed to pass a 2 mm sieve. Soil subsamples were analyzed according to Solvita® CO_2-Burst test packaged instructions. Soil subsamples from depths 0-15 and 0-30 cm taken at preplant and at corn GS V4-V5 to provide PPNT and PSNT values for comparison, respectively. These subsamples were extracted with 2 M KCL (Bremner and Keeney, 1966) and analyzed for NH_4^+ (Nelson, 1983) and NO_3^- (Dorich and Nelson, 1984; Keeney and Nelson, 1982) using automated flow injection analysis (Hofer, 2001; Knepel, 2003). Duplicate soil subsamples were brought to 50% water-filled pore space as outlined by Franzluebbers (1999) and incubated for 28-days at 25° C ± 1° C. After 28-day aerobic incubation soil samples were dried at 40° C, extracted with 2 M KCL, and analyzed for NH_4-N and NO_3-N as mentioned previously. Differences between pre- and post-incubation inorganic N are considered net N mineralization.
- Corn was harvested from the center two rows of each plot with a small plot combine, and grain yield, grain moisture, and test weight determined using a Graingage™ system (Juniper Systems, Logan, UT). Grain yields from all trials are reported 155g kg^{-1} moisture content.
- Means and variance were analyzed using the General Linear Model (GLM) procedure of the Statistical Analysis System (SAS) (SAS Institute, 2008). A protected Least Significant Difference (LSD) procedure with a probability level of 0.05 was used to determine significant differences between treatment means. Yield response to sidedress N rate was evaluated via regression and single degree of freedom contrasts for linear and quadratic trends.

Abstract

Environmental and economic goals have encouraged the use of soil nitrogen (N) tests to improve fertilizer N management in corn (*Zea mays* L.). However, many producers still rely on expected yields for fertilizer N management instead of in-season soil N tests. Recent attention has been given to the Solvita® CO_2-Burst test as a tool to predict the soils inherent net mineralizable N potential. Our objective is to evaluate the efficacy of this, and other soil-based tests in a typical crop rotation in the mid-Atlantic coastal plain that includes winter cover crops (WCC). Winter cover crop effect on presidedress nitrate test (PSNT) soil N test was highly significant (P<0.001) for V5 sampling period. Winter CC affected grain yield at one site where high cover crop biomass levels were observed. Cover crop treatment did not result in differences in preplant soil test N (any method). However at V5, differences in soil test N levels due to cover crop were observed at total inorganic N at 0-15 cm and nitrate at 0-15 and 0-30 cm. Winter cover crop did not affect the values for the preplant or V5 Solvita® CO_2-Burst test or 28 day aeriobic incubation test. The Solvita® CO_2-Burst test digital number and 28-d net N mineralization were not strongly correlated at either preplant or V5.

Table 1. Initial surface (0-15cm) routine soil test characteristics and soil classification for experimental locations.

Site	pH[a]	NO_3-N[b]	NH_4-N[b]	P[c]	K[c]	Total N[d]	Organic C[d]	Soil Organic Matter[e]	Surface Bulk Density
		-------------mg kg^{-1}-------------				----------g kg^{-1}----------			g cm^{-3}
BRM	6.7	5.4	3.9	48.5	169	0.92	9.3	17.8	1.4
Soil Classification:	Berthera/Daleville association (fine, mixed, semiactive, thermic Typic Paleaquult)								
CCM	6.3	3.4	5.2	17.3	107	0.91	10.5	17.5	1.3
Soil Classification:	Suffolk fine sandy loam (fine-loamy, siliceous, semiactive, thermic Typic Hapludult)								
JBE	6.0	4.2	4.6	11.8	116	0.94	9.1	15.8	1.4
Soil Classification:	Kempsville sandy loam (fine-loamy, siliceous, subactive, thermic Typic Hapludult)								
PDE	6.1	2.9	3.4	15.0	135	1.1	9.9	18.5	1.3
Soil Classification:	Kempsville sandy loam (fine-loamy, siliceous, subactive, thermic Typic Hapludult)								

[a] pH: 1:1 soil:water.
[b] NH_4-N and NO_3-N: 2 M KCL; automated flow injection analysis
[c] P and K: Mehlich I.
[d] Organic C and total N: dry combustion.
[e] Soil Organic Matter: Walkley-Black method.

Table 2. WCC and soil N values at WCC termination, corn planting, and corn growth stage V5

Site	WCC TRT	WCC DM	WCC N Content	WCC C:N	Preplant NH_4-N & NO_3-N		V5 NH_4-N & NO_3-N		V5 NO^3-N		Preplant Net N Min	V5 Net N Min
		----------Kg ha^{-1}----------			------------------------mg N kg^{-1}------------------------							
					0-15 cm	0-30 cm	0-15 cm	0-30 cm	0-15 cm	0-30cm	0-15 cm	0-15 cm
BRM	Rye	6253	39	63	4.1	5.3	6.8	6.6	4.0	4.4	35.2	28.4
BRM	RV Mix	2999	84	16	8.7	9.6	12.3	16.1	8.5	10.6	35.6	26.1
BRM	Vetch	5087	146	14	6.9	8.8	15.0	12.0	10.9	9.6	37.3	35.3
CCM	Rye	778	14	22	2.7	4.9	11.5	7.6	6.9	4.3	30.1	27.4
CCM	RV Mix	922	19	19	1.7	3.3	9.8	10.3	6.3	5.8	33.9	24.4
CCM	Vetch	635	23	10	4.8	5.8	13.5	9.8	8.3	6.3	24.1	24.7
JBE	Rye	1532	21	27	9.8	17.0	13.8	12.5	8.3	7.3	38.2	20.1
JBE	RV Mix	1338	18	28	18.3	28.4	15.6	11.0	10.0	6.4	22.8	23.5
JBE	Vetch	1101	48	9	8.7	17.4	18.6	13.3	12.9	9.1	38.7	20.5
PDE	Rye	858	13	25	9.3	11.7	12.4	12.6	7.5	7.6	42.8	35.8
PDE	RV Mix	743	18	16	13.2	17.8	13.0	12.6	7.7	7.6	37.6	25.2
PDE	Vetch	632	22	10	5.4	16.0	14.3	13.1	9.8	8.8	45.1	32.0
AVG	Rye	2355	22	34	6.5	9.7	11.1	9.8	6.7	5.9	36.6	27.9
AVG	RV Mix	1500	35	20	10.5	14.8	12.7	12.5	8.1	7.6	32.5	24.8
AVG	Vetch	1864	60	11	6.4	12.0	15.4	12.0	10.5	8.4	36.3	28.1

Table 3: ANOVA table for corn yield response

Site	BRM		CCM		JBE		PDE	
Preplant N Rate	0	45	0	45	0	45	0	45
Source	--------------------Pr>F--------------------							
WCC	**	**	*	ns	ns	ns	ns	ns
Sidedress N	**	**	**	**	**	**	**	**
WCC*Sidedress N	ns	ns	ns	ns	*	ns	ns	ns

*, ** - significant at P<0.05 and 0.01, respectively
ns – not significant

Table 4: Linear and Quadratic Orthogonal Contrasts for WCC Effects

Site	BRM		CCM		JBE		PDE	
Preplant N Rate	0	45	0	45	0	45	0	45
Contrasts	--------------------Pr>F--------------------							
Rye Linear	**	**	**	**	**	**	**	**
Rye Quadratic	ns	*	ns	**	*	ns	ns	ns
RV Mix Linear	**	**	**	**	**	**	**	**
RV MixQuadratic	ns	ns	**	**	ns	ns	*	ns
Vetch Linear	**	**	**	**	**	**	**	*
Vetch Quadratic	ns	**	*	**	*	*	ns	**

*, ** - significant at P<0.05 and 0.01, respectively
ns - not significant

Table 5: Regression equations for best fit models of WCC treatments by site and preplant N

Site	Preplant N	WCC Treatment: Rye	RV Mix	Vetch
BRM	0	y= 0.0353x+3.7294	y= 0.0267x+6.6936	y= 0.0167x+10.018
	45	y = -9E-05x² + 0.0451x + 5.1582	y = 0.0241x + 7.487	y = -6E-05x² + 0.0326x + 10.167
CCM	0	y = 0.033x + 5.7327	y = -0.0001x² + 0.0482x + 6.4939	y = -7E-05x² + 0.0511x + 5.5671
	45	y = -0.0002x² + 0.0552x + 6.6869	y = -0.0002x² + 0.06x + 7.0647	y = -5E-05x² + 0.0327x + 7.9703
JBE	0	y = -0.0002x² + 0.0717x + 4.6347	y = 0.0384x + 6.5129	y = -7E-05x² + 0.0329x + 8.0533
	45	y = 0.0323x + 7.6192	y = 0.0209x + 9.3924	y = -0.0002x² + 0.0647x + 8.2078
PDE	0	y = -0.0002x2 + 0.0543x + 6.1046	y = 0.0207x + 7.5108	y = -6E-05x2 + 0.0293x + 7.2257
	45	y = -0.0001x² + 0.049x + 6.8135	y = -6E-05x² + 0.0226x + 8.4384	y = -7E-05x² + 0.0268x + 8.3544

Table 6: Analysis of variance of WCC effects on preplant and V5 soil N

	NH_4-N & NO_3-N		NO_3-N		Net N Min	Solvita Digital Number	Solvita CO2 ppm
Depth	0-15 cm	0-30 cm	0-15 cm	0-30 cm	0-15 cm	0-15 cm	0-15 cm
Preplant							
	--------------------Pr>F--------------------						
Source							
WCC	ns	ns	na	na	ns	ns	ns
LOC	*	**	na	na	ns	*	*
LOC*WCC	ns	ns	na	na	ns	ns	ns
V5							
	--------------------Pr>F--------------------						
Source							
WCC	*	ns	**	*	ns	ns	ns
LOC	*	ns	*	*	*	**	**
LOC*WCC	ns	ns	ns	*	ns	ns	ns

*, ** - significant at P<0.05 and 0.01, respectively
ns – not significant; na- not applicable

Table 7: Average Soil Test N Values at preplant and V5

WCC TRT	Preplant NH_4-N & NO_3-N		V5 NH_4-N & NO_3-N		V5 NO^3-N		Preplant Net N Min	V5 Net N Min	Preplant Solvita		V5 Solvita	
	----------mg N kg^{-1}----------								Digital Number	CO2 ppm	Digital Number	CO2 ppm
Depth	0-15 cm	0-30 cm	0-15 cm	0-30 cm	0-15 cm	0-30 cm	0-15 cm	0-15 cm	0-15 cm	0-15 cm	0-15 cm	0-15 cm
Rye	7	10	11	10	7	6	37	28	2.4	17.5	2.3	15.1
RV Mix	11	15	13	13	8	8	33	25	2.5	18.8	2.2	14.4
Vetch	6	12	15	12	11	8	36	28	2.4	16.3	2.2	14.8

Figure 1: Corn Grain Yield Response to Fertilizer Nitrogen Rate And Winter Cover Crops

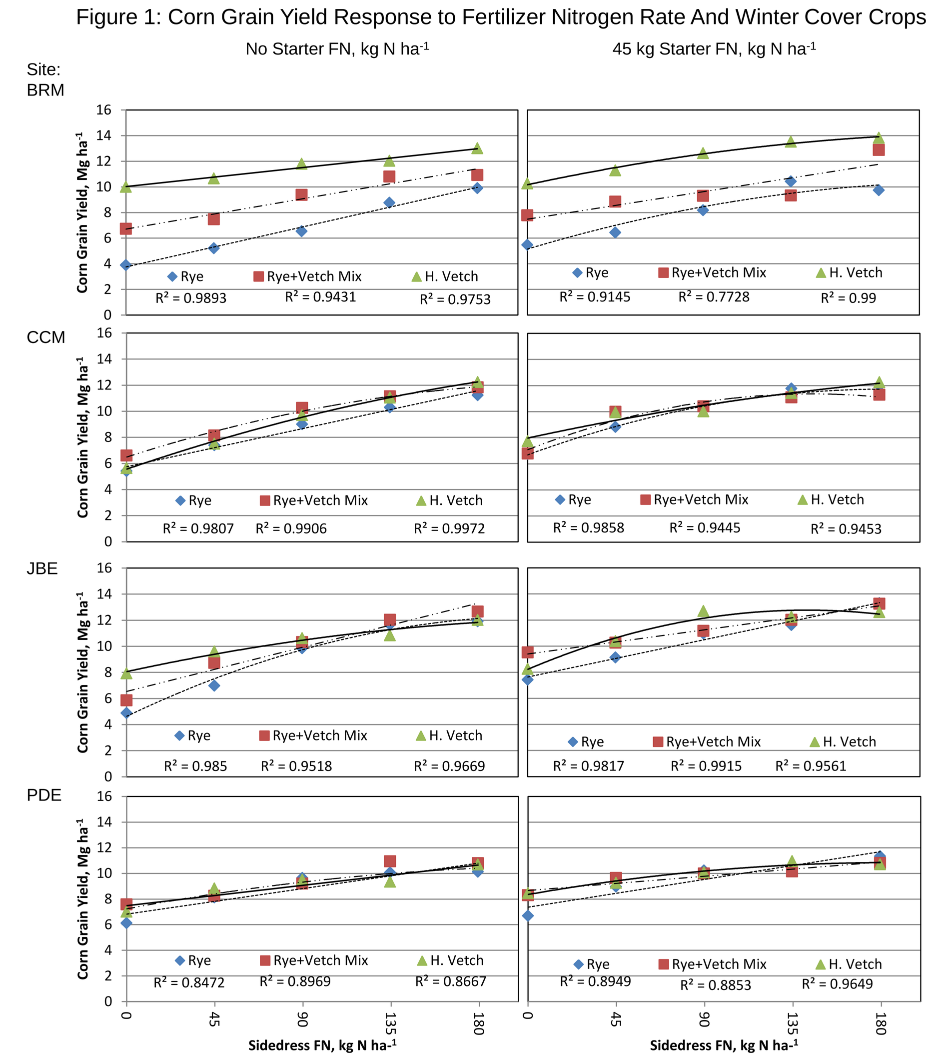
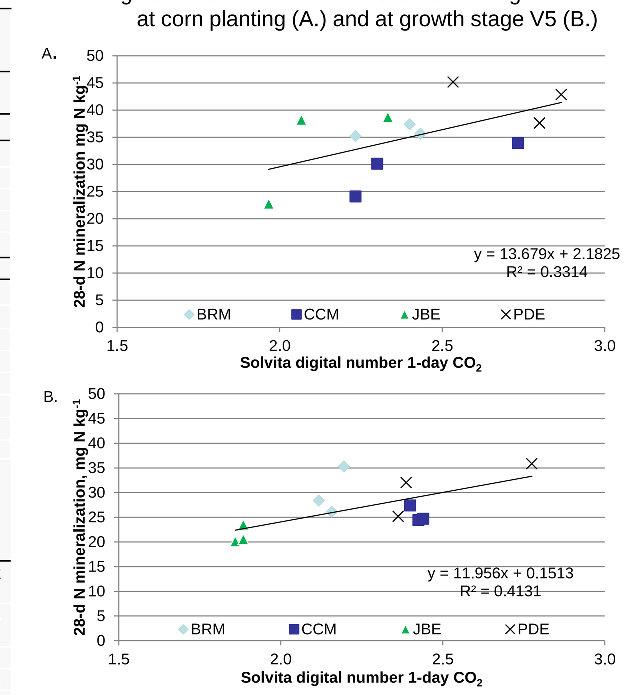
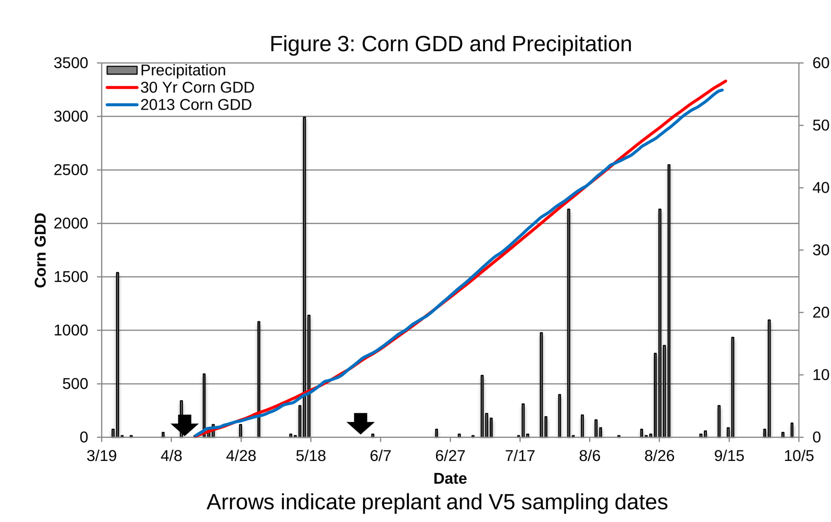


Figure 2: 28-d Net N Min versus Solvita Digital Number at corn planting (A.) and at growth stage V5 (B.)





Arrows indicate preplant and V5 sampling dates

PRELIMINARY RESULTS

- Mean temperature and corn GDD at experiment sites were near the 30 year average throughout the corn growing season. Precipitation was approximately 300 mm above 30 year average (Figure 3).
- Initial soil parameters indicate similar soil characteristics at all sites (Table 1).
- WCC DM biomass was highest at BRM due to its late termination. This also led to later corn planting. WCC biomass was similar across the other sites (Table 2)
- Corn grain yield response to WCC was significant (P<0.05) at two of the four sites when zero preplant N was applied and at one of the four sites that received 45 kg N ha^{-1} preplant N (Table 3).
- Corn grain yield response to sidedress fertilizer N was highly significant (P<0.01) at all sites (Table 4).
- Interaction between WCC and Sidedress N was significant (P<0.05) at one of four sites (JBE, with no preplant N) (Table 4).
- PSNT values (V5) averaged 7.3 mg kg^{-1}, well below VA established critical value of 20 mg kg^{-1} NO_3-N in the 0-30 cm depth (Table 7).
- WCC effect on soil N tests were not significant (P<0.05) for preplant sampling period (Table 6).
- WCC effect on PSNT soil N test was highly significant (P<0.001) for V5 sampling period (Table 6).
- WCC effect on Solvita® CO_2 Burst test and 28-d Incubation was not significant (P<0.05) (Table 6).
- Solvita® values indicate "low" potential N mineralization of approximately 15-25 kg N ha^{-1} yr^{-1} (Table 7, interpretive data not provided).
- 28-d incubations resulted in net N mineralization of 35 and 27 kg N ha^{-1} from soils collected at preplant and at corn growth stage V5, respectively (Table 7).
- Solvita® CO_2 Burst test and the 28-day net N mineralization were not strongly correlated with R^2-values of 0.33 and 0.41 at preplant and corn growth stage V5 soil sampling dates, respectively (Figure 2).

CONCLUSIONS

- 2013 had very favorable growing conditions that resulted in above average corn grain yields.
- Winter cover crops did not affect any of the preplant soil N parameters tested but did affect surface soil N at V5 indicating that none of these methods would likely predict the effect of WCC on corn N need when samples are collected preplant.
- Since WCC effects on soil NO_3-N and inorganic N were detected via soil test methods, it may be possible to modify N sidedress N rate recommendations, but more research is needed.
- Since neither the 28-d Net N mineralization or the Solvita® CO_2 Burst Test detected effects of WCC at V5, it does not appear that these tests could be used to modify sidedress N rate recommendations based on WCC impacts.
- Correlations between the Solvita® CO_2-Burst Test and 28-d N mineralization were not strong as observed by other researchers at either sampling period. This may be due to the relatively low organic matter concentrations in these soils.