PROGRESS REPORT 2005

Variable Source N Fertilizer Applications to Optimize Crop N Use Efficiency

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Accomplishments for First Year:

Research was initiated in 2005 to determine methods to delineate and map areas in fields which are more vulnerable to N loss due to wet conditions, to examine the use of a *variable-source* strategy to optimize crop N fertilizer use efficiency and, to calculate the cost-effectiveness of using this *variable-source* strategy compared to uniform applications of conventional or other N fertilizer sources.

Two field trials were initiated in 2005 at the MU Greenley Experiment Station and in a farmer's field in Centralia (Fig. 1A&B). Both sites were mapped for elevation and apparent electrical conductivity (EC_a) using a EM-38 sensor (Fig. 1A&B). Measurement of soil EC_a gives an indication of relative depth to the claypan subsoil layer (Kitchen et al., 1999). Soil gravimetric water content was determined on 6 in depth soil samples collected in a 10 by 25 ft grid over the Greenley site on March 31st in order to compare the effects of spatial distribution of elevation and EC_a on the distribution of soil water content.

At the Greenley site, N fertilizer treatments included a control and 150 lb N/acre of either urea, polymer-coated urea (ESN, Agrium, Inc.), a 50% urea/50% polymer-coated urea mixture, or anhydrous ammonia were injected or broadcast-applied and incorporated in 10 m by 1500 ft strips across three landscape positions representing shallow, deep and low-lying areas (Fig. 1A). At the Centralia site, N fertilizer treatments of 150 lb N/acre of either urea or polymer-coated urea (ESN, Agrium, Inc.) were broadcast surface-applied in 15 by 1470 ft strips across landscape positions representing shallow and deep areas (Fig. 1B).

Corn (*Zea mays.* L.) silage and grain yields were determined at each site. Site harvest locations are shown in Fig. 1A&B. Total aboveground biomass tissue samples at harvest and periodically during the growing season were taken and are currently being analyzed for total N content in order to determine fertilizer N use efficiency.

The rate of soil N_2O gas loss or efflux was also measured periodically over the growing season at the Greenley site for each N fertilizer treatment and landscape position. Soil N_2O gas was collected using small sealed chambers fitted with rubber septa inserted into PVC collars in the soil. The head space gas was collected from the chambers in the different treatments and analyzed by gas chromatography (GC).

Rainfall during the 2005 cropping year was relatively low during the growing season at both field sites with a long period of drought after the middle of July (Fig. 2 A&B). Despite similar cumulative rainfall (an average of 342 mm or approximately 13.4 in) at both sites, the Greenley site (Fig. 2A) had better rainfall distribution than the Centralia site (Fig. 2B), and, therefore, crop growth and crop N fertilizer response was greater at the Greenley site compared to that of Centralia.

Measurement of the spatial distribution of soil water content in the top 6 in depth at the Greenley site was undertaken prior to planting to evaluate whether measurements of elevation and EC_a would assist in predicting spatial differences in soil water content that might affect the fate of applied N fertilizer. Initial evaluation of the distribution of surface soil water content (Fig. 3), suggests that elevation may be a better predictor of spatial patterns of surface soil water content. However, this analysis did not take into account the possible effect of differences in soil water availability deeper in the soil profile on the fate of applied N fertilizer. In claypan soils, the amount of available water in the soil profile is probably affected by the depth to the claypan layer which is a property related to soil EC_a.

At the Greenley site, visual symptoms of plant N deficiency were observed both in control plots and in low-lying areas, possibly due to water collecting in those areas from spring and early summer rainfall. However, lack of sufficient water for crop growth after the middle of June also affected corn growth response to added N fertilizer at both field sites. Grain yields at Greenley increased 19.9 to 46.2 bu/acre with added N fertilizer at the summit (shallow) and low-lying landscape positions (Table 1). The polymer-coated urea (ESN) and anhydrous ammonia had grain yields that were 24.4 and 23.5 bu/acre greater than urea in the low-lying area and had the highest yields of all the N sources in the low-lying area (Table 1).

Silage yields observed at the Centralia site were highest in the footslope (deep) area and no effects of the different N fertilizer sources were observed (Table 2). Relatively higher amounts of available water in the deeper soil profile during the drought period may account for the landscape response and lack of N response at the Centralia site.

Summary:

Both polymer-coated urea and anhydrous ammonia had higher grain yields compared to urea in the low-lying area at Greenley. However, there were no differences among these fertilizer sources at the other landscape positions, which suggests that response to N fertilizer source may vary across fields depending on landscape position.

Yield response at Centralia was apparently due to relative differences in soil water storage between soils with different depths to the claypan layer and not due to applied N sources. Surface application of the N sources at Centralia versus incorporation of N sources at Greenley may also have been a factor.

This first year of research indicates that the concept of variable source application may have some validity for N fertilizer management. However, further research is required under wetter climatic conditions when risk of N loss is higher.

Outreach and Training:

An undergraduate student majoring in soil science has been involved in working on this project as part of their training. The first year research results were presented at the 2005 American Society of Agronomy National Meetings and to growers and agricultural professionals at the 2005 Greenley Center Field Day in Northeast Missouri.

Objectives for Year 2:

The objectives for the second year of this research will continue similar to the first year. These objectives are:

1. To determine methods to delineate and map areas in fields which are more vulnerable to N loss due to wet conditions.
2. To examine the use of a *variable-source* strategy to optimize crop N fertilizer use efficiency.
3. To calculate the cost-effectiveness of using this *variable-source* strategy compared to uniform applications of conventional or other N fertilizer sources.

The field studies will be repeated for a second year to assess variation in climate on crop performance and N use efficiency in response to the differences between the two sites, the N fertilizer sources and the landscape positions that represent different elevations and depths to the claypan layer. In addition, we will be testing whether elevation and soil EC_a are useful predictors of differences in soil water in the field to allow for variable source applications of different N sources. An economic analysis will be also conducted to determine whether use of this strategy would be cost-effective for Missouri farmers.

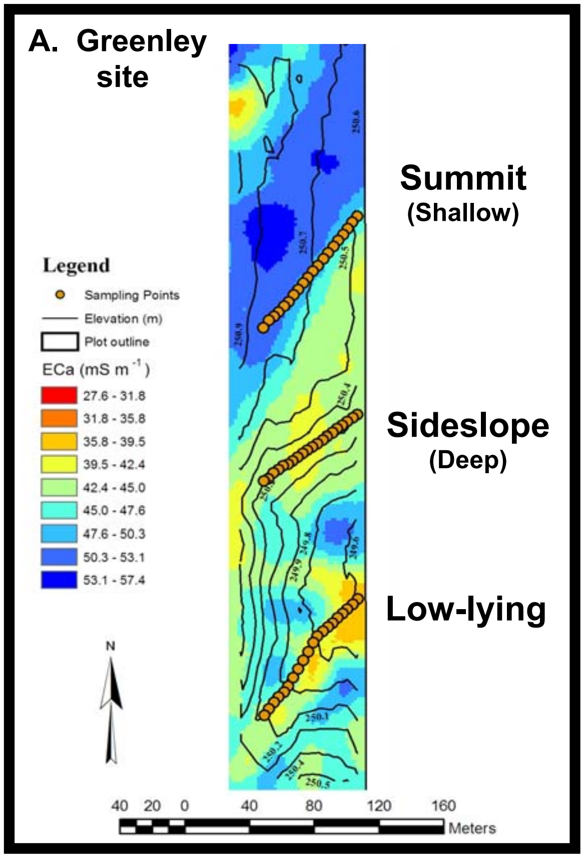
Table 1. Effects of N fertilizer source and landscape position on corn grain yields at the Greenley site

N Fertilizer Treatment	Landscape Position: Summit	Sideslope	Low-lying	$LSD_{(0.05)}$
	bu/acre			
Control	73.6	72.3	71.0	NS
Urea	93.5	79.1	92.8	NS
ESN	94.0	73.9	117.2	29.5
ESN/Urea	95.1	77.2	104.2	NS
Anhydrous	100.6	88.7	116.3	24.1
$LSD_{(0.05)}$	8.7	NS*	19.6	

*NS = not significant

Table 2. Effects of N fertilizer source and landscape position on silage yields at the Centralia site.

N Fertilizer Treatment	Landscape Position: Summit (Shallow)	Footslope (Deep)	$LSD_{(0.05)}$
	tons/acre		
Urea	4.71	8.19	1.04
ESN	4.38	8.38	1.46
$LSD_{(0.05)}$	NS	NS	



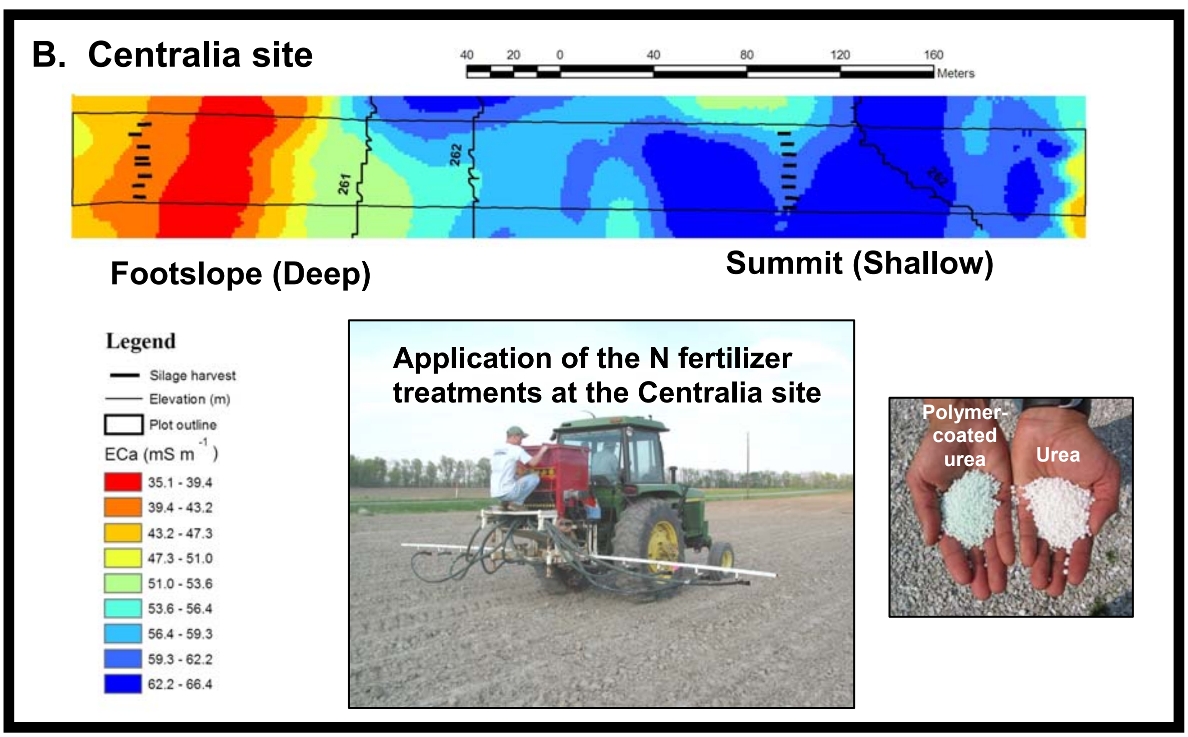


Fig. 1 A & B. Maps showing the spatial distribution of elevation and EC_a at the A) Greenley and B) Centralia farm sites. Circles in the Greenley site map show the location of the sampling collars for soil N_2O gas loss and the approximate location for the grain and silage harvests. The lines in the Centralia map show the location of the silage harvest.

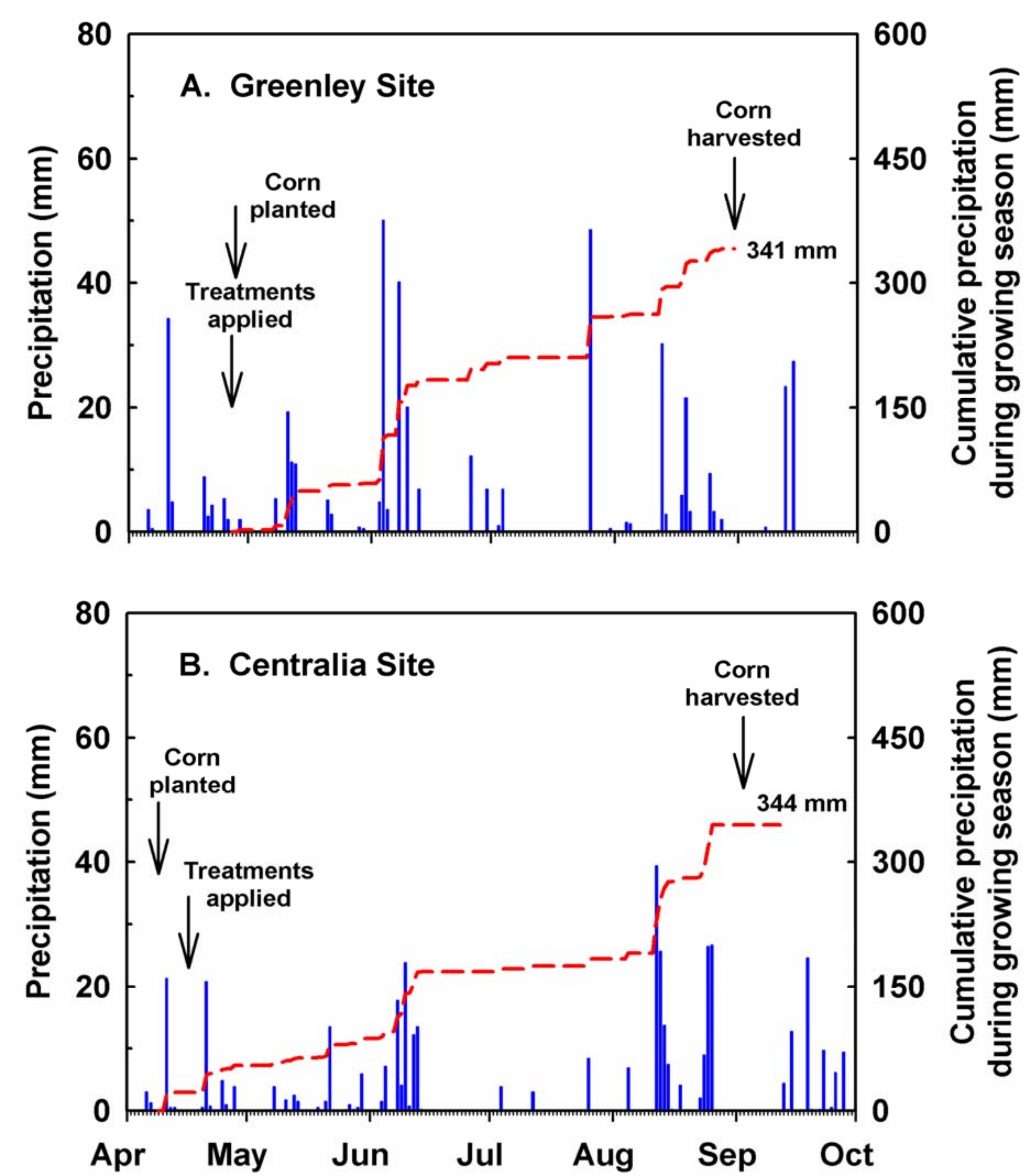


Fig. 2 A & B. Daily and cumulative precipitation at the A) Greenley and B) Centralia sites. Figures also show the times of important cropping events in relation to rainfall.

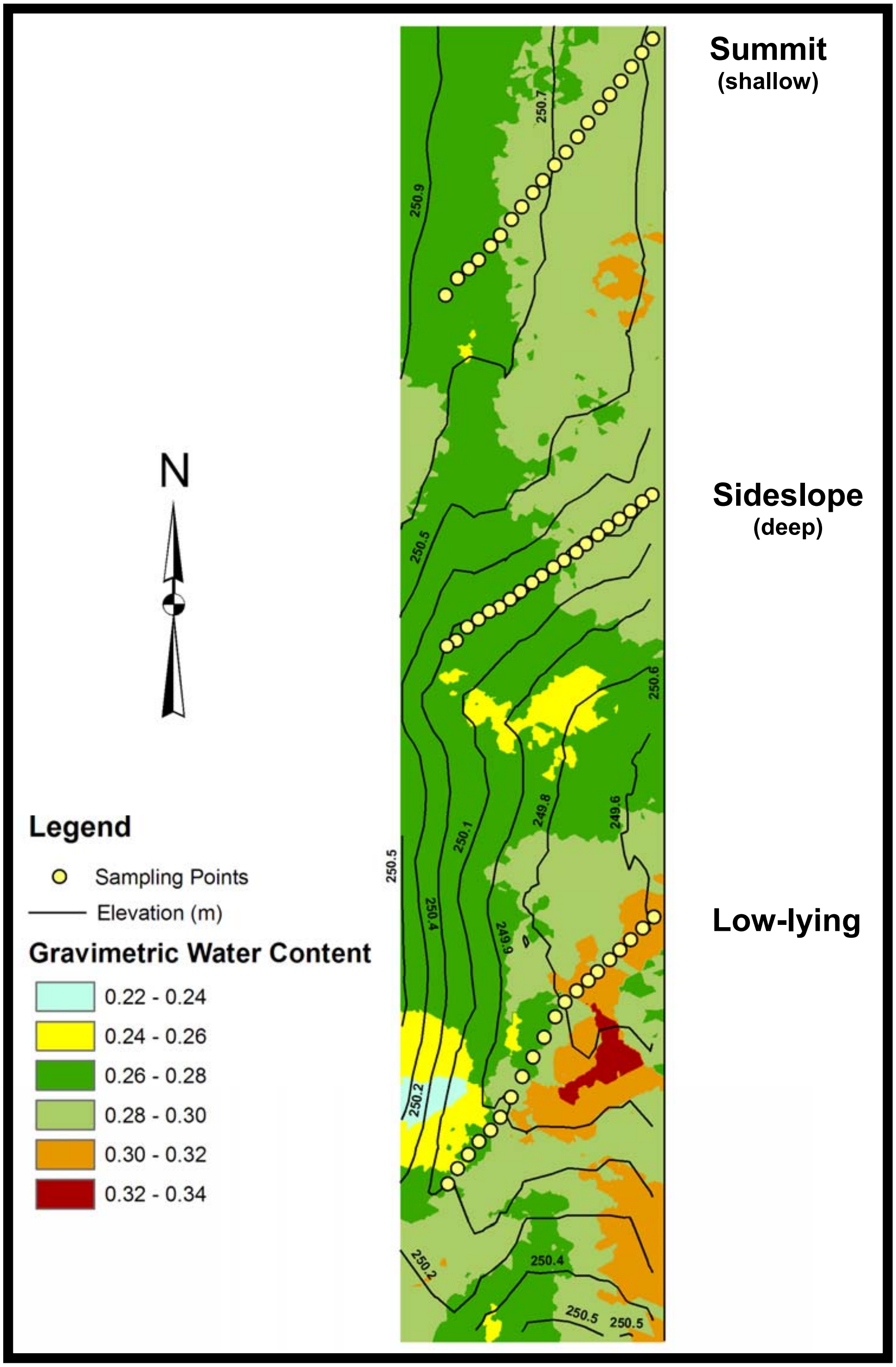


Fig. 3. Spatial distribution of soil gravimetric water content at the Greenley site on March 31st.

<u>Proposed Budget for Year 2</u>:

CATEGORIES	YEAR TWO
A. Salaries Research Technician (50%)	 $13,390
B. Fringe Benefits Fringe for research specialist	 $3,922
TOTAL SALARIES AND FRINGE BENEFITS	$17,312
C. Travel Travel to field site Travel to professional meeting	 $375 $300
TOTAL TRAVEL COSTS	$675
D. Equipment	$0
TOTAL EQUIPMENT COSTS	$0
E. Other Direct Costs Laboratory reagents and supplies Field supplies Publications/Documentation	 $2,000 $1,500 $500
TOTAL OTHER DIRECT COSTS	$4,000
TOTAL REQUEST	$21,987

<u>Justification:</u>
Salaries and Fringe Benefits: Funds are requested for support of a research technician (50% time@ $26,000/year the first year). Fringe benefits for the technician are 28.26% for the first year and 29.29% the second year.

Travel: Covers cost of travel to the Greenley Research Center and the two field sites at a rate of 37.5 ¢/mile. In the second year, $300 is requested to cover cost of travel and board for one researcher to attend a professional conference for presentation of results.

Laboratory Reagents and Supplies: Covers cost of laboratory reagents, sample containers, and other materials used in soil and plant tissue analyses.

Field: Cost of fertilizer, seed, plot preparation, planting, weed control and harvesting, soil samplers, flags, pots and other field supplies and operations.

Publications/Documentation: Defrays cost of publication and documentation of results and conclusions.