# Nitrogen Management in Irrigated Corn Using Remotely-Sensed Imagery and Small-Plot Experiments

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## Introduction

Nitrogen management for irrigated corn (*Zea mays L.*) grown along the Arkansas River Valley in Kansas is a concern due to the highly leachable soils and high water tables (ranging from 10-50 ft). Irrigated corn usually requires a high input of N fertilizer to achieve maximum yields, and most farmers in this area have been applying a uniform rate of nitrogen across their fields every growing season based on the following KSU N recommendation.

N Rec = [YG * 1.35 lbs $bu^{-1}$] STA - PCA - PYM - PNST

N Rec—nitrogen recommended (lbs $acre^{-1}$)
YG—a realistic yield goal (bu $acre^{-1}$)
STA—soil texture adjustment (1.1 for sandy soils and 1.0 for medium and fine textures)
PCA—previous crop adjustment
PYM—previous years manure
PNST—profile nitrogen soil test

(Kansas State University, AES, and CES, 1994)

Applying a uniform N rate over an entire field may result in an over-application in areas of high soil profile N content and/or low yield potential, or an under-application in areas of low soil profile N content and/or high yield potential. An over-application of N increases the risks for N leaching into the groundwater while an under-application may result in less-than-potential yield. With the availability of site-specific technologies, these risks associated with an N application can be minimized.

Nitrogen mineralization is an important part of N management. Soil organic matter (SOM) mineralizes during the growing season, increasing the inorganic N in the soil available for plant uptake. If mineralization can be accurately predicted, this would help the producer lower his overall N input from inorganic sources, which should result in less leaching of nitrates into the groundwater. This is especially true for farmers in south central Kansas where there are course-textured soils which are susceptible to nitrate leaching. Scheier (1988) demonstrated that aerial photographs can be used to successfully quantify SOM. If N mineralization can be related to SOM content, then an aerial photograph could serve as a proxy for soil N availability.

Infrared aerial photography, a remote sensing tool, can also be an effective tool for monitoring crop stresses such as nutrient deficiencies, pest damage, and water stress during the growing season (Silva, 1998). Light reflectance in the visible wavelength (400-700 nm) increases as the amount of chlorophyll decreases because of the ability of chlorophyll to absorb visible light. Using aerial imagery to define the spots of high and low chlorophyll levels can tie a direct correlation to N deficiency. However, N deficiencies can be detected using aerial imagery only if areas of sufficient N are used as a reference level (Blackmer, 1996). If N stress is observed prior to sidedressing, then additional units of N can be subsequently applied to solve the deficiency. Finding areas

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of N deficiency in the field can help the farmer adjust his N recommendation on a field to field basis thus leading to improved N use efficiency.

The objective of this project is to increase N use efficiency for irrigated corn using site specific management. This includes characterizing the spatial distribution of potentially mineralizable nitrogen (PMN) through remote sensing and small plot research, minimizing the amount of nitrates leaching into the groundwater and maximizing yield.

## Materials and Methods

The study was conducted on four, 130-acre irrigated, continuous corn fields in south central Kansas. Each field was divided into 160 ¾-acre grid cells. Small plots were located in each field in two to four areas selected to represent the range of SOM levels in the field. Experimental design for each small plot was a randomized complete block design using five N rates (0, 75, 150, 225, and 300 lb N acre$^{-1}$) with four blocks. The N source was ammonium nitrate, topdressed immediately after planting. An additional 47 lb N acre$^{-1}$ was also applied by the cooperator to both locations at this field site. At planting, 25 lb N acre$^{-1}$ was applied as APP. There was also 22 lb N acre$^{-1}$ applied after R1 through the centerpivot irrigation system as 28% UAN.

Soil samples (0-12 in) were collected from each N treatment within the small plots at preplant (before fertilizing), V8, V12, and R1. Samples were dried at 105°F, ground to pass a 2 mm stainless steel sieve, and analyzed for total inorganic N using a 2 *M* KCL extraction. Chlorophyll meter readings and tissue samples were collected from the most fully developed leaf at V8 and V12, and the leaf below and opposite the ear at R1. All leaves were dried at 120°F, ground to pass a 2 mm sieve using a stainless steel mill, and analyzed for total N content. At VT and physiological maturity, plants from 8 ft of row were collected within each N treatment and weighed. After weighing, the sample was chopped and a subsample was collected for determining total dry weight and N content. At physiological maturity, grain yield was calculated based on harvesting two 15-ft rows within each N treatment. Following harvest, four-ft soil samples (1-ft increments) were collected from the 0,150, and 300 lb N acre$^{-1}$ treatments for determination of residual N.

Infrared aerial photographs were taken of each field at the following growth stages: preplant, V8, V12, and R1. The images were then separated into three bands (infrared, red, and green) and pixel values were obtained for each band at approximately 3 ft resolution. For each ¾-acre grid cell, an average pixel value was calculated for each band within 5 ft of the center point for the preplant images. A 15 ft radius was used for the various growth stage images.

Data was evaluated using General Linear Models (GLM) procedures (SAS Institute, 1990). The F tests for analyses of variances were considered significant at the 0.05 probability level.

Data presented here represent initial results from 1998 at one field site. Soil at this field site was mapped as a Pratt-Carwile loamy fine sand (Sandy, mixed, thermic Cumulic Haplustolls and Fine, mixed, thermic Typic Argiaquoll, respectively) (Dodge, 1981).

## Results and Discussion

Soil $NO_3$-N content (0-12 in) for within-field Location A9 (V8 growth stage) increased from 6.3 to 36.6 ppm as N rates increased from 0 to 300 lb N acre$^{-1}$ (Fig. 1). This response was similar to the other Location, D13, in which soil $NO_3$-N increased from 6.6 to 55.8 ppm $NO_3$-N. Although the soil $NO_3$-N content for Location D13 appeared to increase more rapidly with N rates than compared to Location A9, there was not a significant Location by N rate interaction. However, the average soil $NO_3$-N content for Location D13 was 10 ppm greater than the average soil $NO_3$-N content for Location A9. Coinciding with the greater amount of soil $NO_3$-N content, SOM content for Location D13 was 2.4%, compared to 1.4% for Location A9. Pre-plant soil $NO_3$-N content was similar for both Locations, 4.75 ppm for Location D13 and 4.1 ppm for Location A9. Greater soil $NO_3$-N content early in the growing season (V8 growth stage) coincided with an area of the field with greater SOM, implicating greater N mineralization at Location D13.

Leaf N content response as a function of increasing N treatments depended on Location within the field. For Location A9 (SOM = 1.4%), leaf N content increased from 3.26% to 3.96% as N rates increased from 0 to 300 lb N acre$^{-1}$ (Fig. 2). Whereas for Location D13 (SOM = 2.4%), leaf N content ranged from 3.69% to 3.96%. These results indicated that a greater amount of N was available with the control treatment for the location with greater OM.

Chlorophyll meter (SPAD) readings at V8 reflected similar trends as the soil $NO_3$-N content and leaf N content at V8. Greater average SPAD reading (56.4) for Location D13, compared to 52.2 for Location A9, corresponded to greater leaf N content for Location D13 (compare Figs. 2 and 3). For both Locations, SPAD readings increased with increasing N treatments, but there was not a significant Location by N rate interaction effect.

Yield for Location D13 averaged 25 bu acre$^{-1}$ more than yield for Location A9 (Fig. 4). Increasing N rates did not affect yield at either Location, indicating that N was sufficient for optimum yield. However, for Location A9, yield for the control treatment was visually less than the other N rates.

## Summary

Two locations within one field were selected to represent the range of SOM content in this field. The SOM content for Location D13 was 2.4% compared to 1.4% for Location A9. Coinciding with the greater SOM content, soil $NO_3$-N content at V8 averaged 10 ppm greater, leaf tissue content at V8 averaged 0.12% greater, SPAD readings at V8 averaged 4.2 units greater, and grain yield averaged 25 bu acre$^{-1}$ greater than the corresponding parameters for the lower SOM location. Greater N mineralization

for the location with greater SOM was implicated as the source of the additional available N. These preliminary results suggest that SOM could be used as an indicator for potentially mineralizable N on this field.


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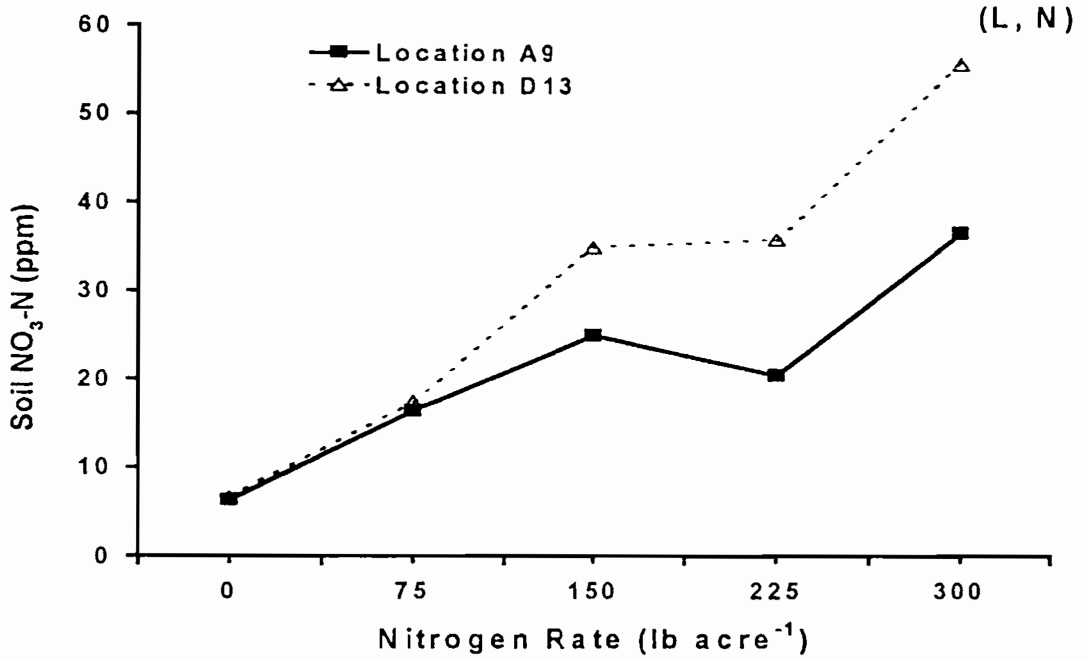


Figure 1: Soil $NO_3$-N at V8 as a function of applied N for two locations in one field. L and N indicate significant Location and N treatment effects, respectively.

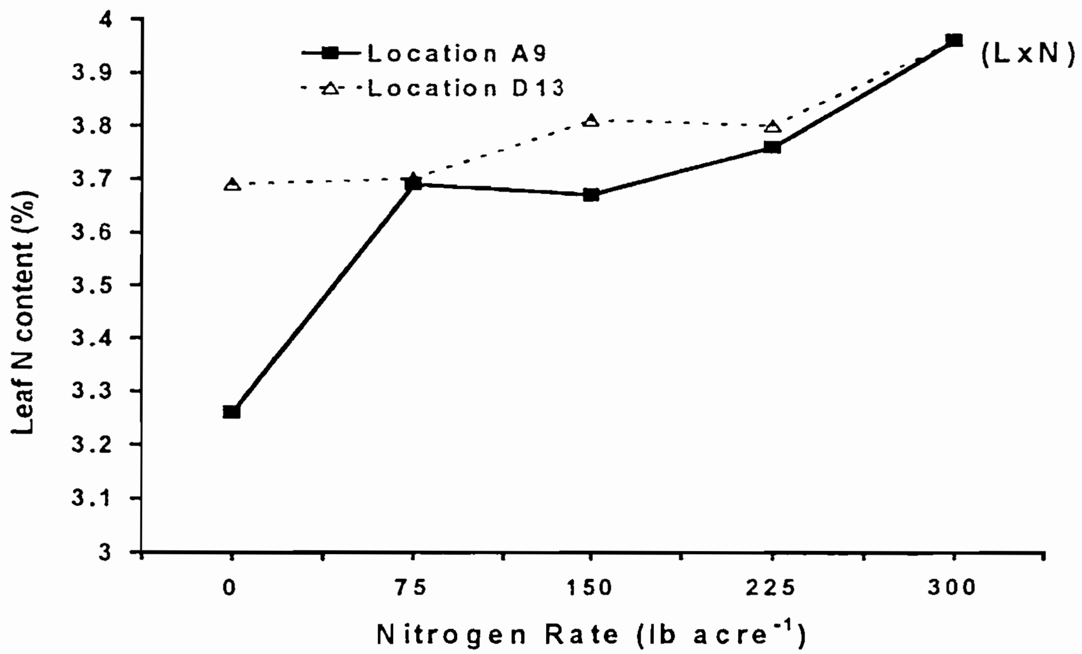


Figure 2: Leaf N content at V8 as a function of applied N for two locations in one field. LxN indicates significant Location x N treatment interaction effect.

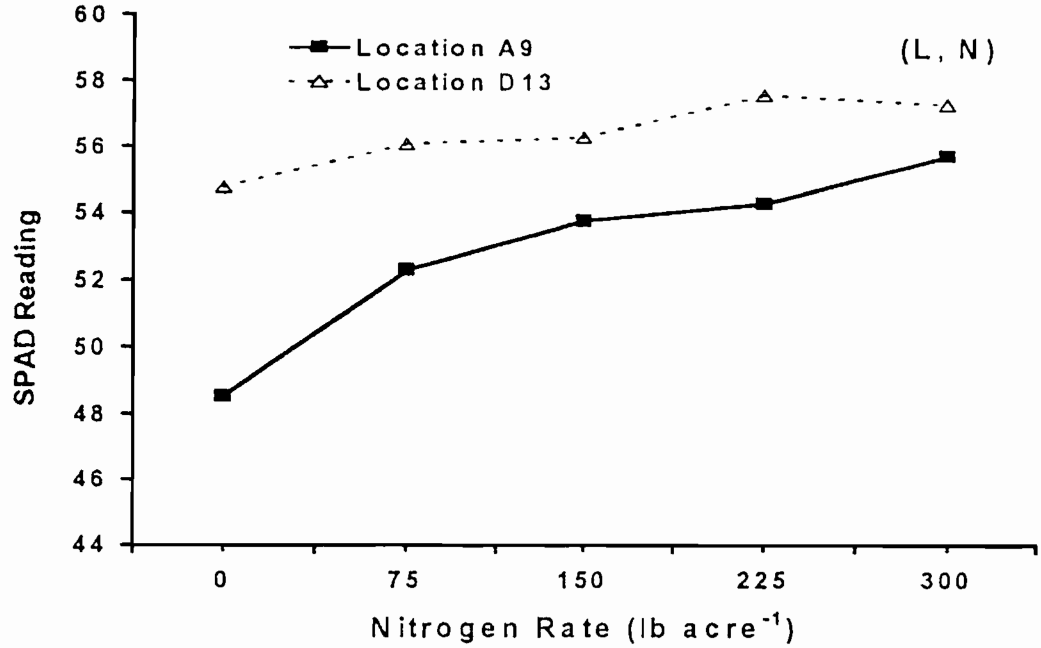


Figure 3: Chlorophyll (SPAD) reading at V8 as a function of applied N for two locations in one field. L and N indicate significant Location and N treatment effects, respectively.

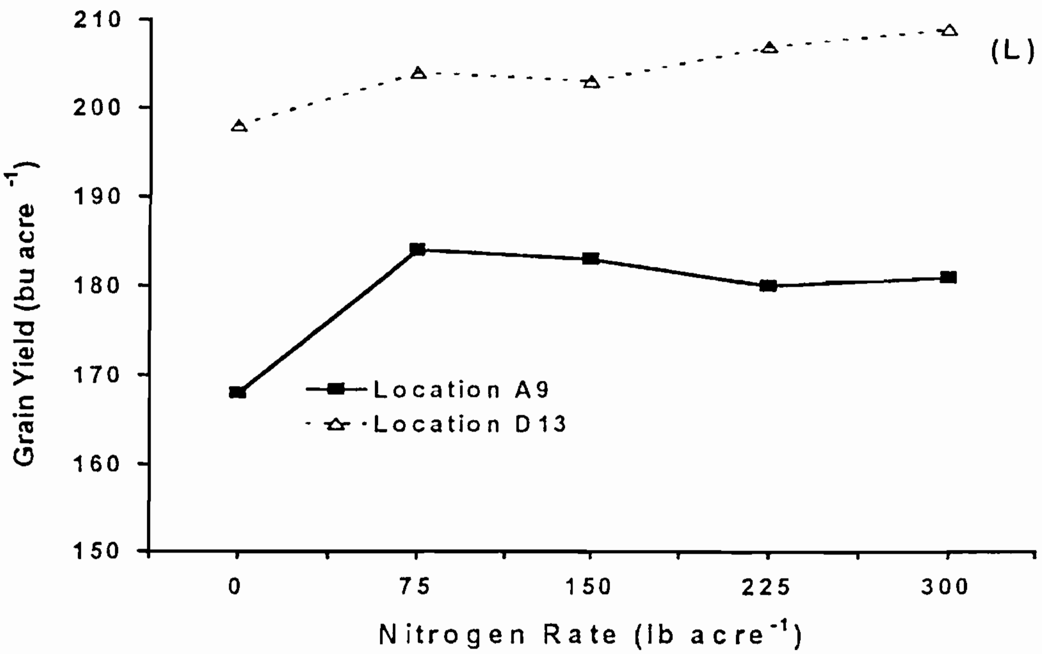


Figure 4: Grain yield as a function of applied N for two locations in one field. L indicates significant Location effect.

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