Demonstration of In-Season Nitrogen Management Strategies For Corn Production

2005 Crop Year Report

March 31, 2006

John Sawyer, Associate Professor, Soil Fertility Extension Specialist
John Lundvall, Extension Program Specialist
Jennifer Hawkins, Graduate Research Assistant
Department of Agronomy, Iowa State University
515-294-1923 (Sawyer)
515-294-5429 (Lundvall)
jsawyer@iastate.edu
jlundval@iastate.edu

Introduction:

Water quality impairment related to nitrogen (N) continues to be an important issue in Iowa. Proposed Environmental Protection Agency surface water quality criteria for N could dictate strict guidance for N inputs to corn, which occupies large acreage and is important for economic vitality of Iowa farmers. This focus could even designate N use practices that require very high levels of management and risk, with unknown economic consequences. Therefore it is important to demonstrate emerging N management strategies that have potential to improve N use and economic return to corn production.

Rate of N application is an important N management factor in corn production related to increase in nitrate reaching surface and groundwater. Rate is also important in regard to economics of corn production. Application exceeding crop need increases the pool of nitrate remaining in soil after crop harvest – nitrate with the potential to move out of the soil profile. Excessive N application to corn also reduces a corn producer's profits. While applying only the needed fertilizer N rate in a given year will not stop nitrate from leaving cornfields, nor necessarily achieve proposed water quality criteria, it can result in reduced residual soil nitrate and help lessen corn production's impact on water quality. Therefore, it is possible that being able to assess corn N need differentially each season could improve corn N use efficiency and reduce nitrate susceptible to loss compared to application of an average agronomic rate each year.

Monitoring the corn plant to determine N status and seasonal N availability has advantages in that the plant integrates N supply over a wide period of time, and hence can reflect the soil N supply as affected by weather, soil processing, and fertilization. It can also reflect spatial variation. The longer the corn plant has grown, the larger the fraction of total N accumulated (corn accumulates approximately 50-65% of total N by the R1 growth stage). The total crop N need (and season-long soil N supply) is better reflected in the crop late in the season (after R1). This is a limitation with corn plant monitoring to determine N status as the best time to closely determine crop N need is likely after it is too late to apply and have N be accessible for plant uptake. The corn N uptake pattern also implies that small plants sensed early in the season will only indicate large N shortage and cannot differentiate total season N need, especially if available soil N plus preplant N is fairly high. A compromise is to sense the crop before the R1 stage, but after considerable N has been taken up. This might allow time for N to be effective if application is needed, and limit potential yield loss because of delayed application or crop N stress; however, if severe N stress develops unrecoverable yield loss may occur. The potential for irreversible yield loss can be reduced by applying preplant or early-sidedress N, monitoring for development of plant N deficiency, and making in-season applications timed before significant N stress occurs. Nitrogen can be applied with high clearance equipment and research has shown that N applied as late as the R1 growth stage can still add to the pool of N being accumulated during seed fill and improve yield if N supply is short.

Limitations to in-season monitoring and N application are dry surface soils where applied fertilizer is not accessible for uptake by active roots, or wet periods that limit field access. Also, to date sensors for assessing corn plant N status can only determine plant N stress (lack of adequate N). This means that to adjust seasonal N rates using this approach the corn crop must be showing N stress before an application need can be predicted. Having effective systems that allow N rate prediction and application later (later than traditional sidedress timing) into the growing season does provide a wider window for N application in corn.

Several emerging technologies now allow in-season N application and rate adjustment to be practiced. One, high clearance equipment can move through tall corn, some even at full growth height. Two, high clearance equipment has been developed that can inject urea-ammonium nitrate (UAN) fertilizer solutions into the soil (Hagie Manufacturing Co. NTB applicator; Miller Applications Technologies Co. NITRO toolbar applicator). Three, a plant chlorophyll sensor (Minolta SPAD 502 chlorophyll meter) is available and well-researched in regard to the relationship with N rate and N status. Other handheld, machine-mounted, and remote aerial sensors are being commercially developed, with research for determination of efficiency and N-rate prediction underway. Therefore, it is feasible for producers to begin investigating in-season N management systems based on plant monitoring. However, field-scale demonstration is needed to document and resolve several issues: integration into corn production systems, feasible strategy for in-season N management, corn productivity, and economics compared to preplant and early-sidedress N.

Objectives:

Objectives of this project include: one, demonstrate use of corn plant N deficiency/sufficiency monitoring to determine need and rate of in-season N application and effect on corn yield; two, demonstrate the impact of set preplant or early-sidedress N rates (referred to as pre-applied N) on corn plant N sufficiency and N stress development, frequency and rate of needed in-season N application, total fertilizer N applied, and corn yield; and three, compare corn yield response and economic return using pre-applied N versus pre-applied plus in-season monitoring and additional N application.

Field Demonstration Description:

Demonstrations use cooperating producer fields, with fertilizer applications in replicated strips across field lengths. At each site cooperators are asked to avoid making broadcast applications of manure or N fertilizer to the site area, other than replicated N treatment strips. All other field activities are completed as normal by the cooperator, including grain harvest of treatment strips. Each demonstration strip is replicated three times in order to compare demonstration effects.

A summary of the application strategies is given in Table 1. Set pre-applied N rates are either fall- or spring-applied preplant or early-sidedress (hereafter referred to as pre): 1) a no-N control; 2) reference N rate at 240 lb N/acre (corn after soybean) or 270 lb N/acre (corn after corn); 3) reduced N rate at 60 lb N/acre (corn after soybean) or 90 lb N/acre (corn after corn); 4) agronomic N rate at 120 lb N/acre (corn after soybean) or 180 lb N/acre (corn after corn). In-season N applications vary and are determined from corn plant N stress sensing at the V10-VT vegetative growth stages: 5) reduced pre N rate (see number 3 for rate) plus in-season N applied before the R1 corn growth stage (applied if needed and rate determined from corn plant sensing); and 6) agronomic pre N rate (see number 4 for rate) plus in-season N applied before the R1 corn growth stage (applied if needed and rate determined from corn plant sensing). The in-season applications are applied to one of two strips of the reduced and agronomic pre rates in each replication. The in-season fertilizer N source is UAN solution surface-dribbled or coulter-injected with high-clearance equipment.

The agronomic N rate, set at 120 lb N/acre (corn following soybean) or 180 lb N/acre (corn following corn), is based on the approximate mid-point of current Iowa State University published recommended ranges for each rotation. A recent economic summary of 100 site-years of corn yield response data from across Iowa indicated an economic N rate near 125 lb N/acre for the corn-soybean rotation. The demonstration allows for the following comparisons: 1) field response to applied N and relative magnitude of response with each strategy; 2) rates of application; 3) pre N application and in-season application of additional N; 4) frequency and rate of needed in-season N with each strategy; 5) timing of N deficiency development between pre N rates; 6) ability of the monitoring system to determine needed in-season N rate; and 7) economics of using pre N rates versus pre N rates plus in-season N application adjustment strategies.

Two pre N rates are used to demonstrate two overall strategies of in-season monitoring and potential for in-season N application by producers. One strategy is to apply an agronomic N rate and then monitor to see if a problem develops in regard to N sufficiency. This is a management strategy where in-season N applications might be infrequent across years; it allows producers to confidently use agronomic N rates while having a backup system available in case N deficiency problems develop during early vegetative growth (for example, high N loss or a year of greater than expected fertilizer N need). This approach does not allow for adjusting rates if less than an average agronomic rate would suffice in a particular year. The second strategy is to apply a reduced rate of N, expecting that more N will be applied in-season most years. This approach could allow for a closer match between corn N need and N application each year. Having some N pre applied can help limit severity of N stress and therefore potential development of irreversible yield loss.

Corn plants are sensed throughout each strip before in-season N application to monitor N deficiency development and to determine in-season N rate. A Minolta SPAD 502 chlorophyll meter is used to monitor N deficiency development. The SPAD chlorophyll meter is hand held, allows for determination of corn N deficiency in defined field areas, and provides instant feedback. The SPAD chlorophyll meter has been intensely researched, with well documented relationships to plant N and development of N deficiency in corn. In addition, work being conducted in the Iowa Department of Agriculture, Division of Soil Conservation Integrated Farm/Livestock Management

(IFLM) demonstration program project "Determining Corn Nitrogen Fertilization Requirements and Soil Carbon Status in Diverse Soil Nitrogen Supply Environments" has shown a positive relationship between relative (normalized) SPAD readings (RSPAD) and the average N rate difference (lb N/acre) between an applied rate and the economic N rate (ND). This relationship is described by the quadratic-plateau equation: $RSPAD = 0.97 + 0.00059ND – 0.00000499ND^2$ (plateau at 0.99 RSPAD at a ND of 59 lb N/acre; with the RSPAD being 0.97 when the average N rate is at the economic rate, ND=0). This equation is used to determine the in-season N rate to be applied to each of the planned in-season strategies.

The reference N rate is included in the demonstration because research with chlorophyll meters and with remote imagery has shown that readings should be adjusted (normalized) to an adequately N-fertilized reference area to reduce color effects other than from N deficiency (drought, hybrid greenness differences, and diseases). Each strip is sensed after all N applications are completed (R3, corn milk growth stage) to monitor plant response to applied N.

Corn is harvested by cooperators using combines equipped with a yield monitor and GPS positioning equipment, with grain yields adjusted to 15.5% moisture. Combines equipped with GPS positioning equipment allow strip yield determination and comparison of within-field differences in response to applied N using GIS technology.

Eighteen demonstration sites were established with sixteen cooperators in thirteen Iowa counties in 2005 (Figure 1). Crop year 2005 demonstration sites varied in soil type, tillage system, yield history, recent N application rate history, and manure application history (Table 2). Fifteen crop year 2005 demonstration sites were corn following soybean (corn-soybean); three 2005 demonstration sites were corn following corn (corn-corn).

Planting dates at 2005 demonstration sites ranged from April 15 to May 3 (corn-soybean sites, Table 3; corn-corn sites, Table 4). Pre N application (preplant or early sidedress) timing at 2005 demonstration sites ranged from early October 2004 to June 21, 2005, with four fall 2004 applications. Fall 2004 pre N applications included three sites with late fall-applied anhydrous ammonia (Boone, Greene, and Webster; N-Serve® was applied with anhydrous ammonia at Greene and Webster sites) and one site with encapsulated urea (ESN) applied on October 8, 2004 (Monona-1 site). Pre N was applied via early-sidedress methods at five 2005 demonstration sites (Franklin, Marshall, and Page corn-soybean sites; Franklin and Wright corn-corn sites). Pre N source at nine demonstration sites was anhydrous ammonia (three sites late fall-applied, four sites spring-applied, and two sites early sidedress-applied); pre N source at eight demonstration sites was UAN solution (four sites broadcast-applied and four sites injected); pre N source at one site was fall-applied encapsulated urea (ESN).

Preliminary 2005 Results:

Leaf Greenness Measurement and In-Season N Application Rates

Corn plant N status (leaf greenness) was monitored at all 2005 demonstration sites using a SPAD chlorophyll meter (Figure 2); preliminary chlorophyll meter data collection was targeted for approximately V13 corn growth stage (uppermost leaf with a visible leaf collar was the thirteenth leaf on the majority of plants at a site). Chlorophyll meter (SPAD) readings were collected from twenty corn plants surrounding multiple pre-flagged points throughout each treatment strip. Readings were collected from the uppermost developed leaf with a collar fully visible until the corn reached tassel emergence (VT), when readings were collected from the ear shoot leaf. Within each treatment strip, the average SPAD reading was calculated. Relative chlorophyll meter (RSPAD) values, normalized relative to chlorophyll meter readings collected from the 240 lb N/acre (corn-soybean sites) or 270 lb N/acre (corn-corn sites) reference treatment strips, were calculated for each treatment. As expected, measurements of the vegetative stage corn leaf greenness increased with higher pre N rates at most sites. The SPAD readings and leaf chlorophyll (leaf greenness) does not indicate excess N, but will show deficiency or N stress; therefore, readings do not increase once maximum greenness is reached, even with more N.

In-season N application rates for planned in-season treatments (60+ and 120+ at corn-soybean sites, 90+ and 180+ at corn-corn sites) were calculated for each site by entering RSPAD data into the aforementioned quadratic-plateau equation that describes the relationship between RSPAD readings and the average N rate difference (lb N/acre) between an applied N rate and the economic N rate. Equation-prescribed in-season N application rates at 2005 corn-soybean demonstration sites ranged from 0 to 85 lb N/acre for the 60+ treatment (Table 3); equation-prescribed in-season N application rates at 2005 corn-corn demonstration sites ranged from 45 to 80 lb N/acre for the 90+ treatment (Table 4). The 120 lb N/acre pre rate was indicated to be N-deficient at four of 15 corn-soybean field sites in 2005; equation-prescribed in-season N application rates at 2005 corn-soybean demonstration sites ranged from 15 to 45 lb N/acre for the 120+ treatment (Table 3). The 180 lb N/acre pre rates were estimated to be N-sufficient at all three corn-corn field sites in 2005; therefore, no 180+ treatment strips required in-season N applications (Table 4).

At three of 18 demonstration sites (Franklin and Guthrie sites) high-clearance N toolbars equipped with coulter-injectors were used to apply in-season UAN treatments (Figure 3). At 12 other demonstration sites in-season UAN treatments were surface-applied using high-clearance spray booms equipped with drop nozzles to direct UAN solution below the leaf canopy and onto the soil surface. Extreme corn height and extended wet field conditions prevented in-season N application at the Mahaska and Wright demonstration sites, respectively. Chlorophyll meter readings suggested that no additional N was needed in either 60+ or 120+ treatment strips at the Greene site. In 2005 corn yellowing from N deficiency before in-season UAN application was less apparent than in 2004; Figure 4 illustrates an example of extreme deficiency in the zero N strips.

Corn response to in-season N application was monitored at all 2005 demonstration sites by collecting follow-up SPAD chlorophyll meter readings from the same pre-flagged strip points throughout each treatment strip. Follow-up chlorophyll meter data collection was targeted for the R3 corn reproductive stage (milky kernel stage). Relative SPAD values for before and after the in-season N applications are summarized for all 2005 demonstration sites in Table 5 (corn-soybean sites) and Table 6 (corn-corn sites). Generally, in-season N applications did not result in significant increases in corn leaf greenness; however, reductions in corn leaf greenness between early and late chlorophyll meter data collections were less where in-season N was applied. Better retention of leaf greenness (indicating more-sufficient N levels) during the critical pollination and early reproductive growth stages may explain corn grain yield response to in-season N.

Growing Season Precipitation

Growing season (March 15 to October 15) precipitation totals and precipitation totals recorded two weeks before and two weeks after in-season N application are summarized for all 2005 demonstration sites in Table 7. Precipitation records were used from nearby National Weather Service weather stations. Weather stations were generally within 5 to 10 miles of demonstration sites. Precipitation to maintain moist soil during the critical period two weeks before and after UAN application, and move applied N into the rooting zone, should increase response to the in-season N application. Based on that assumption, we might expect greater response to in-season N at the Franklin, Guthrie, and Page field sites in 2005 relative to the Boone, Monona, and Shelby county sites, which received less precipitation during the two weeks after in-season N application. Several other sites had over two inches of precipitation after the in-season N application, but less precipitation before application.

Corn Grain Yield Response to N Fertilizer Rate and Timing – 2005 Corn-Soybean Sites

Corn yield level and response to N fertilizer rate/timing varied among corn-soybean sites in 2005 (Table 8). Corn yield increase with pre N application was statistically significant at all 2005 demonstration sites. Zero-N application (control) treatment strips yielded from 62 to 191 bu/acre, with an average yield of 138 bu/acre. Reduced pre N application (60 lb N/acre) treatment strips yielded from 118 to 207 bu/acre, with an average yield of 172 bu/acre. Corn yield response to the first 60 lb N/acre was statistically significant ($P \leq 0.10$) at 13 of 14 demonstration sites (Monona-1 fall-applied encapsulated urea site did not include a zero-N treatment), with yield increase at those sites ranging from 9 to 85 bu/acre. Agronomic pre N application (120 lb N/acre) treatment strips yielded from 154 to 216 bu/acre, with an average yield of 186 bu/acre. Corn yield response to increasing pre N from 60 to 120 lb N/acre was statistically significant ($P \leq 0.10$) at eight of 15 demonstration sites, with yield increase ranging from 4 to 48 bu/acre at those sites. Reference area pre N application (240 lb N/acre) treatment strips yielded from 154 to 220 bu/acre, with an average yield of 188 bu/acre. Corn yield response to increasing pre N from 120 to 240 lb N/acre was statistically significant at three demonstration sites (Dallas-2, Grundy, and Marshall), with yield increase ranging from 9 to 15 bu/acre. Overall, the Mahaska site was least N-responsive in 2005, with 8 bu/acre separating zero-N and adequate-N rate yield averages. The Grundy (114 bu/acre increase from zero-N to adequate-N rate yield averages), Marshall (92 bu/acre increase), Dallas-2 (89 bu/acre increase), and Page (80 bu/acre increase) sites were most N-responsive in 2005.

The 60+ treatment strips (in-season application average 49 lb N/acre, range 30 to 85 lb N/acre; total-N rate average 109 lb N/acre, range 90 to 145 lb N/acre) yielded from 137 to 204 bu/acre, with an average yield of 177 bu/acre. In-season N was applied to 60+ treatment strips at 13 sites, as called for by plant N stress sensing. Corn yield response to in-season N (versus pre N application of 60 lb N/acre with no in-season N) was statistically significant ($P \leq 0.10$) at five of 13 sites; yield responses included -9 (Shelby-2), 7 (Boone), 17 (Dallas-2), 21 (Grundy), and 32 bu/acre (Marshall), respectively. The reason for the negative yield response at the Shelby-2 site is unknown, as no apparent crop damage was noted after high-clearance UAN application. The 60+ treatments yielded less than the 120 lb N/acre pre rate at six of 13 sites in 2005 (average 15 bu/acre less). The need to apply in-season N to the 60 lb N/acre pre rate was correctly identified by plant N stress sensing at 11 of 13 sites. Yield increase from in-season N was significant at four of 13 sites, and this strategy (60+ treatment) returned yield as high as the 120 lb N/acre pre rate at three of 13 sites. This means full yield recovery from the N stress was achieved at three sites. There was no increase in yield with N rates above 60 lb N/acre at either Monona site, suggesting that in-season N applications based on plant N stress sensing were not needed; alternatively, rainfall deficits near the time of in-season N application and throughout the growing season limited corn yield potential and corn plant

N uptake. Plant N stress sensing suggested the need for 35 lb N/acre of in-season N at the Mahaska site; however, corn height made high-clearance N application at the Mahaska site impossible. There was no increase in yield with N rates above 60 lb N/acre at the Mahaska site, meaning the in-season N application was not needed. Plant N stress sensing at the Greene site correctly identified that in-season N application was not needed beyond 60 lb N/acre.

Plant sensing in the 120+ treatment indicated need for in-season N application at the Monona-2 (+15 lb N/acre; 135 lb total-N/acre), Marshall (+20 lb N/acre; 140 lb total-N/acre), Shelby-1 (+30 lb N/acre; 150 lb total-N/acre), and Shelby-2 (+45 lb N/acre; 165 lb total-N/acre) sites. Corn yield response to in-season N was statistically significant ($P \leq 0.10$) at only the Shelby-2 site, where yield response to extra N was -9 bu/acre; as noted previously, the reason for the negative yield response is unknown as no apparent crop damage was noted after high-clearance UAN application. At the other sites, plant sensing of the 120 lb N/acre pre agronomic rate did not indicate additional N need, which was correct as no statistical difference in yield was measured between the pre 120 and 240 reference N rates.

Corn Grain Yield Response to N Fertilizer Rate and Timing – 2005 Corn-Corn Sites

Corn yield level and response to N fertilizer rate/timing varied among corn-corn sites in 2005 (Table 9). Corn yield increase with pre N application was statistically significant at all 2005 demonstration sites. Zero-N application (control) treatment strips yielded from 103 to 154 bu/acre, with an average yield of 129 bu/acre. Reduced pre N application (90 lb N/acre) treatment strips yielded from 171 to 198 bu/acre, with an average yield of 189 bu/acre. Corn yield response to the first 90 lb N/acre was statistically significant ($P \leq 0.10$) at all three corn-corn demonstration sites, with yield increases ranging from 43 to 68 bu/acre. Agronomic pre N application (180 lb N/acre) treatment strips yielded from 188 to 207 bu/acre, with an average yield of 199 bu/acre. Corn yield response to increasing pre N from 90 to 180 lb N/acre was statistically significant ($P \leq 0.10$) at two of three demonstration sites, with yield increases of 10 and 17 bu/acre at those sites. Reference area pre N application (270 lb N/acre) treatment strips yielded from 191 to 207 bu/acre, with an average yield of 201 bu/acre. Corn yield response to increasing pre N beyond 180 lb N/acre was not statistically significant at any 2005 corn-corn demonstration site. Among 2005 corn-corn sites, the Franklin site was least N-responsive, with 46 bu/acre separating zero-N and adequate-N rate yield averages. The Shelby site was more N-responsive, with 67 bu/acre separating zero-N and adequate-N rate yield averages; however, yields did not respond to additional N beyond the 90 lb N/acre reduced pre N rate. The 2005 Wright site (83 bu/acre separating zero-N and adequate-N rate yield averages) was the most N-responsive corn-corn demonstration site.

The 90+ treatment strips (in-season application average 63 lb N/acre, with 45 and 80 lb N/acre applied in-season, resulting in total-N rates of 135 and 170 lb N/acre at the Franklin and Shelby sites, respectively) yielded 178 (Shelby) and 201 bu/acre (Franklin). Corn yield response to in-season N (versus pre N application of 90 lb N/acre with no in-season N) was statistically significant ($P \leq 0.10$) at only the Shelby site, where applying 80 lb N/acre actually reduced average yields by 20 bu/acre. The reason for the negative yield response at the Shelby site is unknown, as no apparent crop damage was noted after high-clearance UAN application. Plant N stress sensing identified N deficiency and need for additional N application beyond the 90 lb N/acre pre N application at all three corn-corn sites; however, extended wet field conditions from mid to late July prevented in-season N application at the Wright demonstration site. The need to apply additional N in-season to the 90 lb N/acre pre rate was correctly identified by plant N stress sensing at the Franklin site, and yield increase from in-season N was sufficient to return yield as high as the 180 lb N/acre pre N rate. The need to apply in-season N to the 90 lb N/acre pre rate was incorrectly identified by plant N stress sensing at the Shelby site; since there was no increase in yield with N rates above 90 lb N/acre, the in-season N application was not needed.

Plant sensing of the 180 lb N/acre pre agronomic rate did not indicate additional N need at any 2005 corn-corn sites, which was correct as no statistical difference in yield was measured between the pre 180 and 270 reference N rates.

Summary

One of our project objectives is to evaluate corn yield response and economic returns using strategies of pre N rates versus pre rates plus in-season N application. We will make economic analyses of N application strategies after additional field sites are included in the dataset; however, some preliminary conclusions can be drawn from 2005 results. Corn yield response to increasing the pre N rate from 60 to 120 lb N/acre was statistically significant ($P \leq 0.10$) at eight of 15 corn-soybean demonstration sites, with yield increase averaging 21 bu/acre. At 12 of 15 demonstration sites the pre N rate of 120 lb N/acre produced top yields, or yields that were statistically the same as the site's top-yielding N treatment. The 60+ treatments yielded less than the 120 lb N/acre pre rate at six of 13 sites in 2005 (average 15 bu/acre less); at the seven other sites where in-season N was applied to the 60+ treatment in 2005, corn yield from 60+ and 120 lb N/acre pre rates were statistically similar. These 2005 results indicate an economic advantage to using the 120 lb N/acre preplant or early-sidedress application. These results indicate that a pre application of 120 lb N/acre may be more desirable with the strategy of N stress sensing in-season to determine if additional N is required.

Site history differences likely accounted for variable corn yield response to N at 2005 demonstration sites. The Franklin corn-soybean site, which was treated with poultry manure in the fall of 2001 and 2003, demonstrated minimal response to N beyond 60 lb N/acre; similarly, the Mahaska site, which was treated with liquid swine manure in the fall of 1999 and 2003, demonstrated minimal response to N beyond 60 lb N/acre. The Franklin corn-corn site, which was treated with poultry manure in the fall of 1999, 2000, and 2003, demonstrated minimal response to N beyond 90 lb N/acre in 2005. Perhaps in-season plant N sensing can help identify or confirm those situations when corn N response in a particular field, or field area, is much different than expected because of previous years' management practices.

Education Component and Outreach Activity:

The following outreach activities occurred at the project sites in 2005. Field signs indicating the project name, program, and cooperating organizations were located at many sites (Figure 5).

An important educational multiplier is the extensive use of the project information in extension programs. Between January 2005 and February 2006 the project leader made presentations integrating results of this project to 1450 people at 17 ISU Extension and agribusiness meetings.

2005 Field Days

In cooperation with producers, site cooperators, Iowa State University Extension staff, and the Iowa Department of Agriculture and Land Stewardship multiple late summer field days were conducted at demonstration sites in 2005. Local crop farmers, commercial fertilizer applicators, dealers, certified crop advisors (CCA's), and the general public attended the field days and viewed the demonstration sites. Following is a list of the field day activities.

Shelby County – September 7, 2005
Wright County – September 8, 2005
Page County – September 13, 2005
Webster County – September 15, 2005

Expected Benefits:

One, producer recognition of the demonstration project and importance of corn N rate/timing management as a result of visibility through field signage and field days; two, multiple cooperating and neighboring producers consider use of in-season N application as a direct result of their participation in the project; and three, enhanced and refined information about corn response to N rate application by producers, crop consultants, and N suppliers across Iowa.

Several project outputs are expected: 1) increased awareness of demonstration activities that reinforce the economic and environmental importance of corn N management; 2) through a strong producer-field specialist-agbusiness-agency cooperative practice demonstration program, extensive outreach information transfer mechanism to producers and agbusiness via field days and meetings, promotion of experiences learned through the demonstrations, and use of information learned for corn N management educational literature; and 3) improved understanding of corn yield response and economic return to in-season corn N management practices.

Additional Project Partners:

Iowa Crop Producers
Iowa State University and ISU Extension
Division of Soil Conservation, Iowa Department of Agriculture and Land Stewardship
HAGIE Manufacturing, Clarion, IA, providing HAGIE NTB High-Clearance N Toolbar
Platte Valley Equipment, Fremont, NE, providing NITRO High-Clearance N Toolbar
John Deere Ag Management Solutions, coordination of in-season aerial imaging efforts

Report Prepared By:

John Lundvall
Extension Program Specialist
Department of Agronomy
Iowa State University
(515) 294-5429
jlundval@iastate.edu

Figure 1. In-season corn nitrogen management strategies project demonstration sites, 2005.

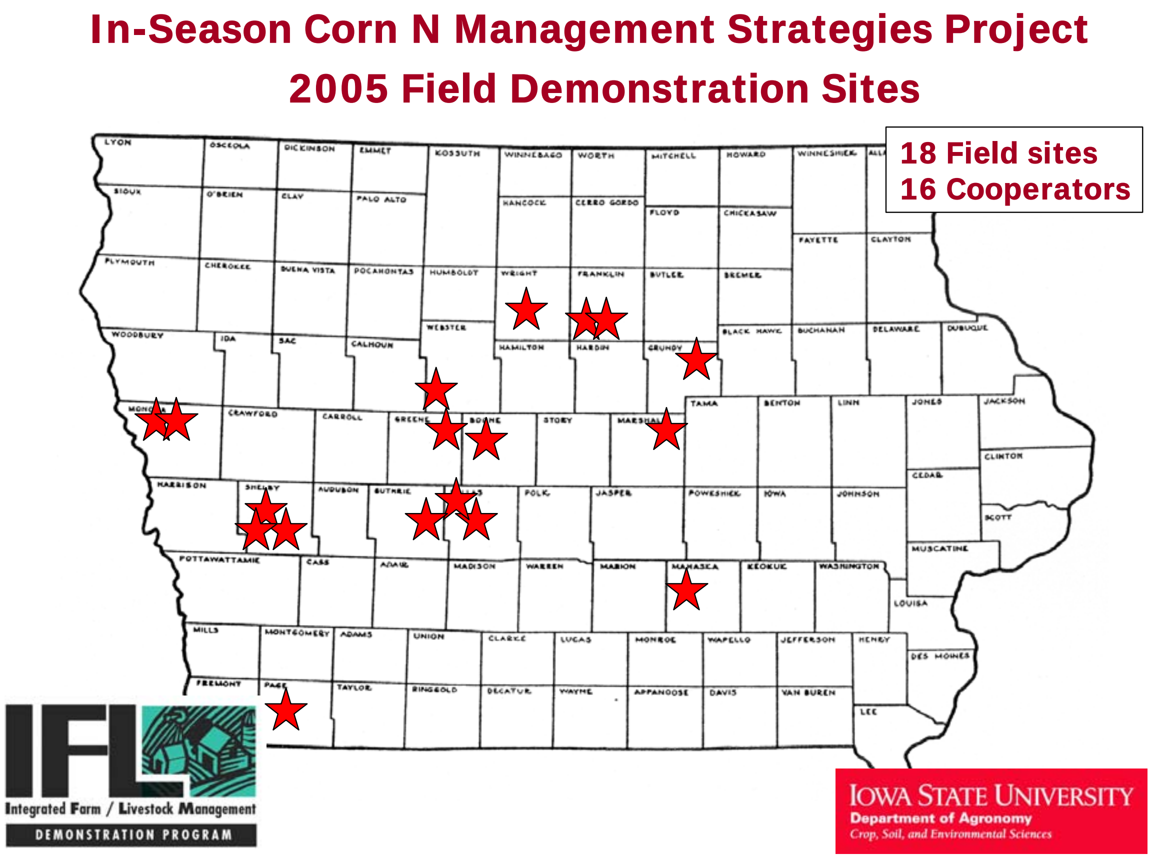

Figure 2. Demonstration of a SPAD chlorophyll meter measuring corn leaf greenness (N status).

Figure 3. Twelve row-wide, high-clearance nitrogen toolbar used to apply at-tassel N fertilizer in selected N treatment strips at a project demonstration site.

Figure 4. Mid-July view of corn response (leaf greenness) to field-length N rate strips.

Figure 5. Example project demonstration signage at a 2005 field site.

Table 1. Nitrogen application strategies, 2005 in-season corn N demonstration project.

Pre N rate†	In-season N Application	N Application Treatment	Treatment Identifier
lb N/acre			
0	- - - - -	Control	0
60 (90)	- - - - -	Pre reduced N rate	60 (90)
60 (90)	At rate determined in-season	Pre reduced + in-season N rate	60+ (90+)
120 (180)	- - - - -	Pre agronomic N rate	120 (180)
120 (180)	At rate determined in-season	Pre agronomic + in-season N rate	120+ (180+)
240 (270)	- - - - -	Pre well-fertilized reference N rate	240 (270)

† Corn-soybean rotation N rate (corn-corn rotation N rate). Pre refers to N applied preplant or early sidedress.

Table 2. Site characteristics, management, recent years' corn N application rate and crop yield history, 2005 in-season corn N project sites.

County-Site	Soil(s)	Tillage[†]	Yield History[‡] Corn	Yield History[‡] Soybean	Average N-Rate History[§]	Manure History
			- - - bu/acre - - -		lb N/acre	
Boone	Clarion, Canisteo, Nicollet	Conservation Tillage	174	51	150	None
Dallas-1	Nicollet, Webster, Clarion	Strip Tillage (Fall 2004)	149	47	135	None
Dallas-2	Nicollet, Clarion, Webster	Conservation Tillage	145	57	163	None
Franklin	Clarion, Webster, Nicollet	Conservation Tillage	165	51	145	Poultry - Fall 2001, 2003
Greene	Marna, Nicollet	Conservation Tillage	180	46	161	Dry Swine - Fall 2000
Grundy	Clyde, Floyd, Lawler	Conservation Tillage	177	53	128	None
Guthrie	Clarion, Nicollet	Conservation Tillage	170	51	135	None
Mahaska	Otley, Ladoga	Strip Tillage (Fall 2004)	172	56	163	Liq. Swine - Fall 1999, 2003
Marshall	Tama	No-Tillage	177	49	110	None
Monona-1	Luton	Strip Tillage (Fall 2004)	117	42	160	None
Monona-2	Luton	Strip Tillage (Fall 2004)	117	42	160	None
Page	Colo-Judson complex	No-Tillage	102	40	110	None
Shelby-1	Monona, Judson complex	Conservation Tillage	163	50	100	None
Shelby-2	Zook, Kennebec	Conservation Tillage	149	50	85	None
Webster	Nicollet, Webster, Canisteo	No-Tillage	175	49	150	None
Franklin-CC	Harps, Nicollet	Conservation Tillage	165	48	205	Poultry - Fall 1999, 2000, 2003
Shelby-CC	Judson-Nodaway-Colo complex	Conservation Tillage	149	48	145	None
Wright-CC	Webster, Canisteo	Conservation Tillage	185	43	173	None

[†] Tillage system for the current crop year.

[‡] Yield history is average of last five to six crop years. Fifteen 2005 demonstration sites were corn following soybean; three 2005 demonstration sites were corn following corn (sites identified as "CC").

[§] Nitrogen application history for the last two or three corn crops.

Table 3. Planting dates, pre-applied N and in-season N applications, 2005 in-season corn N project (corn-soybean) sites.

County-Site	Planting Date	Pre N Application Timing	Pre N N Source	In-Season N (UAN solution) Application, lb N/acre Application Timing	60+	120+
Boone	April 18	Preplant, December 4, 2004	Anhydrous ammonia	Drop nozzle-applied July 14 (R1)	60	- - -
Dallas-1	April 15	Preplant, March 8	Anhydrous ammonia	Drop nozzle-applied July 16 (R1)	35	- - -
Dallas-2	April 15	Preplant, March 23	Anhydrous ammonia	Drop nozzle-applied July 15 (R1)	55	- - -
Franklin	April 28	Early-sidedress, June 2 (V4)	Anhydrous ammonia	Coulter-injected July 19 (R1)	30	- - -
Greene	April 18	Preplant, November 26, 2004	Anhydrous ammonia	No In-season N needed	- - -	- - -
Grundy	April 18	Preplant, April 5	Anhydrous ammonia	Drop nozzle-applied July 15 (R1)	70	- - -
Guthrie	April 15	Pre-emergence, April 15	Injected UAN solution	Coulter-injected July 14 (R1)	40	- - -
Mahaska	April 18	Post-emergence, May 30 (V4)	Broadcast UAN solution	In-season N not applied	- - -†	- - -
Marshall	May 2	Early-sidedress, June 21 (V6)	Injected UAN solution	Drop nozzle-applied July 13 (V13)	85	20
Monona-1	April 30	Preplant, October 8, 2004	Encapsulated urea (ESN)	Drop nozzle-applied July 11 (V15)	65	- - -‡
Monona-2	April 30	Post-emergence, May 21 (V2)	Broadcast UAN solution	Drop nozzle-applied July 11 (V15)	80	15
Page	May 3	Early-sidedress, May 31 (V3)	Injected UAN solution	Drop nozzle-applied July 16 (VT-R1)	60	- - -
Shelby-1	April 28	Pre-emergence, May 5	Broadcast UAN solution	Drop nozzle-applied July 15 (R1)	80	30
Shelby-2	April 27	Pre-emergence, May 5	Broadcast UAN solution	Drop nozzle-applied July 16 (R1)	55	45
Webster	April 18	Preplant, November 13, 2004	Anhydrous ammonia	Drop nozzle-applied July 25 (R2)	30	- - -

† Leaf greenness data collected at VT corn growth stage suggested adding 35 lb N/acre; corn height made high-clearance N application at R1 reproductive stage impossible.

‡ Leaf greenness data collected at V14 corn growth stage suggested adding 70 lb N/acre to 120+ treatment; however, no additional N was applied due to erratic leaf greenness data.

Table 4. Planting dates, and pre-applied N and in-season N applications, 2005 in-season corn N project (corn-corn) sites.

	Planting	Pre N		In-Season N (UAN solution) Application, lb N/acre		
County-Site	Date	Application Timing	N Source	Application Timing	90+	180+
Franklin-CC	April 29	Early-sidedress, June 6 (V3)	Anhydrous ammonia	Coulter-injected July 19 (R1)	45	- - -
Shelby-CC	April 30	Preplant, March 8	Anhydrous ammonia	Drop nozzle-applied July 16 (R1)	80	- - -
Wright-CC	April 29	Early-sidedress, June 6 (V4)	Injected UAN solution	In-season N not applied	- - -†	- - -

† Leaf greenness data collected at V15 corn growth stage suggested adding 45 lb N/acre; wet field conditions and corn height made high-clearance N application at R1 reproductive stage impossible.

Table 5. Effect of N application rate on average corn relative leaf greenness in field-length strips, 2005 in-season corn N demonstration project corn-soybean sites.

	N Application Treatment†					
Site, Corn Stage‡	None	60	60+	120	120+	240
	- - - - - - corn leaf greenness, relative to 240 lb reference N rate (%) - - - - - -					
Boone, V14	85	93	93	94	99	100
Boone, R3	81	92	96	96	100	100
Dallas-1, V13	77	95	95	97	97	100
Dallas-1, R3	66	91	92	96	97	100
Dallas-2, V13	77	91	94	99	101	100
Dallas-2, R3	67	85	93	98	97	100
Franklin, VT	88	95	96	99	99	100
Franklin, R3	78	89	95	96	99	100
Greene, VT	90	96	98	98	98	100
Greene, R3	82	94	95	97	97	100
Grundy, V15	77	89	93	97	98	100
Grundy, R3	66	84	91	96	95	100
Guthrie, V14	83	96	94	99	98	100
Guthrie, R3	73	92	90	96	99	100
Mahaska, VT	90	95	95	98	99	100
Mahaska, R3	- - -	- - -	- - -	- - -	- - -	- - -
Marshall, V13	81	89	89	99	95	100
Marshall, R3	67	84	95	98	96	100
Monona-1, V15	- - -*	92	92	91	91	100
Monona-1, R3	- - -*	99	98	97	90	100
Monona-2, V15	83	91	89	96	97	100
Monona-2, R3	88	94	102	97	100	100
Page, VT	75	92	88	103	103	100
Page, R3	63	92	98	98	98	100
Shelby-1, V14	86	90	90	95	96	100
Shelby-1, R3	92	93	99	100	101	100
Shelby-2, V15	82	95	92	95	92	100
Shelby-2, R3	87	93	99	96	92	100
Webster, VT	87	94	98	95	100	100
Webster, R4	85	95	96	96	96	100

† Refer to Tables 1 and 3 for description of N applications.

‡ Vegetative ("V") corn growth stages designate the number of fully-developed leaves present when "early" leaf chlorophyll meter data was collected; VT corn stage stage designates the tassel emergence stage. Reproductive ("R") corn growth stages designate the stage of reproductive grain development when "late" leaf chlorophyll meter data was collected.

* The Monona-1 field site did not include a zero-N treatment.

Table 6. Effect of N application rate on average corn relative leaf greenness in field-length strips, 2005 in-season corn N demonstration project corn-corn sites.

	N Application Treatment†					
Site, Corn Stage‡	None	90	90+	180	180+	270
	- - - - - - corn leaf greenness, relative to 270 lb reference N rate (%) - - - - - -					
Franklin-CC, V15	81	93	95	96	98	100
Franklin-CC, R3	83	93	100	100	97	100
Shelby-CC, V13	86	100	98	100	103	100
Shelby-CC, R3	75	96	96	100	97	100
Wright-CC, V15	77	91	96	95	98	100
Wright-CC, R3	71	95	95	101	100	100

† Refer to Tables 1 and 3 for description of N applications.

‡ Vegetative ("V") corn growth stages designate the number of fully-developed leaves present when "early" leaf chlorophyll meter data was collected. Reproductive ("R") corn growth stages designate the stage of reproductive grain development when "late" leaf chlorophyll meter data was collected.

Table 7. Precipitation totals, 2005 in-season corn N project sites.

	Precipitation		
County-Site	2 weeks before In-season N†	2 weeks after In-season N‡	March 15 to October 15
	- - - - - - - - - - - - - - - - inches	- - - - - - - - - - - - - - - -	
Boone	0.00	1.22	23.32
Dallas-1	0.82	2.57	17.49
Dallas-2	0.64	2.59	26.60
Franklin	0.75	4.07	28.92
Greene	"no in-season N applied at this site"		22.14
Grundy	0.33	4.67	29.79
Guthrie	2.37	2.49	30.26
Mahaska	"no in-season N applied at this site"		18.89
Marshall	0.58	2.87	30.90
Monona-1	0.70	0.75	20.53
Monona-2	0.70	0.75	20.53
Page	0.02	5.14	25.26
Shelby-1	0.05	1.93	19.21
Shelby-2	0.05	1.93	19.21
Webster	2.07	0.45	14.06
Franklin-CC	0.75	4.07	28.92
Shelby-CC	0.05	1.93	19.21
Wright-CC	"no in-season N applied at this site"		28.79

† Precipitation totals recorded at nearby weather stations during 2- week interval before in-season UAN application.

‡ Precipitation totals recorded at nearby weather stations during 2-week interval after in-season UAN application.

Table 8. Effect of nitrogen application rate on field-length strip corn grain yield, 2005 in-season corn N demonstration project corn-soybean sites.

	N Application Treatment[†]					
Site-Year	None	60	60+	120	120+	240
	- - - - - - - - - - - - -	- - - - - - -	- - - bu/acre	- - - - - - -	- - - - - - -	- - - - - - -
Boone	141a[‡]	172b	179c	182cd	180c	187d
Dallas-1	106a	148b	152bc	163cd	167d	160bcd
Dallas-2	112a	169b	186c	195d	201e	204e
Franklin	171a	192bc	187b	193c	192bc	195c
Greene	161a	189b	190bc	195bc	198c	196bc
Grundy	89a	174b	194c	197c	203cd	212d
Guthrie	164a	194b	201bc	206cd	207cd	213d
Mahaska	156a	173b	164ab	168b	168b	166ab
Marshall	116a	172b	204c	204c	208cd	215d
Monona-1	- - -*	155a	155a	156a	149a	158a
Monona-2	140a	150b	153bc	154c	151bc	154c
Page	62a	118b	137b	166c	143bc	142bc
Shelby-1	186a	207bc	196ab	216cd	211cd	219d
Shelby-2	139a	157c	148b	158c	149b	159c
Webster	191a	198ab	190a	202b	198ab	202b

[†] Refer to Tables 1 and 3 for description of N applications.

[‡] Yields at each site are not significantly different when followed by the same letter ($P \leq 0.10$).

* The Monona-1 field site did not include a zero-N treatment.

Table 9. Effect of nitrogen application rate on field-length strip corn grain yield, 2005 in-season corn N demonstration project corn-corn sites.

Site-Year	N Application Treatment†					
	None	90	90+	180	180+	270
	bu/acre					
Franklin-CC	154a‡	197b	201bc	207c	200bc	207c
Shelby-CC	131a	198b	178c	202b	198b	204b
Wright-CC	103a	171b	173bc	188cd	186bcd	191d

† Refer to Tables 1 and 3 for description of N applications.

‡ Yields at each site are not significantly different when followed by the same letter ($P \leq 0.10$).