Research Techniques Using Precision Agriculture Technology

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INTRODUCTION

Burdened by high production costs and increased environmental concerns, today's farmers are looking for new technologies that can help optimize their production Efficiency. Site-specific fanning is a technique to describe what some are calling the next major revolution in production agriculture which has the potential to address many of these concerns. An experiment was conducted in 1995 to document site-specific yield response of corn *(Zea mays* L.) For different application rates of N fertilizer within soils with varying yield potentials. To accomplish this task, new technologies such as Global Positioning System (GPS), Geographic Information Systems (GIS), grain yield monitoring and variable rate control were integrated into an overall system. A 22-a no-till production corn field located in Milan, Tennessee was selected for this study. Prior to planting an extensive soil survey was conducted and the field was classified based on varying levels of yield potential. Five different application rates of N were applied on the field using a variable rate applicator controlled by a laptop PC with control information being received in real-time from a GPS receiver and digital application map. Soil nutrient samples, leaf N samples, and plant population samples were collected through the season.

MATERIALS AND METHODS

The experiment was conducted at the University of Tennessee Milan Experiment Station. The test field had a total area of 22.5 a and had been continuously used for agricultural research. In the past 10 yr it has been in a corn/wheat *(Triticum aestivum* L.)/soybean *(Glycine max* [L.] Merr.) No-till rotation. In February 1993, 2,204 lb/a of lime were applied to the field test. On 15 March 1995, 80 lb/a of P_2O_5 and K_2O were applied in the field. Corn was planted on 5 April 1995. The cultivar used was 'FFR-943' with a population of 25,000 plants/a.

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Variable rates of liquid N fertilizer were the only treatments applied to the field. Five discrete rates were randomly applied using GPS and variable rate technology. Corn yield was recorded using a yield monitor and GPS equipment. All field data were later analyzed usinga GIS package for analysis of the effect of the various N. rates on corn yield by soil groups. Soils were mapped based on landscape features with a resulting variably sized grid pattern that averaged about 0.4 a. Properties expected to affect yields such as depth to fragipan percent slope, soil drainage, etc. were noted. Mapping units delineated are shown in Table 1

Fertilizer Application

A mixture of urea and ammonium nitrate, containing 32% N, was used as the N fertilizer source in the application. Based on an estimate that used 1.2 to 1.3 lb of N to produce one bu of grain corn and on the yield goal for each class of soils, five different rates were chosen: 0 lb N/a, 90 lb N/a, 120 lb N/a, 150 lb N/a, and 180 lb N/a. After calibrating the applicator based on a speed of 5.8 mph, row spacing of 30 in. and pressure of 40 PSI, the actual rates applied were: 0 lb N/a, 84 lb N/a, 127 lb N/a, 143 lb N/a. And 181 lb N/a.

A fertilizer applicator was adapted, capable of delivering five discrete rates through the combination of three different orifices. The applicator consisted of centrifugal pump with a maximum pressure output of 100 PSI and maximum flow of 90 GPM; a 200-gal tank, three pressure compensating solenoid values that controlled each of the three orifices; line strainers; pressure regulators, and five 20-in bubble coulters. The orifices were mounted in each row directly behind the coulters. The applicator was equipped with five coulter units. The desired rates were achieved through orifice combinations.

To expose all groups of soils to every N rate, the fertilizer was applied according to the following pattern; the field was divided into 22 strips parallel from north to south. Each strip had a width of 90 A. The applicator, equipped with a laptop, a single-board computer, and a GPS system, changed the rates every time it crossed the lines separating each sub-area.

The applicator was controlled by a laptop computer interfaced with a single-board computer (SBC). The laptop computer and the GPS receiver were located inside the tractor's cab. The laptop received information about the geographic position of the sprayer, looked up the desired application rate at that location, and sent the rate information to the SBC. The SBC calculated what orifice combination produced the desired rate and sent an electrical signal to the solenoid valves to open or close the required orifices. The laptop computer recorded each field position during the application, along with the rate applied. The files were later used to create maps of application in the area using GIS.

Yield Data Collection

The corn was harvested on 12 September 1995. A John Deere combine model 4425 with a four-row corn header was used in the harvest. A yield monitor and GPS receiver were used to record the corn yield and its geographic position. Data from the GPS receiver and yield monitor were recorded every second by the laptop PC. A program written in C-language captured the incoming data from both devices and stored it into ASCII format.

Yield Analysis

Yields were separated by Nrate, soil series, soil mapping unit, and previous yield potential grouping. Interactions between rates and series, rates and slope, rates and depth to fragipan, series and slope, series and depth, and slope and depth we found to be significant ($P<0.05$). This indicated the complexity of landscape-soil relationships to yield. Yield results were predicted correctly at each N rate from 84 to 181 lb/a when separated using criteria for potential yield soil groups in Table 2 compared to measured yield (Table 3). A preliminary economics analysis was performed to determine most profitable rate of N relative to yield measured for the mapping units.

CONCLUSIONS

Variable rate application of N in corn based on yield potential shows promise as a method for maximizing profit potential within a field. The variable rate applicator used in this research proved to be an effective system for varying liquid N at predetermined discrete rates. The commercially-available yield monitor proved to be an accurate method of documenting yield variability. The yield monitor was calibrated to an accuracy of 1.8%. The GPS receivers provided a very reliable system for geo-referencing data acquisition within the test field. With a local base station and real-time radio links for GPS, positional accuracy was maintained at one meter or better 95% of the time. The GIS proved to be an effective and essential tool for managing all geographically related information within the field.

Table 1. Soil types identified in the test area.

Soil Unit	Description
LoA0	Loring series, 0-2% slope, fiagipan at or greater than 36 in.
LoA2	Loring series, 0-2% slope, fiagipan between 20-30 in
LoA3	Loring series, 0-2% slope, fiagipan between 12-20 in.
LoB0	Loring series, 2-5% slope, fragipan at or greater than 36 in
LoB	Loring series, 2-5% slope, fragipan between 30-36 in.
LoB2	Loring series, 2-5% slope, fragipan betweenn 20-36 in.
LoB3	Loring series, 2-5% slope, fragipan between 12-20 in.
LoB4	Loring series, 2-5% slope, fiagipan between 12-20 in.
LxC	Lexington series, 5-8% slope
LoC2	Loring series, 5-8% slope, fragipan between 20-30 in.
LoC3	Loring series, 5-8% slope, fiagipan between 12-20 in.
GrA	Grenada series, 0-2% slope, fragipan between 30-36 in
HeA2	Henry series, 0-2% slope, fragipan between 20-30 in.
PrB3	Providence series, 2-5% slope, fragipan between 12-20 in.
PrC4	Providence series, 5-8% slope, fragipan between 0-12 in.
CoA	Collins series, 0-2% slope

Table 2. Soil groups created based on projected yield potential.

Group	Yield Potential	Definition
	---------- bu/a----------	
High	140	Moderately well-drained soils with at least 36 in. of depth to the fragipan and less than 5% slope. Units in this group: LoA0, GrA, LoB0, LoB.
Good	120	Soils with 2 to 5% slope and depth to the fragipan between 20 and 30 in. Soils with 0 to 2% slope and depth to the fragipan of 12 to 20 in. Deep soils (no fragipan) on 5 to 8% slope. Units in this group: LoA2, HeA2, LoA3, LoB2, LxC.
Fair	90	Soils with a combination of slope between 2 to 5% and 12 to 20 in. of depth to the fragipan. Soils on 5 to 8% slope depth to a fragipan between 20 and 30 in. Units in this group: LoB3, PrB3, LoC2.
Poor	70	Soils with a depth to the fragipan less than 12 in. Soils with depth to the fragipan between 12 to 20 in. and slope between 5 to 8%. Units in this group: LoB4, LoC3, PrC4.
Bottomland	*	Units in this group: CoA, FaA

*This part of the field was used to calibrate the yield monitor and not used to compute yields.

Table 3. Yield results by group of soils within nitrogen rates.

		Rates (lb N/a)				
		0*	84	127	143	181
HIGH	Yield (bu/a)	107.6	177.3	170.7	108.3	183.8
	Area (a)	0.6	1.9	1.7	1.9	1.7
GOOD	Yield (bu/a)	88.2	169.7	162.7	176.8	175.1
	Area (a)	0.6	0.8	0.9	1.1	1.2
FAIR	Yield (bu/a)	97.1	164.3	163.2	172.1	166.0
	Area (a)	0.2	1.2	0.9	0.5	0.8
POOR	Yield (bu/a)	132.4	161.1	148.1	163.4	161.8
	Area (a)	0.2	0.6	0.5	0.4	0.8

*Insufficient data at the 0 rate on *certain* soil mapping units.