MINNESOTA

Corn Yield Response Variability and Potential Profitability of Site-Specific Nitrogen Management

By Gary L. Malzer

The potential profitability of site-specific nitrogen (N) management depends on predicting the spatial variability of profitability of N use. Four studies conducted over two years showed that profitability of N use varies widely across landscapes. The potential profitability of site-specific N management ranged from $4 to $37 per acre.

Precision farming is attracting a great deal of interest among producers, industry and the public sector. Although the methods of precision farming can be used with any agricultural input (cultivar selection, plant population, pest control, etc.), its origin was with soil fertility and nutrient management. Applying nutrients at rates according to plant need has the potential to increase profitability for the producer, and in certain cases may reduce nutrient loss and lessen the environmental impacts associated with nutrient application. The challenge is to interpret field spatial variability in a manner that will allow the most profitable rates of application without over-fertilization.

Minnesota Studies

Four experiments were conducted on production corn fields in southern Minnesota during 1994 and 1995 to determine the potential for site-specific N rate management. Six replications of six constant N rate treatments were applied as strips across the fields. Geo-referenced grain yields were obtained from 50 ft. continuous segments from each treatment strip. Regression techniques were used to fit fertilizer N response curves within small regions composed of groups of yield segments. From the response curves, the economic optimum N rate (EONR) and profitability of N use were calculated specific to each small region.

The economic analysis used prices specific to each growing season. Nitrogen prices were based on fall-applied anhydrous ammonia (12¢/lb in 1994 and 17¢/lb in 1995) and fall cash prices were used for corn ($2.00/bu in 1994 and $3.00/bu in 1995). This year's higher prices have little impact on the calculated EONR but will result in substantially increased profitability of N use.

DOES FIELD VARIABILITY WARRANT DIFFERENT RATES OF N? Crop response to applied fertilizer N was variable across the landscape at all locations in each of the two years. Some areas within a field showed little or no response to fertilizer N, while other areas required substantial amounts of N to attain the most economic yield. **Figure 1** provides a spatial representation of the amount of N required to attain maximum economic yield (MEY) at Hanska, Minn., in 1994.

FIELD AVERAGES DO NOT TELL THE ENTIRE STORY. Each field is unique. At

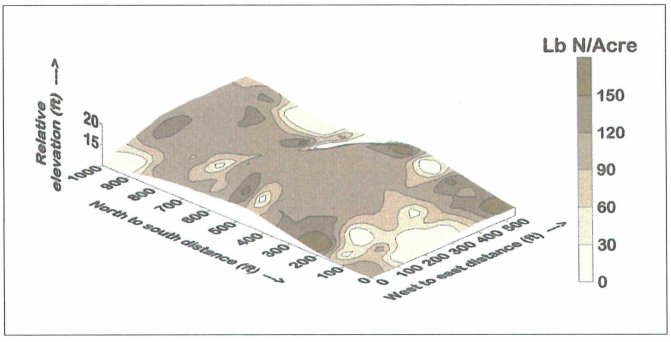

FIGURE 1. Topography and spatial distribution of EONR within a 12-acre portion of a corn field. (Hanska, Minn., 1994)

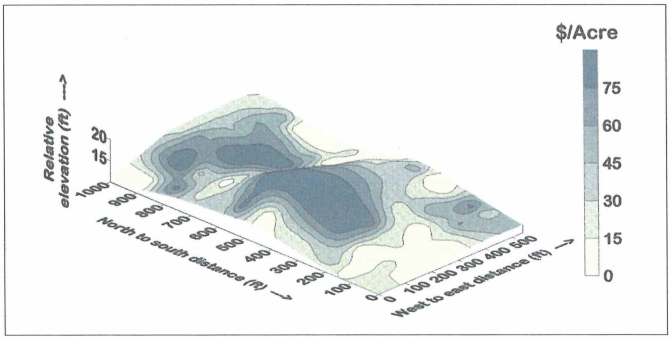

FIGURE 2. Topography and spatial distribution of profitability of N use within a 12-acre portion of a corn field at Hanska, 1994.

Hanska in 1994 the EONR was 40 lb/A less fertilizer N than recommended by the University of Minnesota. A summary of all four locations (**Table 1**) suggests that the average rate of N needed on some fields may be lower than current recommendations while other fields may require more. All locations did, however, show a wide range of optimum N rates around that average.

Variability in EONR led to under-fertilization and over-fertilization of large portions of each field (**Table 2**). Under-fertilized areas cost the producers potential income, while over-fertilized areas waste fertilizer and might cause environmental problems. Adequately fertilized areas were defined as those areas of the field within a 30 lb/A window (plus or minus 15 lb/A) of the current recommendation. Even within the fields where the current recommendation was similar to the weighted average rate required using optimum site-specific management, the amount of the field adequately fertilized was less than 50 percent.

PROFITABILITY IS NOT UNIFORM. As field variability in EONR is considered, there is no reason to think that profitability of N use will be constant within a field. Profitability of N use was calculated as the increased value of yield minus the cost of the N

TABLE 1. Weighted field average and range of N rates (EONR) required to attain MEY as compared to current uniform recommendations.

	Fertilizer N rates		
	Variable site-specific		Constant
Location	Range	Average	recommendation
	lb/A		
Hanska1994	0-180	89	130
Hector 1994	92-180	142	150
Hanska 1995	108-180	138	130
Morgan 1995	135-180	168	130

TABLE 2. Percent of field area that would have been under-fertilized or over-fertilized with recommended uniform application rates of N.

Location	Percent of field area and rate				
	Over-fertilization		Under-fertilization		Adequate
	%	lb/A	%	lb/A	%
Hanska1994	72	42	7	4	21
Hector 1994	56	18	36	11	8
Hanska 1995	29	5	29	12	42
Morgan 1995	0	–	75	36	25

fertilizer on a per acre basis. The spatial distribution pattern of profitability did not match that of EONR (**Figure 2**). The range across the landscape in profitability of N use was wide at all locations (**Table 3**). Focusing on the areas of the field that show the most profitability of N use may be more successful than attempting to match the EONR at every point in the landscape. The potential returns of the ideal site-specific recommendation in comparison with a constant rate recommendation ranged from $4 to $37 per acre.

Needs for the future

The ability to attain the potential profitability of site-specific N rate management will depend upon accurate N rate predictions related to site-specific profitability of N use. Since the rate of N required to provide maximum profitability (EONR) varied widely within each field, the procedure used to predict that rate must also be sensitive to site-specific conditions. Factors currently used to make N recommendations, such as the use of appropriate yield goals, previous cropping histories, organic matter content, and even residual nitrate N, were capable of predicting only a portion (seldom more than 50 percent) of the potential benefit of site-specific management. Additional factors will need to be considered in order to develop spatial relationships that maximize the profitability of site-specific N management. BC

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TABLE 3. Range and average of profitability of N use associated with site-specific N rate management compared to recommended constant rate of application.

Location	Profitability of N use			
	Variable site-specific		Constant rate	
	Range	Average	recommendation	Difference
	$/A			
Hanska1994	0-88	42	38	4
Hector 1994	11-200	90	79	11
Hanska 1995	56-217	127	118	9
Morgan 1995	103-233	176	139	37