Soil Nitrogen and Carbon Management Project, Crop Year 2002

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Introduction:

An important component for predicting nitrogen (N) application needs (regardless of productivity level) is to estimate the soil capacity to supply plant-available N each year corn is grown. Differences in N supply between fields have been difficult to predict, and are often underestimated when N applications are made to production fields. In a general sense differences are incorporated into N recommendation systems (for example crop rotation effects). However, for improving prediction of corn N needs, and especially avoidance of over application and environmental consequences, knowing if and how much response may occur in a field is highly desirable. This would be particularly useful to producers if known ahead of preplant N applications. This is important in situations where little to no supplemental N is required, and where rates based solely on yield may direct more N application than the system needs.

Tests that measure soil nitrate as a means to estimate available N have been available for some time, such as the presidedress or late spring soil nitrate test. But producers desire alternative methods that are not based solely on nitrate, and that can be utilized before planting. An example of such a test would be one that estimates mineralization of specific soil organic-N fractions. It is also important to conduct research in high-yield environments (where corn uses large amounts of N) so concerns about limiting corn yield potential or negatively impacting soil can be documented or allayed.

Nitrogen management and cropping system history (tillage and crop rotation) have direct impacts on soil organic N and carbon (C) pools, and the tie between soil organic N and C. Soil organic C levels have important implications for organic N retention/release and carbon dioxide (CO_2) fluxes. Specific organic-N pools in soil can be an important source of plant-available N. Nitrogen availability in the soil environment also plays a significant role in determining soil C status, as it is an essential nutrient for microbial metabolism. Nitrogen availability, through influence on yield, will also affect the quantity and quality of plant residue available as a source of soil C. The integral tie between soil organic N and C should be incorporated into the study of crop N requirements and determination of impacts from historical N use, tillage, and crop rotation.

Soil C storage is a long-term process. However, short-term changes in soil C status due to N and soil management can be estimated by monitoring the impact of N and soil management on CO_2 flux. Long-term changes in soil C are indicators of soil potential for storing C and the impact of management on that potential. However, immediate relationships and short-term changes in soil C can be developed through changes in CO_2 emission by monitoring the impact of different N rates on CO_2 flux during the growing season. The maintenance of organic matter can help prevent soil degradation. Soil, as an open system, can play an important role in regulating greenhouse emissions to the atmosphere. Since changes in agricultural practices, like N use, can influence the soil organic C storage in, and greenhouse gas fluxes from soils, the net benefit due to changing agricultural practices needs to be considered.

Nitrogen use rate is an important consideration for soil C retention and potential nitrate movement to water systems. If farmer use practices are not consistent with recommended N and C management practices, then work as proposed in this project could help farmers predict appropriate field-specific N rates and C management practices. With demonstrations being conducted locally and availability of tools for individual site assessment, then producer confidence should improve that productivity can be maintained if a production practice is changed.

Basis for the Illinois Soil N Test

Study of organic soil N forms has often utilized a chemical fractionation procedure based on liberation of N compounds by heating soil with strong acid for 12 to 24 hours. This process is called acid hydrolysis. The N forms are separated by various analysis procedures into the following fractions: acid insoluble-N, ammonia-N, amino acid-N, amino sugar-N, and hydrolyzable unknown-N. Recent research by Mulvaney and Khan at the University of Illinois (published in 2001) documented a flaw in the conventional procedure used for determining the amino acid and amino sugar fractions. In particular, the amino-sugar fraction has been underestimated in past fractionation work. This has likely caused an underestimation of the effects of cropping, tillage, rotation, and N management on the amino sugar level in soils. Especially pertinent to predicting crop responsiveness to applied N, the hydrolyzable amino sugar-N fraction has not previously been shown to be sensitive to these differences. Hence, the amino sugar fraction has not been well correlated to crop N responsiveness or predictive of nonresponse.

Amino sugars in soils are generally assumed to be of microbial origin. While the amino sugar-N fraction is a labile source of soil N, it should be more stable than an inorganic form such as nitrate.

The University of Illinois researchers developed a diffusion procedure for analysis of soil hydrolysates that improved accuracy and specificity in determination of the amino sugar and other organic N fractions. Using soil samples (mid-March to mid-April, 0-12 inch depth before planting) and corn yield response data from eighteen previous field research sites in Illinois, they found that the newly developed diffusion analysis procedure resulted in the amino sugar-N fraction being predictive if a site would respond to applied N (correctly categorized all tested sites as either responsive or nonresponsive – most importantly those that previously could not be by other tests). They also found the amino sugar-N fraction was related to the relative magnitude of corn yield increase to applied N at responsive sites. Since the acid hydrolysis and fractionation procedure requires at least 12 hours of complicated laboratory work, the researchers developed a simple and rapid soil test procedure designed for use in routine laboratory analysis (the Illinois Soil N Test). The Illinois Soil N Test measures N liberated from soil organic-N compounds (assumed to be amino sugar-N) and exchangeable ammonium-N during direct soil diffusion for five hours at 48-50ºC with 2 *M* sodium hydroxide. The test does not measure nitrate-N, but does include exchangeable ammonium-N. Development work at the University of Illinois indicated correct classification of 25 Illinois soils (0-12 inch depth) as corn-N responsive if the Illinois Soil N Test was <225 mg kg^{-1} and nonresponsive if the test was >235 mg kg^{-1}. Test results are expected to be higher with 0-6 inch depth samples.

Objectives:

The objectives of this project are twofold. One is to demonstrate corn N fertilization needs and the short- and long-term N–C relationships across diverse soils, productivity, and crop management systems. The second is to demonstrate the potential of the new soil N test, the Illinois Soil N Test (based on a readily mineralizable organic-N fraction – amino sugar-N) as a predictor of soil N supply, corn response to applied N, and for adjustment of corn N fertilization.

Field Demonstration Description:

The strategy for this project is to conduct on-farm field demonstrations with concurrent data collection at approximately ten field sites yearly that encompass a range of soil characteristics, tillage, yield potentials, and N use and N source histories. A history of N application, manure use, tillage, rotation, and crop yield for each site is obtained from the cooperating producer.

Multiple rates of N are applied shortly after corn planting in replicated treatments. Application areas reflect standard field protocols and producer equipment. Normal producer crop management practices are used for the geographic area the site represents (such as tillage, adapted hybrids and pest control). Producers apply no N to the demonstration site. Soil pH and other soil nutrients are maintained by application of lime and fertilizers as needed.

Multiple sampling and analyses are conducted to measure site characteristics and N responsiveness: routine soil tests, soil N tests, plant N status, corn grain yield, soybean plant dry matter, and soybean grain yield. Additional soil samples from various depths in the fall, spring, and sidedress are collected to determine the potential viability and sampling protocol of the new Illinois Soil N Test. Soil is sampled by depth increments before N application to measure soil organic and inorganic C, to measure particulate organic matter, and to provide baseline soil C and estimated bulk density. Carbon dioxide flux is monitored at selected sites and selected N rates during the growing season, after harvest, and in the following soybean crop. After harvest plant residue is collected and analyzed for total N and C.

Field Activity:

This project began in the spring of 2001. The field sites for 2001 and 2002 were chosen based on criteria of corn after soybean, no manure or primary fertilizer N applied in the fall or spring of the current crop year, and a conservation tillage or no-tillage system. Cooperators were asked not to apply N or manure to the area designated for the demonstration site. All other field activities are completed as normal by the cooperator.

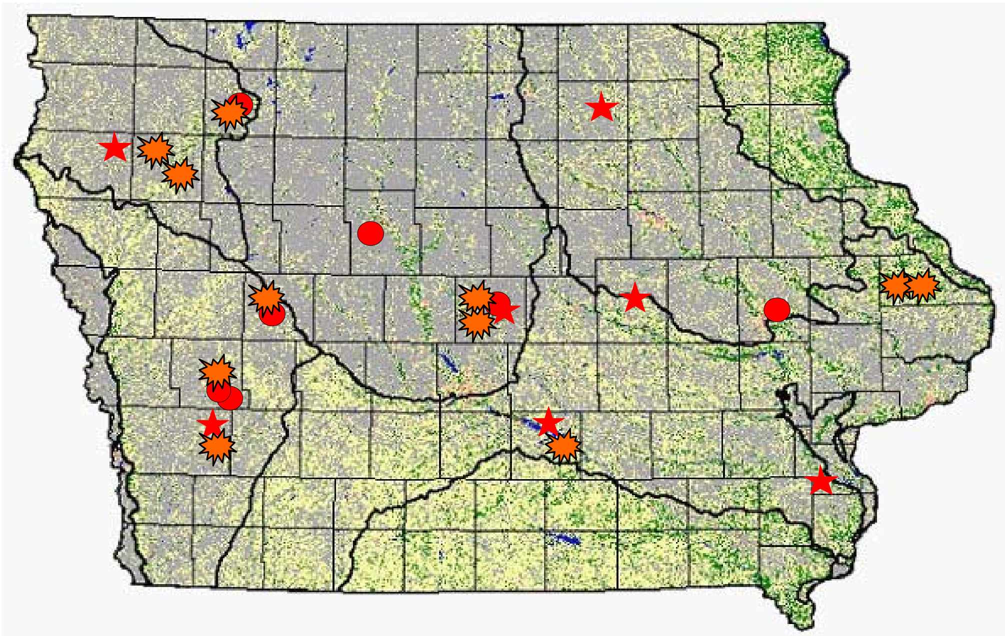
Fourteen sites were located for the project in 2001 and eleven sites in 2002 (Table 1). Seven of the fourteen sites in 2001 were identified for multi-year soil C sampling and analysis (Figure 1).

Table 1. Site characteristics, management, and prior crop yield history, 2001 and 2002 project sites.

County-Site	Soil	Tillage†	Yield History‡ Corn	Yield History‡ Soybean	N History§	Manure History
			- - - bu/acre - - -		lb N/acre	
2001						
Boone-N	Canisteo	Conservation Tillage	153	45	140	None
Boone-S	Clarion	Conservation Tillage	153	45	140	None
Carroll	Marshall	Conservation Tillage	138	41	132	Finishing Swine – last applied 1996
Clay	Nicollet	Conservation Tillage	152	52	130	None
Floyd	Clyde	Conservation Tillage	165	54	140	None
Linn	Kenyon	Conservation Tillage	160	57	150	Solid Beef – last applied 1999
Louisa	Mahaska, Otley	Conservation Tillage	159	52	135	None
Plymouth	Galva	Conservation Tillage	156	49	130	None
Pottawattamie	Marshall	No-Tillage	165	54	150	None
Shelby-E	Marshall	Conservation Tillage	148	45	150	None
Shelby-W	Zook	Conservation Tillage	170	68	150	None
Tama	Tama, Garwin	Conservation Tillage	149	52	170	Dairy Pit – applied 1997, 1998, 1999, 2000
Warren	Nevin	No-Tillage	150	50	150	None
Webster	Webster	Conservation Tillage	169	54	175	None
2002						
Boone-P	Zenor, Spillville	Conservation Tillage	172	49	75	Finishing Swine – applied 1997, 1998, 2000, 2001
Boone-SN	Webster, Clarion	Conservation Tillage	-	-	125	None
Carroll	Marshall, Exira	No-Tillage	145	40	120	Finishing Swine – last applied 2000
Cherokee-O	Galva	Fall Strip Tillage	171	58	160	None
Cherokee-S	Galva	Conservation Tillage	150	51	100	Finishing Swine – applied 1996, 1998, 2000
Clay	Marcus	Conservation Tillage	163	52	115	None
Jackson-E	Downs	No-Tillage	152	53	100	None
Jackson-W	Downs	No-Tillage	159	53	100	Beef Feedlot – applied prior to 1990
Pottawattamie	Marshall	No-Tillage	173	58	133	None
Shelby	Marshall	Conservation Tillage	147	50	140	None
Warren	Macksburg	No-Tillage	-	-	-	None

† Tillage system for the current crop year.
‡ Yield history is average of last two to five crop years. In each project year corn followed soybean.
§ Nitrogen application history for the last two to three corn crops.

Figure 1. Demonstration sites in 2001 (circles and stars) and 2002. Stars indicate sites identified for multi-year C measurements.



These same seven sites were monitored in 2002 for soil C, soybean residue C, and soybean yield. All sites are used for corn N response and soil N testing. In 2001, the two sites in Shelby County were with the same producer, but had different soils and yield potentials. In 2001, the two sites in Boone County were in the same field and had the same management practices and history, but the sites were on different soils. In 2002, the two sites in Jackson County were on the same landscape position and soil, but had different manure histories. Field site information and cropping history is collected from each producer (Table 1).

Six rates of N (0 to 200 lb N/acre in 40 lb increments) are applied shortly after planting (from planting to V2 growth stage) as surface applied ammonium nitrate. The N rates are replicated four times. No other N is applied except for incidental N in starter or with phosphate fertilizer, which occurred at the Carroll (12 lb N/acre in starter) and Shelby-E (13 lb N/acre in diammonium phosphate) sites in 2001.

Each site is soil sampled for routine soil tests, soil N tests, and soil C and N. Soil test results for each site are listed in Table 2. Sampling for soil N tests includes fall, spring preplant, in-season, post-harvest, and weekly temporal at selected sites. Soil is collected at 0-6 inch and 0-12 inch depths. The Illinois Soil N Test is determined for each sampling and depth. Soil nitrate is determined for 0-1 and 1-2 foot depth soil samples collected in the spring before planting and for one-foot samples collected when corn is 6- to 12 inches tall (late spring soil nitrate test). At two to four contrasting N response sites, post-harvest four-foot profile soil samples are collected for residual nitrate from the 0 and 120 lb N/acre rates. Corn response to N is also monitored through leaf greenness using a Minolta® SPAD 502 chlorophyll meter at the R1 (silking) growth stage at all sites.

Table 2. Routine soil tests and soil N test data, 2001 and 2002 project sites.

Sites	STP[†]	STK[†]	pH[†]	O.M.[†]	LSNT[‡]	Illinois Soil N Test[§]
	- - - - ppm - - - -			%	- - - - - - ppm - - - - - -	
2001						
Boone-N	28	90	8.1	6.59	7	336
Boone-S	19	110	6.0	4.44	5	309
Carroll	44	272	6.5	4.00	6	290
Clay	43	174	7.0	5.51	13	345
Floyd	32	115	6.3	9.20	12	510
Linn	149	324	7.5	4.06	30	275
Louisa	43	292	6.3	3.96	4	273
Plymouth	63	354	7.1	5.11	5	344
Pottawattamie	29	246	7.5	4.18	9	272
Shelby-E	18	279	5.8	3.96	9	285
Shelby-W	162	420	7.1	4.14	8	278
Tama	49	190	7.9	3.68	6	220
Warren	25	209	6.5	3.88	3	276
Webster	29	140	6.1	5.44	10	330
2002						
Boone-P	183	308	6.3	4.05	12	297
Boone-SN	23	136	6.1	3.95	8	253
Carroll	110	379	6.2	4.45	10	319
Cherokee-O	22	166	6.4	4.75	11	314
Cherokee-S	46	208	5.9	4.88	12	336
Clay	27	196	6.5	6.28	11	448
Jackson-E	22	141	6.8	4.05	13	291
Jackson-W	202	383	7.4	4.78	17	289
Pottawattamie	33	239	7.2	4.05	22	276
Shelby	21	232	6.0	3.50	11	257
Warren	26	188	6.5	4.00	9	273

[†] Routine soil tests from 0-6 inch samples collected in the fall or spring prior to planting. Soil test P (STP) determined by Mehlich-3 P and soil test K (STK) determined by ammonium acetate.
[‡] Late spring soil nitrate test (LSNT) from 0-12 inch depth soil samples collected when corn was 6- to 12 inches tall from the no-N check (control) plots.
[§] Illinois soil N test from 0-12 inch depth soil samples collected in the spring prior to planting.

In order to monitor change in soil C throughout the project life, initial soil samples are collected at 0-2, 2-4, 4-6, 6-12, and 12-24 inch depths. Bulk density is determined at each depth and samples are analyzed for total N and C. Particulate organic matter (POM) is also determined at each site. After harvest, plant residue is collected, weighed, and analyzed for total N and C. At three sites (Boone-S, Floyd, and Warren) emission of CO_2 is monitored throughout the year with a Li-Cor 6400 CO_2 analyzer (Figure 2) at the 0, 80, 160,and 200 lb N/acre rates.

Figure 2. Carbon dioxide emission analysis, 2002.

Grain yield is determined for each N rate by hand harvest of measured areas, with yields adjusted to 15.5% grain moisture for corn and 13.0% for soybean. Seed protein, oil, and starch are determined by near-infrared spectroscopy (NIR) analysis. Soybean grain yield and aboveground plant dry matter is determined by harvesting plants from three rows, each three feet long, at physiological maturity.

As of this reporting date, not all soil and plant analyses have been completed and therefore are not reported.

Preliminary 2001 and 2002 Results:

Corn Response to Applied N

Corn grain yield level and yield increase from applied N varied considerably between sites (Table 3 and Figures 3 and 4). Site responsiveness to N was calculated as the maximum yield increase from applied N compared to the yield with the zero N rate, and expressed on a percent of the zero N rate yield (Table 3). Overall productivity was high both years (average maximum yield of 183 bu/acre), with the grain yield produced with no applied N quite large (average of 158 bu/acre). The Pottawattamie site in 2002 had low yield due to low summer rainfall. These results document that with the right conditions, Iowa soils have the capacity to supply large quantities of plant-available N. The measured range in site responsiveness was hoped for the project as this provides a good data set for evaluation of soil N supply, and for this demonstration project evaluation of the Illinois Soil N Test.

An economic N rate estimate from fitted response curves to applied N at each site (an economic break-even rate at a corn to N price ratio of 10:1) indicates a wide range in economic rates (Table 3 and Figures 3 and 4), with five sites having essentially an economic rate of zero lb N/acre and seven sites greater than 100 lb N/acre. All sites had an economic rate less than 150 lb N/acre. Generally the need for applied fertilizer N was not high. This can change substantially between years. At all sites corn was rotated after soybean, which moderates N response. The calculated economic rate is less than the rate to produce maximal yield increase from applied N (Table 3). The overall response to the applied N and shape of the fitted response equation determines the magnitude of difference between the maximal response and economic rate. At some sites where overall yield increase from applied N was low, this difference in rates is large (Carroll, Floyd, Shelby-E, Shelby-W, and Tama sites in 2001 as examples). A reason for this is that the magnitude of yield increase to pay for fertilizer N is small (the yield response slope across N rates is low); therefore the economic rate is quite lower than the maximal rate.

Table 3. Corn grain yield response to applied N, 2001 and 2002.

Site	No-N Check Yield[†]	Economic Response[‡] N Rate	Economic Response[‡] Yield	Maximal Response[§] N Rate	Maximal Response[§] Yield	Yield Increase[¶]
	bu/acre	lb N/acre	bu/acre	lb N/acre	bu/acre	%
2001						
Boone-N	149	36	172	39	173	16.2
Boone-S	148	103	167	163	170	15.5
Carroll	160	0	158	174	165	3.3
Clay	118	137	181	157	182	54.6
Floyd	158	3	161	169	170	7.6
Linn	200	47	211	65	212	5.8
Louisa	126	73	181	79	181	43.7
Plymouth	150	143	174	200	178	19.0
Pottawattamie	167	31	176	39	176	5.7
Shelby-E	166	0	168	200	177	6.6
Shelby-W	182	38	185	162	191	5.0
Tama	150	38	159	184	166	10.5
Warren	137	102	208	111	209	52.2
Webster	140	82	165	105	166	18.7
2002						
Boone-P	221	0	221	0	221	0.0
Boone-SN	138	148	177	196	179	30.2
Carroll	171	86	188	120	190	10.9
Cherokee-O	174	76	200	91	201	15.6
Cherokee-S	137	102	178	118	179	30.3
Clay	160	73	189	86	189	18.0
Jackson-E	174	58	216	62	216	24.4
Jackson-W	217	0	217	0	217	0.0
Pottawattamie	53	96	67	152	70	32.9
Shelby	168	82	190	110	191	14.0
Warren	181	133	239	153	240	32.8

[†] Yield with no applied N.

[‡] Economic N rate and yield at economic rate calculated at a break-even 10:1 corn:nitrogen price ratio (example $2.00/bu corn and $0.20/lb N).

[§] Nitrogen rate and yield at maximum response to applied N from the fitted response equation.

[¶] The percent yield increase from applied N at the maximal response above the no-N check.

Note: Carroll 2001 site had 12 lb N/acre applied at corn planting with starter. Shelby-E 2001 site had 13 lb N/acre applied as DAP.

Figure 3. Corn grain yield response to applied N at each demonstration site, 2001 (economic N rate calculated at a break-even 10:1 corn:nitrogen price ratio).

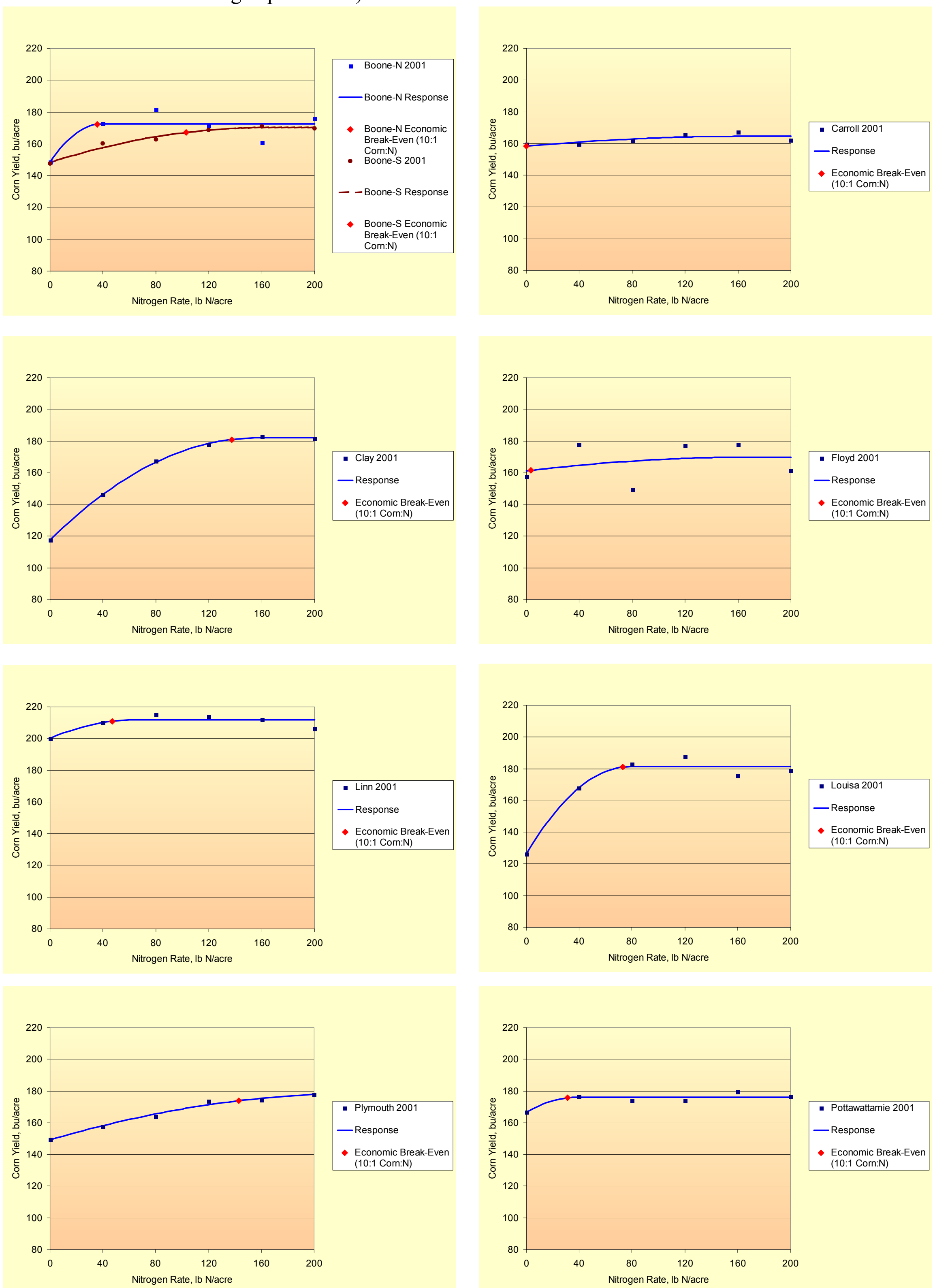


Figure 3 continued. Corn grain yield response to applied N at each demonstration site, 2001 (economic N rate calculated at a break-even 10:1 corn:nitrogen price ratio).

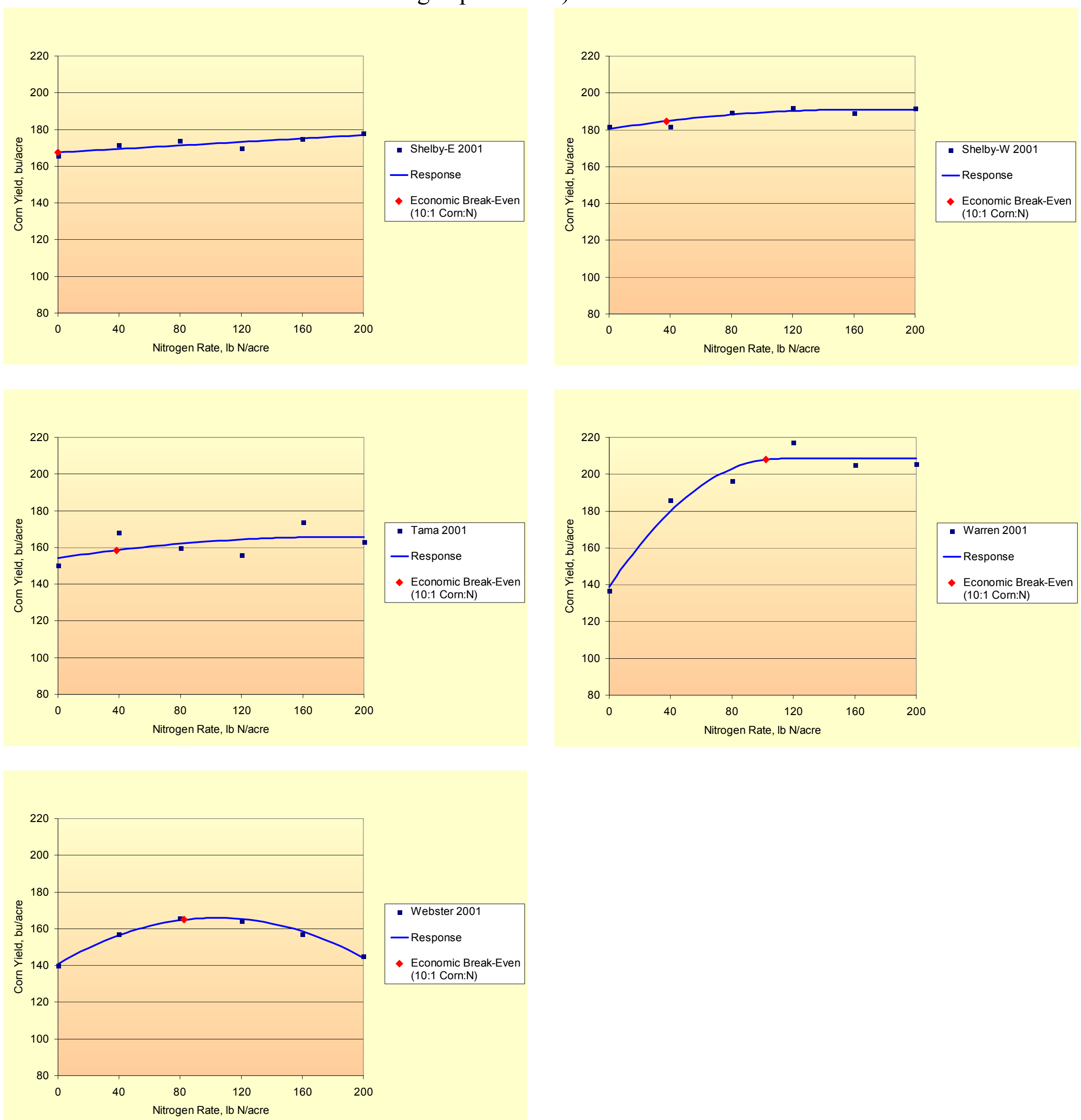


Figure 4. Corn grain yield response to applied N at each demonstration site, 2002 (economic N rate calculated at a break-even 10:1 corn:nitrogen price ratio).

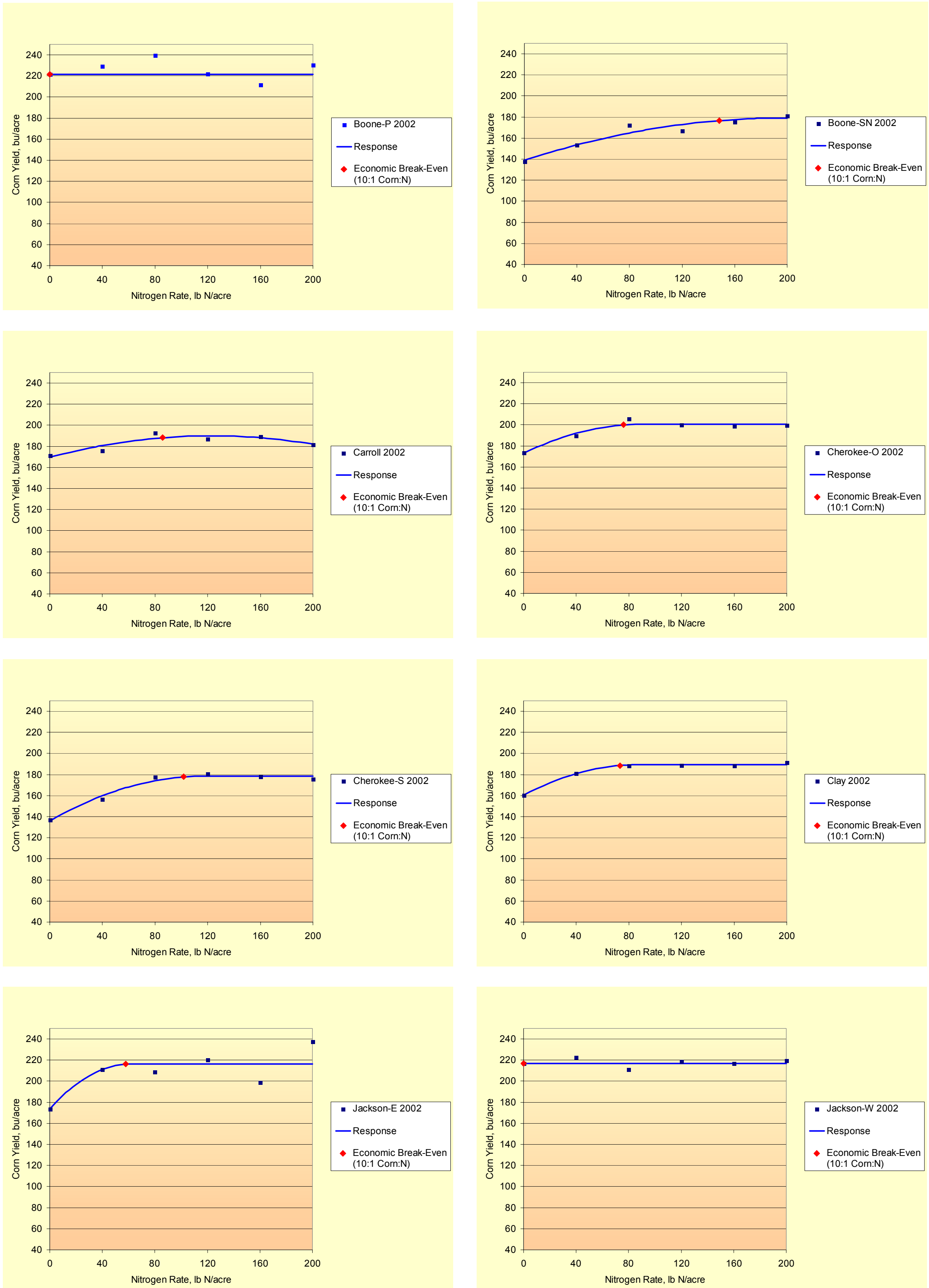
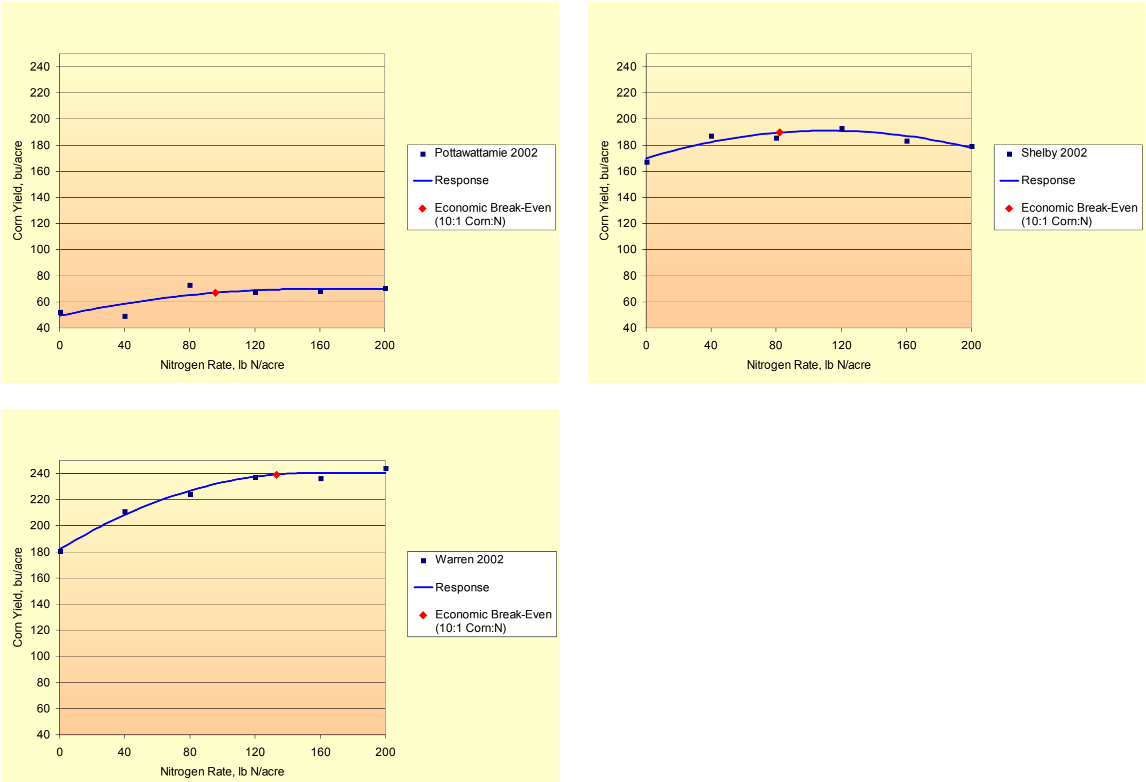


Figure 4 continued. Corn grain yield response to applied N at each demonstration site, 2002 (economic N rate calculated at a break-even 10:1 corn:nitrogen price ratio).



The corn crop can also be used as an indicator of soil N supply and responsiveness to applied N. Table 4 lists Minolta SPAD meter readings taken on the ear leaf at approximately the R1 growth stage (silking). The SPAD meter measures leaf greenness, with readings being related to leaf chlorophyll and N concentration. Therefore, this meter provides a non-destructive method to assess the N status of corn during the growing season, and an alternative to leaf or plant sampling and laboratory determination of N concentration. Many variables can affect leaf greenness (examples are hybrid, moisture stress, and growth stage), and this can be noticed in differences between sites at the highest N rate. However, within a site the readings are a good indicator of the N status. Taking readings at silking is an important growth stage timing to determine N stress, but is somewhat early in the season for determining the final relationship to yield. Most sites with greatest response to applied N had low SPAD readings in the zero N rate check. Sites with high check (zero N) rate SPAD values, and little change in SPAD values compared to the maximal N rate, also showed small yield response to applied N. These high zero N rate SPAD values are another indicator of high soil N supply to corn.

Table 4. Corn ear leaf greenness response to applied N (R1 silking growth stage measured with a Minolta SPAD chlorophyll meter), 2001 and 2002.

Site	No-N Check†	Economic N Rate‡	Maximum§
	- - - - - - - - SPAD Reading - - - - - - - -		
2001			
Boone-N	49.1	56.0	61.3
Boone-S	51.0	59.0	59.0
Carroll	50.5	50.5	61.9
Clay	51.9	61.1	61.7
Floyd	49.0	49.0	59.2
Linn	56.0	57.7	60.6
Louisa	41.5	56.2	57.4
Plymouth	45.0	56.6	56.8
Pottawattamie	58.1	60.2	62.4
Shelby-E	59.3	59.3	62.7
Shelby-W	59.8	61.6	65.1
Tama	51.0	55.3	58.0
Warren	47.5	60.5	61.5
Webster	56.5	61.8	63.1
2002			
Boone-P	62.3	62.3	65.1
Boone-SN	56.8	61.3	62.6
Carroll	52.4	57.8	59.9
Cherokee-O	54.2	58.5	59.2
Cherokee-S	48.6	56.7	60.3
Clay	53.5	58.7	59.5
Jackson-E	51.4	57.9	59.2
Jackson-W	57.7	57.7	61.5
Pottawattamie	54.4	61.6	62.0
Shelby	51.5	54.8	57.0
Warren	49.3	63.4	64.1

† SPAD reading with zero N applied.

‡ Interpolated SPAD reading at the economic N rate calculated at a break-even 10:1 corn:nitrogen price ratio (example $2.00/bu corn and $0.20/lb N).

§ At highest N rate.

In some instances the low yield response to applied N related to indicated recent history of N and manure inputs, but not in all cases. Sites with manure application histories generally had high soil test P (Table 2). To help producers better understand the potential soil supply of plant-available N, corn responsiveness to applied N, and N input needs, then a test like the Illinois Soil N Test may provide valuable information that can improve economics of corn production and reduce potential for nitrate movement to water bodies. Most important will be identification of the non-responsive sites, which the Illinois Soil N Test has shown good potential to do. Also, as producers change N inputs, it will be important to monitor the soil N supply and adjust N fertilization as the supply capability adjusts. This monitoring may be possible with the new amino sugar-N based soil test.

Preliminary Evaluation of the Illinois Soil N Test

Figures 5 and 6 show the relationship between the Illinois Soil N Test and corn yield response to N fertilizer at the 2001 and 2002 sites. Figure 5 has results for spring preplant soil samples collected from the 0-12 inch depth, and Figure 6 has results for spring preplant soil samples collected from the 0-6 inch depth. Based on a 235 mg kg^{-1} critical level for 0-12 inch samples (published value based on research at the University of Illinois), only one site would be predicted as responsive to applied N (Figure 5). That site was responsive but had only a small yield increase from N application, 5.7% increase above the control yield. All other sites had Illinois Soil N Test values above 235 mg kg^{-1} and would be predicted to be nonresponsive. However, of those 24 sites only 3 were nonresponsive to applied N. These results provide a correct prediction rate by the test of only 16%. Looking at the distribution of soil test values versus percent yield increase in Figures 5 and 6, one can easily see the lack of predictive relationship between the Illinois Soil N Test and corn yield response to applied N.

Figure 5. Relationship between the Illinois Soil N Test (0-12 inch soil sample depth) and corn yield response to applied N for 2001 and 2002. The N fertilizer response calculated as 100 x (optimal yield – control yield)/control yield.

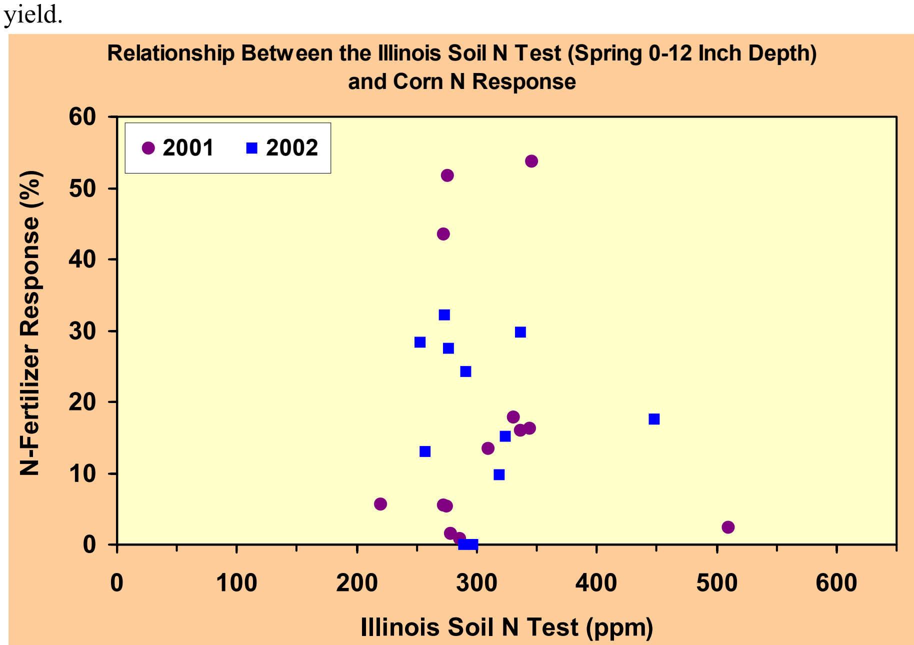
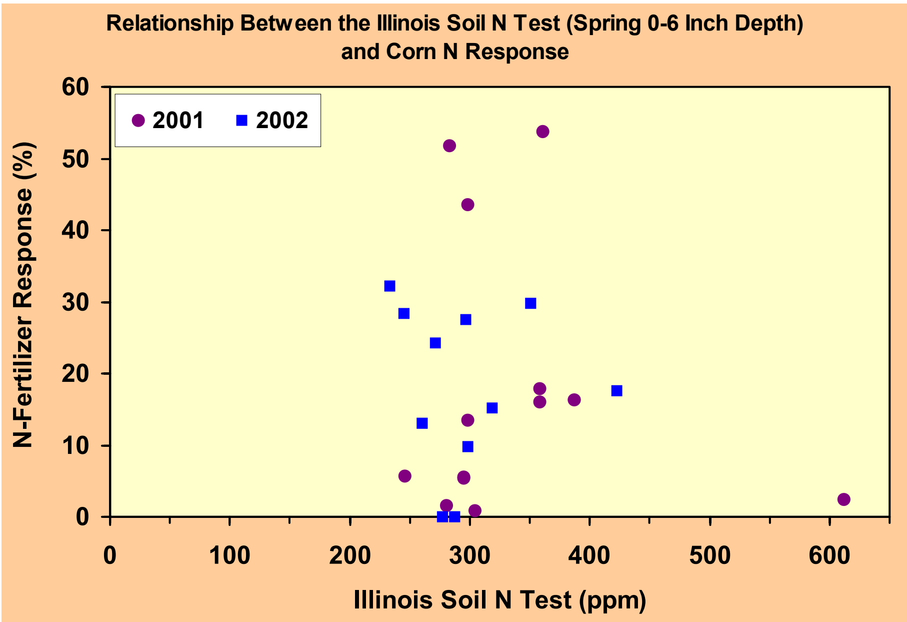
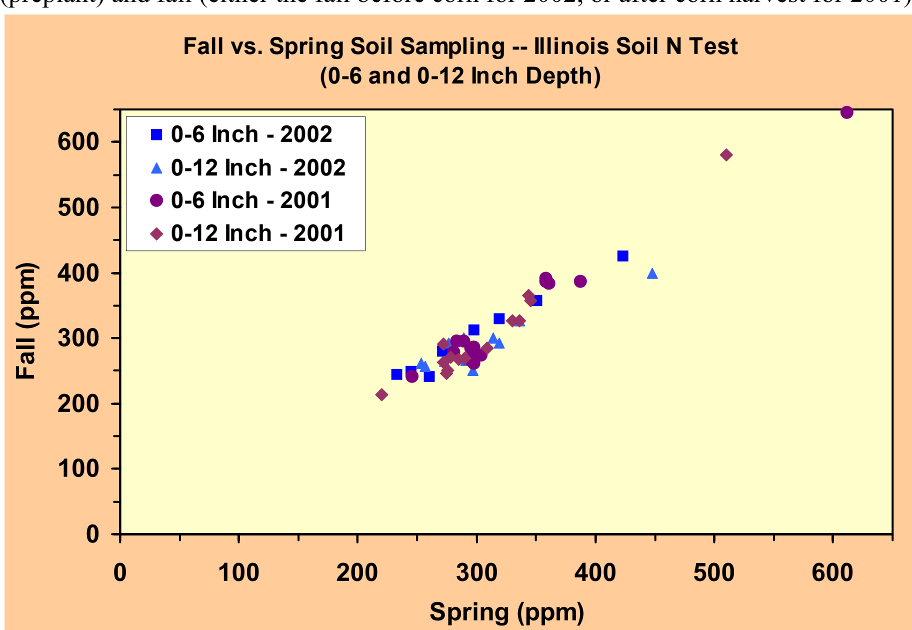


Figure 6. Relationship between the Illinois Soil N Test (0-6 inch soil sample depth) and corn yield response to applied N for 2001 and 2002. The N fertilizer response calculated as 100 x (optimal yield – control yield)/control yield.



There would be great utility for a soil N test to have recommended sampling in the fall before planting corn. Figure 7 shows there was a good relationship between the Illinois Soil N Test values for soil samples collected in the fall and spring. This indicates the potential that soil sampling could occur either in the fall or spring. On-going work at project sites is also comparing test results for soil samples collected in-season and on a weekly schedule.

Figure 7. Relationship between the Illinois Soil N Test for 0-6 and 0-12 inch samples collected in the spring (preplant) and fall (either the fall before corn for 2002, or after corn harvest for 2001), 2001 and 2002.



One possible reason for the lack of predictive ability of the Illinois Soil N Test is the general relationship between the test values and soil organic matter (0-12 inch depth samples shown in Figure 8). A similar relationship exists for the 0-6 inch depth samples (data not shown). Across the sites in this study there was no correlation between soil organic matter and corn response to applied N (data not shown, but the relationship basically looks the same as that in Figures 5 and 6) or economic N rate (Figure 9). In other words, soil organic matter was not predictive of N response or N application need across the 25 sites. It is possible that the Illinois Soil N Test is reflecting general soil organic matter and not being specific to amino sugar-N. This indication is seen in comparison of results from other N rate studies in Iowa where amino sugar-N determined by the soil hydrolysis procedure was better related to N responsiveness.

Figure 8. Relationship between the Illinois Soil N Test (spring 0-12 inch soil sample depth) and soil organic matter, 2001 and 2002.

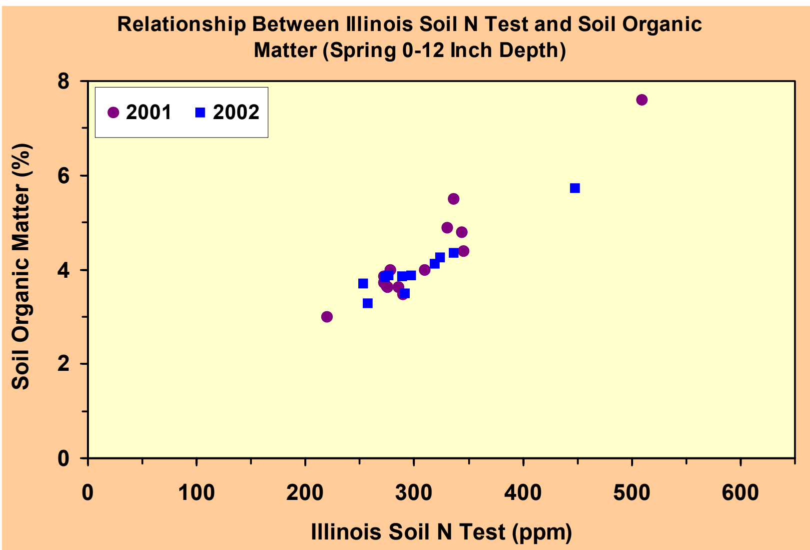
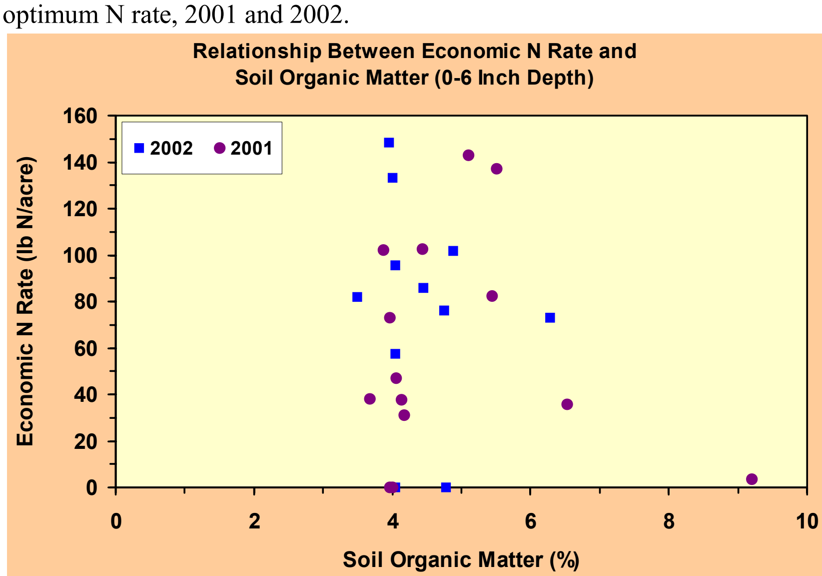


Figure 9. Relationship between soil organic matter (0-6 inch soil sample depth) and the calculated economic optimum N rate, 2001 and 2002.



Preliminary conclusions from the Illinois Soil N Test evaluation in this project tends to indicate there may be different pools of soil organic-N measured by the hydrolyzable amino sugar-N procedure and the Illinois Soil N Test. This needs to be further studied by analyzing soil samples from this project with both procedures. It is possible that the specific amino sugar-N fraction measured by acid hydrolysis will be a better predictor of N responsiveness than the Illinois Soil N Test, but that needs to be confirmed for these sites. This indicates that the underlying basis for the Illinois Soil N Test (acid hydrolyzed soil amino sugar-N) may be correct (can predict site N responsiveness), but the procedure developed for routine soil analysis (the Illinois Soil N Test) is not. At this point in time caution should be exercised with use of the Illinois Soil N Test for interpreting the need for N application in corn production (at least for Iowa soils). Further evaluation is needed to clarify predictability of the test. Also, the soil samples from this project need to be analyzed for exchangeable ammonium-N to see if that inorganic N form is contributing to test results.

Total Soil N and C

Soil samples were collected at depths of 0-2, 2-4, 4-6, 6-12, and 12-24 inches at selected sites in 2001 prior to the application of fertilizer N rates. They were air-dried and passed through a 2mm mesh sieve to be analyzed for total C, N, and organic matter using a Leco CHN dry combustion analyzer. The results are shown in Table 5.

The results in Table 5 show the total C, total N, and C:N ratio for seven sites with a corn-soybean rotation across the state representing different soil types and management histories. The results show considerable differences in the amount of total C and total N among sites. This can be attributed to differences in soils, particularly clay content along with differences in past farming practices. The results also show total C and total N tends to decrease with increasing depths for most soils. The trend of total C and total N to decrease with depth can be attributed to soil physical and chemical properties along with soil management practices. Also, soil management, N management, manure management, crop rotation, and soil type affect the relationship between total soil C and total N content or what is called C:N ratio. The C:N ratio is essential for microbial activity in the soil system.

The C:N ratios shown in Table 5 can be used as an indicator of potential microbial activity. Having a C:N ratio below or above 10 parts of C to one part of N can affect microbial decomposition of plant residue and conversion to bio-available nutrient forms that can be used by plants or to help improve soil tilth. This relation is an important consideration in our N fertilization programs. Change in the C:N ratio due to an improper nutrient management program may provide more or less N than the optimum crop need, and can affect the microbial efficiency in converting raw organic materials to plant-available inorganic forms.

Soil microbes break down dead plant material transforming it to soil organic matter. The upper soil profile contains greater organic matter, thus, greater microbial activity and a larger C pool. This C pool is called an active pool where most C loss is likely to occur. In general, C and N in organic and inorganic forms, along with other nutrients, can be released in mineral form by microbial processes. Tillage can increase the rate at which organic matter is broken down. The C and N contents of the upper few inches can be affected by the depth, intensity and method of tillage. Increased tillage methods may increase the losses of C and N.

Table 5. Total soil N and C at different depths before N application, 2001.

	Sample Depth (in)														
	0-2			2-4			4-6			6-12			12-24		
Site	C	N	C:N	C	N	C:N	C	N	C:N	C	N	C:N	C	N	C:N
	- - - - - - - - - - - - - - - - - - Total C or N (lb/acre) - - - - - - - - - - - - - - - - - -														
Boone-S	12331	919	13.4	12590	927	13.6	12323	886	13.9	15388	1111	13.9	12125	795	15.3
Floyd	20836	1979	10.5	19365	1897	10.2	19569	1939	10.1	21757	2220	9.8	11967	1402	8.5
Louisa	14693	1099	13.4	13126	994	13.2	11441	860	13.3	11358	815	13.9	8029	528	15.2
Plymouth	14679	1221	12.0	13237	1117	11.8	11560	1053	11.0	13921	1155	12.0	9975	814	12.3
Pottawattamie	13490	1022	13.2	10899	859	12.7	9629	753	12.8	11209	859	13.1	7821	585	13.4
Tama	13368	1164	11.5	10580	959	11.0	8708	826	10.5	7777	775	10.0	5254	515	10.2
Warren	12018	944	12.7	10229	808	12.7	9891	753	13.1	11245	855	13.1	10691	829	12.9

The amount of total N shown in Table 5 generally declines with soil depth and varies with soil type. Variations within soil type may be due to cropping system and past management practices. Not all of the total N reported in Table 5 is plant available. Most of this N is in organic forms and is not readily available to crops unless it is converted into a mineral form of N by microbial processes. This processing is called mineralization and depends on many factors; among them is the C:N ratio. In general, most of the total N shown in Table 5 is tied up in organic forms as a part of total C and N pools. The amount of mineral N is a very small fraction of the total N. Therefore, the amount of mineral N that can be utilized by the plant annually is very small. The conversion of the plant-unavailable organic form of N to an available form depends on the fertilization program that growers adopt in crop production, which in turn will affect the microbial activity in mineralizing organic C and organic N. A key factor is a fertilization program based on actual crop need throughout the growing season based on soil N tests.

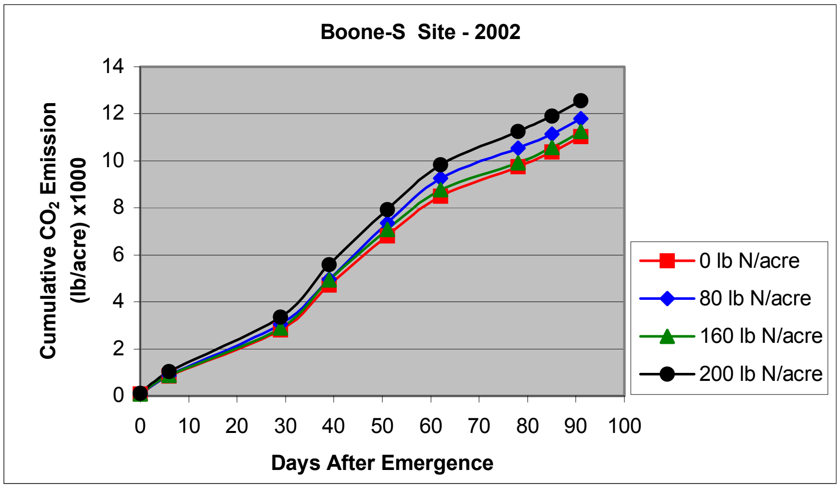
CO_2 Emission

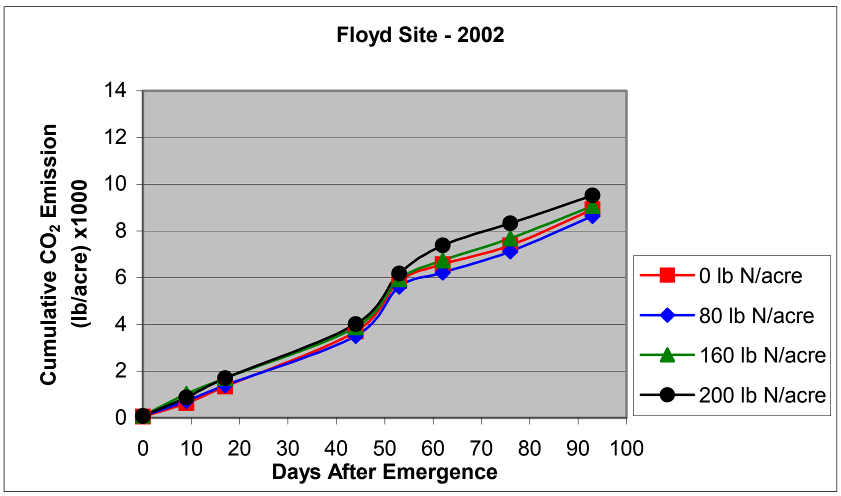
Measuring CO_2 emissions allows the investigation of the short-term impact of N management and crop productivity on soil C dynamics. During the 2002 growing season, CO_2 was measured at the Boone, Floyd, and Warren sites where 0, 80, 160, and 200 lb N/acre had been applied to the prior-year corn crop. Carbon dioxide emission was measured using a Li-Cor 6400 CO_2 analyzer. These measurements were conducted on a bi-weekly basis during the growing season (Figure 10).

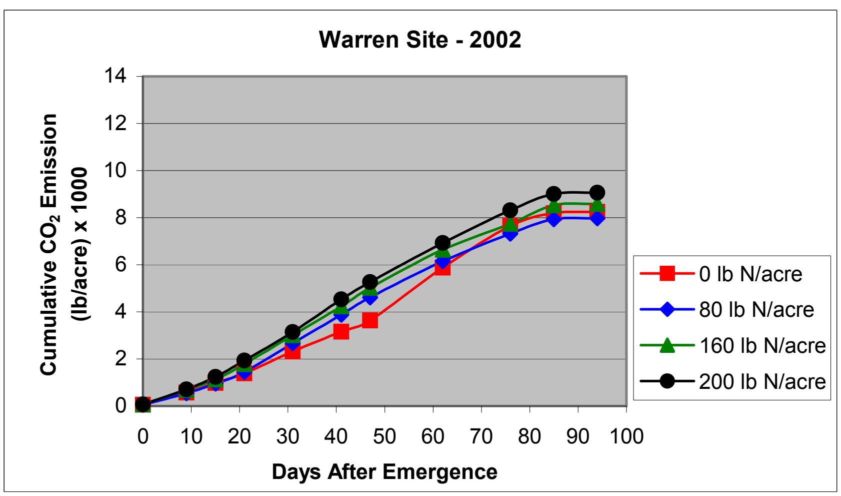
Many variables contribute to the release of C as CO_2 including temperature, soil moisture, soil aeration, soil type, tillage practices, cropping systems, and the availability of other nutrients. By comparing these variables we will be able to determine how applied N affects CO_2 release or C loss and C dynamics of different soils with different tillage systems across the state. Proper N management is essential in maintaining optimum soil organic matter as a significant factor in maintaining soil tilth and productivity. A key factor is for fertilization to sustain soil productivity and crop N supply.

The data in Figure 10 represents an accumulation of C loss as CO_2 over time in soybean fields with N rates that were applied to the previous-year corn crop. The CO_2 release was measured at the soil surface to monitor the impact on microbial activity and the rate of CO_2 release. The results show that the higher N rate resulted in increased CO_2 release. Generally, the 200 lb N/A rate resulted in the highest CO_2 release compared to the other N rates. The increase in CO_2 release with higher N application indicates the impact of residual N supply on microbial activity. In general, optimum N input increases plant residue and root system soil C input, increasing organic matter content of the soil. Nitrogen plays a key role in microbial metabolism, which allows them to decompose plant residue, releasing CO_2 into the soil system and the atmosphere.

Figure 10. Cumulative CO_2 emission from the soil surface in soybean fields following corn with different N rates applied to the prior-year corn crop, 2002.



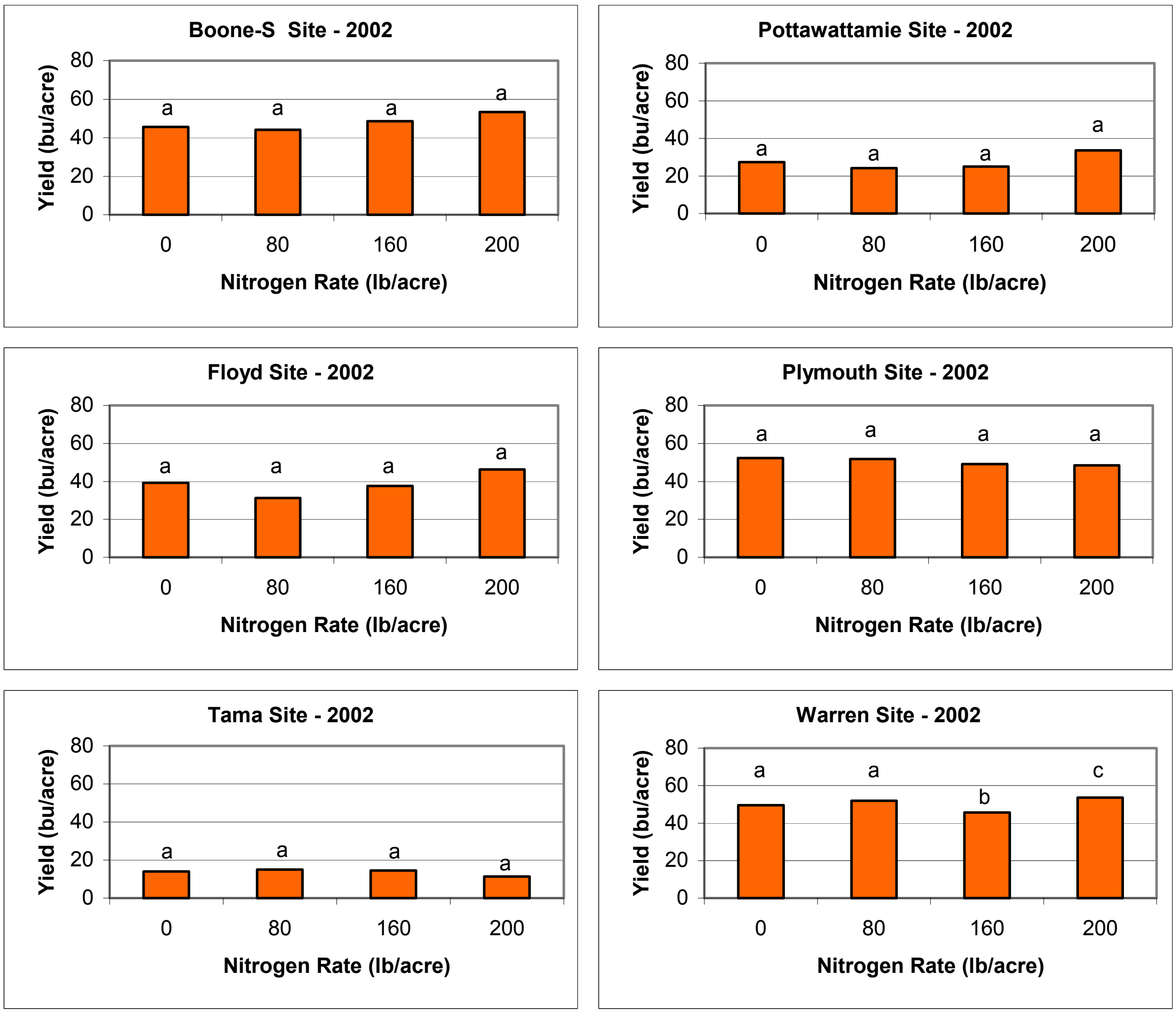




Soybean Grain Yield

Soybean grain yield was measured to determine the effect of N applied to the prior-year corn crop on soybean production in 2002 (Figure 11). Yield data was not collected from the Louisa site due to the farmer harvesting the soybeans before grain samples could be collected. In most cases prior-year N rates had no effect on soybean grain yield. The effects from the previous season N application to corn on soybean grain yield were not significant except for the Warren site where yields were inconsistently higher and lower with increasing prior-year N rate.

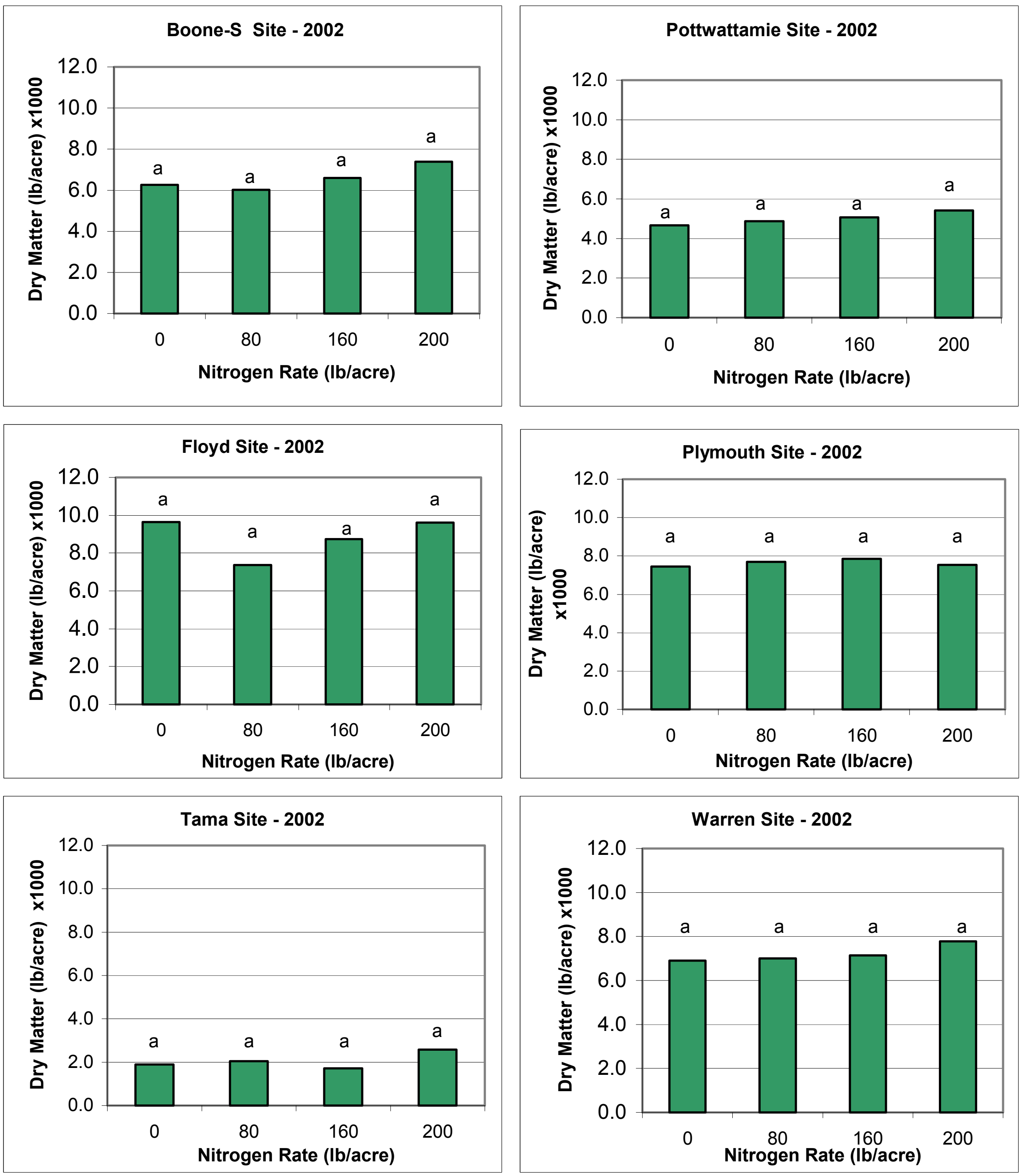
Figure 11. Soybean grain yield with different N rates applied to the prior-year corn crop, 2002.



Soybean Plant Dry Matter

Plant dry matter was estimated to determine total N and C input into the soil. In 2002, soybean plants were harvested at physiological maturity. Figure 12 illustrates the plant dry matter (not including grain) at six project sites. The lack of soybean dry matter production response to prior-year N application rate was similar to soybean grain response. In general, the average amount of residue was 5,500 – 8,800 lb/acre for all sites except for the Tama site, where the average residue return was 1,700 lb/acre for all N rates. The amount of residue left on the soil will affect the total amount of total C and N input into the soil.

Figure 12. Soybean plant dry matter with different N rates applied to the prior-year corn crop, 2002.



Project Success In 2001 and 2002

Overall the project met expectation for the first two years. There are more demonstration sites than anticipated; site cooperators are excellent to work with and have high interest in the project; there is a good range in soils, geographic location, productivity, and tillage; every site was successful and expected field work was completed; and the range of results are excellent for meeting the goals of the project. Sample analysis is still underway and data summary and information development continues. Twenty sites are identified for the 2003 season, with some cooperators participating again with either new sites or the seven sites from 2001 being monitored in 2003. Soil sampling for the 2003 season began this past fall to assess temporal variation in test results.

Education Component and Outreach Activity:

The following outreach activities occurred at project sites and field days. Field signs indicating the project name, program, and cooperating organizations were located at many sites (Figure 13). Information gained from the project was delivered to farmers, agbusiness, CCA's, and agency personnel through meetings, conferences, on-going extension education programs and certification programs, newsletters, and web materials. An important educational multiplier will be use of project information in extension and other education programs. Additional outreach and promotion of the project will occur as results are summarized and reported in various research farm reports. For the future, as information is learned about the Illinois Soil N Test and the applicability to Iowa corn production, then important impacts to Iowa N use, producer economics, and water quality may come if the demonstration project shows it to be feasible for soil test labs to adopt the test method and producers modify N applications.

Figure 13. Signed field site and project field day and education program, 2002.

Project results regarding evaluation of the Illinois Soil N Test were presented at the Wisconsin Fertilizer, Aglime, and Pest Management Conference, January 21, 2003. Approximately 725 attendees were present for the presentation, and included agribusiness, university extension and researchers, CCA's, and agency personnel. A proceedings report was printed in the conference proceedings (Sawyer, J.E., D.W. Barker, and M. Al-Kaisi. 2003. Iowa experience with the Illinois soil N test. p. 46-54. *In* Proc. Wisconsin Fertilizer, Aglime and Pest Manag. Conf., Madison, WI. 21-23 Jan. 2003. Univ. of Wisc., Madison, WI.).

2001 and 2002 Educational Activities, Field Days, Project Presentations

Field Day - Pottawattomie Site, June 28, 2001
Field Day - Linn Site, June 20, 2001
Field Day - Western Research Farm, June 21, 2001
Field Day - Neely-Kinyon Farm, August 21, 2001
Field Day - Tama Site, August 22, 2001
Field Day - Southeast Research Farm, September 6, 2001
Field Day - Webster Site, September 13, 2001
Nutrient Management Information Team Meeting, October 18, 2001
Iowa Corn Promotion Board Meeting, February 6, 2002
Agriliance Agronomy Update Meeting – Ames, February 14, 2002
IDALS/IFLM program Meeting – Mason City, March 12, 2002
Field Day – Pottawattamie Site One, June 27, 2002
Field Day – Pottawattamie Site Two, June 27, 2002
Soil and Water Conservation Society Conference – Indianapolis, IN, July 13, 2002
Field Day – Jackson Site, August 13, 2002
Field Day – Boone-P Site, August 16, 2002
Iowa State University Ag-Chem Dealer Update Meeting – Ames, December 11, 2002
Iowa State University Crop Advantage Series Meeting – Sheldon, January 7, 2003
Iowa State University Crop Advantage Series Meeting – Spirit Lake, January 8, 2003
Iowa State University Crop Advantage Series Meeting – Fort Dodge, January 9, 2003
Iowa State University Crop Advantage Series Meeting – Mason City, January 14, 2003
Wisconsin Fertilizer, Aglime and Pest Management Conference – Madison, January 21, 2003

Expected Benefits:

Full impact of the project cannot be determined at this time because we are early into the project. However, benefits will include a better understanding of corn N requirements and soil N-C dynamics across Iowa, and if successful a new soil N test calibrated to Iowa conditions to aid in determination of soil N supply and identification of corn responsiveness to applied N. These benefits will improve producer understanding of corn N needs and setting appropriate N rates, especially when low or no N application is needed (which is the greatest opportunity for environmental and economic improvement related to N management). This should assist producers in maximizing economic corn production and minimizing environmental N impacts.

Nitrogen application and soil management have a significant impact on soil organic matter, and specifically soil C. The loss of C from the soil as CO_2 can impact the environment, soil tilth, soil C pools, and the degradation of soil organic matter. The outcome of this study will further understanding in regard to the interrelationship of N fertilization on short-term C loss and in the long-term maintenance of soil organic C.

Additional Project Partners:

Iowa Crop Producers
Iowa State University Extension
Iowa State University Extension Crop Field Specialists
Iowa Natural Resources Conservation Service
Division of Soil Conservation, Iowa Department of Agriculture and Land Stewardship
Agribusiness Association of Iowa
Kirkwood Community College
Iowa Central Community College