ECONOMICS OF VARIABLE-RATE N MANAGEMENT ON CORN

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ABSTRACT

Over the past several years' growers have begun to adopt and implement the use of precision farming technologies. Growers and practicing consultants continue to question the profitability of this technology. No data currently exists in the Western Great Plains region demonstrating the economic feasibility of precision farming technology. The objective of this study was to assess the economics of uniform versus variable-rate nitrogen (N) fertilizer application. On farm studies were conducted on one furrow-irrigated and one center-pivot irrigated continuous corn (*Zea mays* L.) cropping systems in northeastern Colorado. The study included various strategies (i.e., grid-based and management zones) for variable-rate N application that are commercially practiced in the region. Global positioning system and geographic information system technology was used to perform uniform and variable-rate N applications and to monitor grain yields in cooperation with the grower. Using enterprise budget software developed by Colorado State University and USDA, operation schedules and enterprise budgets were constructed specific to each site to analyze the economics of each N management strategy and determine which method of N application was the most profitable. Results of this study suggest variable-rate N application utilizing site-specific management zones to be more economically feasible than conventional uniform N application.

INTRODUCTION

Although growers have begun to adopt and implement precision farming technologies, the profitability of this technology is uncertain in nutrient management. The profitability potential for variable-rate management is significantly enhanced if the initial means of forming application maps are inexpensive (Koch and Khosla, 2002; Peterson and Wollenhaupt, 1996). Recent research in precision farming has focused on site-specific management zones (SSMZ) as a means to generate application maps and improve nutrient management in cropping systems (Khosla et al., 2002; Fleming et al, 2001; Khosla and Shaver, 2001: Fleming et al., 2000; Luchiari et al., 2000; Nolan et al., 2000). Site-specific management zones are defined as homogenous sub-regions of a field that have similar yield limiting factors (Doerge, 1999; Khosla and Shaver, 2001). These studies have indicated SSMZ could be an effective alternative to grid soil sampling for quantifying and managing spatial variability. However, these studies did not address the economics of precision nutrient management on management zones versus traditional uniform management.

No data currently exists in the Western Great Plains region demonstrating the economic feasibility of precision farming technology in conjunction with nitrogen (N) management. A comprehensive, on-farm, enterprise-based field study is needed to quantify the economic feasibility of variable-rate N application. The potential profitability of variable rate application depends on isolating areas in the field where additional inputs will increase revenue on a scale

that is greater than the added cost, and in isolating areas where reducing inputs will decrease costs on a scale that is greater than potential revenue reduction correlated with lower grain yield (Snyder et al., 1999). Therefore, the economic feasibility of variable-rate N application is focused on whether increases in gross revenue and/or decreases in N input costs outweigh the added cost of technologies and/or services needed for precision N management (Thikrawala et al., 1999).

One of the objectives of our multi-disciplinary, multi-agency, multi-location, multi-year, and multi-crop precision agriculture project is to assess the economics of uniform N fertilizer application versus variable-rate N fertilizer application and analyze the variable-rate N applications under both a custom and a farmer application scenario. The assessment includes various N management strategies (i.e., uniform N application, grid soil sampling based N application, and management zone based N application using a variable and constant yield goal) that are commercially practiced in the region.

MATERIALS AND METHODS

On-farm studies were conducted on one furrow-irrigated and one center-pivot irrigated continuous corn cropping systems in northeastern Colorado. These studies were initiated to compare and contrast the economics of each N management strategy to determine which method of N application is the most profitable. Fields were grid soil sampled on a 1-acre grid to identify existing soil nutrient levels. Site-specific management zones (SSMZ) were delineated at each study site using a commercially available technique based upon the following data layers: bare-soil imagery, topography, and farmers past management experience (Figure 1).

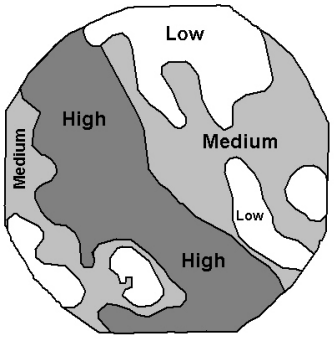

Figure 1. Management zone delineation and zone productivity potential at one study site.

It is documented that these data layers are an effective means of delineating SSMZ and developing variable-rate N application maps (Khosla et al., 2002; Fleming et al, 2001; Fleming et al., 2000). Management zones were classified as high, medium, and low productivity potential zones (Figure 1).

Application rates for each N strategy were calculated using the Mortvedt et al. (1996) N algorithm [N rate=35+(1.2 * EY)-(8*soil ppm $N0_3^-$)-(0.14*EY*OM)-(other N credits)] where EY is expected yield and OM is soil organic matter. The N management strategies were as follows: 1) Uniform N rate, 2) Grid-based, 3) SSMZ-based constant yield goal (SSMZ-CYG) 4) SSMZ-based variable yield goal (SSMZ-VYG). The uniform N strategy was based upon a conventional uniform N application using a constant yield goal. The grid-based strategy was a variable-rate N application based upon intensive grid soil sampling (1 acre grids) and a constant

yield goal. The last two strategies were variable-rate N applications based upon SSMZ using constant and variable yield goal approaches. Global positioning system and geographic information system technology was used to perform the uniform and variable-rate N applications and to monitor grain yields in cooperation with the grower.

Utilizing the cost of materials and services, operation schedules, farm equipment specifications, yield data, N rates, and various technical input, enterprise budgets were constructed using Profit and Loss (PAL) Enterprise Budget software (v.1.2) developed by Colorado State University and the USDA. Enterprise budgets were constructed at both study sites for each N management strategy (Table 1). The market price for corn was established as $2/bu. The net returns for the N management strategies were computed by subtracting total operating cost and total ownership costs from gross revenue. Net returns were used to compare economic differences for N management strategies, observe trends between each study site, and establish the most profitable N management strategy.

Table 1. An example of an enterprise budget by operation as generated by the PAL enterprise budget software.

					Month of Harvest	Yield	Units	Price of Corn	GROSS RECEIPTS
					September	186.30	Bushels	$2.00	**$372.60**
DIRECT COSTS:									
Operation Type	Name	Date	Variable Machine Cost	Material Costs	Non-Mach. Labor	Operating Interest	Total Operating	Ownership Costs	Total Costs
Other	Soil Sample	02/10/2001	0.00	0.53	0.00	0.03	0.56	0.00	0.56
Other	MZ Delineation	02/15/2001	0.00	1.00	0.00	0.06	1.06	0.00	1.06
Tillage	Disc	03/21/2001	2.17	0.00	0.00	0.10	2.27	4.91	7.18
Tillage	Field Cultivate	04/21/2001	1.45	0.00	0.00	0.06	1.51	3.26	4.77
Tillage	Field Cultivate	05/09/2001	1.45	0.00	0.00	0.05	1.50	3.26	4.76
Planting	Plant Corn	05/11/2001	5.14	39.00	0.00	1.48	45.62	7.14	52.76
Fertilization	Band starter	05/15/2001	0.00	16.76	0.00	0.54	17.30	0.00	17.30
Pest Control	Herbicide	06/01/2001	0.00	25.45	0.00	0.70	26.15	0.00	26.15
Fertilization	Variable-rate N	06/26/2001	3.18	18.96	0.00	0.46	22.60	5.78	28.38
Pest Control	Aerial Appl.	07/23/2001	0.00	9.50	0.00	0.13	9.63	0.00	9.63
Pest Control	Aerial Appl.	08/13/2001	0.00	6.50	0.00	0.05	6.55	0.00	6.55
Irrigation	Irrigate	Season-long	0.00	42.18	0.00	0.00	42.18	0.00	42.18
Harvest	Harvest	09/10/2001	5.91	3.73	0.00	0.00	9.64	18.26	27.90
Other	Dry corn	09/10/2001	0.00	18.63	0.00	0.00	18.63	0.00	18.63
Total Per Acre			**$19.31**	**$182.24**	**$0.00**	**$3.66**	**$205.20**	**$42.61**	**$247.81**
Other Ownership Costs:									
General Farm Overhead									10.00
Real Estate Taxes									10.00
Improvements									73.07
Total Other Ownership Costs:									**$93.07**
TOTAL NET RECEIPTS PER ACRE									**$31.73**

RESULTS AND DISCUSSION

Table 2 presents a summary of the net returns for all N management strategies. Results show variable-rate N applications using site-specific management zones increased net returns at both sites compared to uniform N applications. For study site 1, the SSMZ-VYG strategy had the greatest net return with a $8.13 ac^{-1} increase over farmer-applied uniform N application. At study site 2, the SSMZ-CYG and SSMZ-VYG strategies resulted in a $13.80 ac^{-1} and $11.97 ac^{-1} increase over farmer-applied uniform N application. The analysis suggested that variable-rate N applications utilizing site-specific management zones were more economical than conventional uniform applications.

Table 2. Nitrogen management strategies and corresponding weighted mean N rates, grain yields, and net returns for the study site-years.

Site	N Management Strategy [1]	Operation	Weighted Mean N Rate [2] ---- lb N ac^{-1} ----	Weighted Mean Yield [3] ---- bu ac^{-1} ----	Net return ------ ($ ac^{-1})-----
Study Site I	Uniform	Uniform N rate	158	177	155.05
	Grid-based	Variable N rate	160	183	148.82
	SSMZ-CYG	Variable N rate	160	175	138.14
	SSMZ-VYG	Variable N rate	148	182	163.18
Study Site II	Uniform	Uniform N rate	91	174	31.66
	Grid-based	Variable N rate	119	172	18.35
	SSMZ-CYG	Variable N rate	57	175	45.46
	SSMZ-VYG	Variable N rate	49	172	43.63

[1] The SSMZ-CYG and SSMZ-VYG variable-rate N management strategies were based upon site-specific management zones using a constant and variable yield goal, respectively.

[2] SSMZ and grid-based weighted N rates were based upon proportions of management zones and grid cells, respectively.

[3] Yield for the grid-based strategy was an average yield for the entire treatment strip. Yield for the uniform and SSMZ strategies were weighted mean yields

Based upon proportions of management zones. Weighted standard deviations are represented in parentheses next to weighted mean yields.

CONCLUSIONS

Variable-rate N applications utilizing site-specific management zones based upon a variable yield goal were found to be more economically feasible than conventional uniform application. Results from both study sites consistently indicate that less total N fertilizer was used with SSMZ-VYG strategy than with uniform N management, indicating reduction in over application of N fertilizer and increase in N use efficiency due to identification of site-specific management zones. Results show that the SSMZ-VYG strategy produced increased net returns over uniform N management at both study sites. The SSMZ-VYG strategy was also found to be more cost-effective than variable-rate N applications based upon grid soil sampling at both study sites. Additional studies are needed to assess the profitability between the two SSMZ approaches. Results from the on-going study suggest economic potential for precision nutrient management using site-specific management zones.

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