NITROGEN MANAGEMENT ACTIVITIES AT THE MSEA SITE

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INTRODUCTION

Nitrogen (N) management practices for corn production have changed a great deal over the past half century, but in some respects have come around nearly full circle to what they were in the late 1940s. In earlier times, manures, legumes, and soil organic matter were the primary sources of crop N. To illustrate the evolution in N management practices consider that producers in the 1950s were encouraged to use commercial N fertilizers to increase production. As producers started to use more commercial N fertilizers, they experienced considerably higher yields. Over time, producers came to anticipate ever higher yields and when expectations were not met there was a tendency to apply a little extra N fertilizer to make sure N availability did not limit yields. Adoption of this attitude is frequently referred to as "insurance N" because this approach to N management helps to guard against the effects of untimely precipitation that could lead to nitrate leaching and denitrification.

Fertilizer N rates for crops like corn have continued to increase until the 1980s when reports of unacceptable levels of nitrate in ground water became common. Initially, the source of nitrate in ground water was disputed, but once input budgets were developed that identified the various sources of N, it became apparent that there could obviously be multiple sources of the nitrate in ground water. In the past few years, producers have begun to place increased emphasis on improving the timing of N availability in soil with crop N needs. In so doing, producers have once again come to appreciate the contribution that soil organic matter, manures, legumes, residual soil N, and even nitrate in irrigation water make toward plant nutrition. Fertilizer N remains an important source of crop N, but in many cases or at least for certain times during the growing season, fertilizer is no longer considered the dominate source of plant N.

MSEA ACTIVITY

Sustaining productivity while effectively using all sources of N is probably an idealistic goal for N management practices because there will always be factors contributing to N inefficiencies. Some of these factors, such as climatic uncertainties, are frequently thought to be beyond the control of producers, but awareness of why and when N losses occur provides the background information needed to develop improved management systems. The goal of the Management Systems Evaluation Area (MSEA) project located near Shelton, Nebraska, with satellite sites at North Platte, Nebraska, and at two locations in Kansas, is to develop improved N and water management systems that reduce the potential for nitrate leaching while sustaining productivity. Nitrogen management systems under evaluation are to a great extent dictated by the characteristics and capabilities of the irrigation systems. Conventional irrigation with diked-end furrows is being compared with surge-flow furrow irrigation on a field that was laser graded and also with a center-pivot sprinkler irrigation system. Each system offers advantages and disadvantages that must be evaluated in terms of practicality, cost, effect on ground water quality, and technical inputs required.

In retrospect, the irrigation system defines the most appropriate N management practices which change with time because of climate and past management practices. Management systems that provide for more uniform distribution of irrigation water should also require less water and result in less nitrate leaching. As such, management systems that minimize nitrate leaching should also require less fertilizer N. At this point, theory and reality usually part company because of physical limitations and the fact that crop growth and soil microbial activity are dynamic processes that defy anything as crude as an annual N budget.

Nitrogen uptake by corn is predictable within limits and generally occurs at a faster pace than dry matter production. For this reason, adequate N nutrition is very important to young corn plants. The need for adequate early season N nutrition for corn can not be down played because many of the physiological processes of young plants (rooting, ear size, etc.) affect the yield potential of the crop. This is why many corn producers prefer to use preplant N fertilizer and/or starter fertilizer. Producers in Nebraska within the bounds of the Central Platte Natural Resources District may be required to use a nitrification inhibitor with their N fertilizer if more than half of the recommended N is applied preplant.

The use of a nitrification inhibitor with preplant N applications of anhydrous ammonia usually involves a compromise between economics and convenience. It has been well documented that nitrification inhibitors, such as N-Serve, delay the conversion of ammonium to nitrate in soil. Thus, nitrification inhibitors intuitively should reduce the potential for nitrate leaching and offer the potential for increased N availability to the crop. Whether increased N availability results in higher corn yields depends on how effective the crop was in utilizing the additional N at given times during the growing season. Situations where nitrification inhibitors are the most likely to increase corn yields are where excessive rainfall occurs within 6 weeks after ammonium type fertilizers are applied and where residual soil N levels were not already so high that even moderate amounts of nitrate leaching would still result in adequate amounts of N for the crop.

Field Evaluations:

The three 32-acre management blocks described above were all planted to corn in 1990, fertilized at 180 lb N/acre, and irrigated via conventional furrow irrigation. All three fields looked uniform in terms of soil organic matter content and crop color and yielded an average of 196 bu/acre. The surge-flow and sprinkler irrigation systems were installed prior to the 1991 growing season and N management practices were initiated accordingly. Because of improved uniformity of water distribution under both the surge-flow and sprinkler irrigated fields, fertilizer N rates and the net amount of irrigation water applied were greatly reduced compared to the conventional field. A series of three reference strips that received 150 lb N/acre were established in both fields under improved N and water management. Chlorophyll meters were used to monitor crop N status and to determine the need for fertigation. At no time during the growing season was an N stress evident. Grain yields in 1991 were similar for all three fields (Table 1), suggesting that excessive N had been applied to the conventional field.

During the 1991 growing season procedures and guidelines were developed for fertigation of surge-flow irrigated fields, so plans were made to fertigate both the surge-flow and sprinkler irrigated fields in 1992. Chlorophyll meters identified the need for limited fertigation, but by mid July the sprinkler irrigated field was beginning to show variability in terms of crop greenness. Unfortunately, the N deficient areas of the field were not those routinely monitored with the chlorophyll meters. As a result, some areas with the sprinkler irrigated field were N deficient during the last half of the growing season, which resulted in lower yields compared to the other fields (Table 1).

Table 1. Production characteristics for three management systems at the Nebraska MSEA project (1991-1993).

Irrigation system	Water applied	Precip.*	Fertilizer N **	Water N***	Grain yield
	(in)	(in)	(lb/a)	(lb/a)	(bu/a)
1991					
Conventional	37.0	3.0	180	269	199
Surge-Flow	17.7	3.0	110	129	196
Center-Pivot	13.4	3.0	30	97	194
1992					
Conventional	29.1	12.4	170	212	207
Surge-Flow	9.1	12.4	65	66	200
Center-Pivot	8.3	12.4	42	60	175
1993					
Conventional	8.0	30.0	170	65	142
Surge-Flow	4.5	30.0	143	38	128
Center-Pivot	3.1	30.0	141	25	130

* Precipitation during the growing season.
** Sum of N applied including fertilizer and starter.
*** Irrigation water contained an average of 32 mg/L NO_3-N

Residual soil N levels for the sprinkler and surge-flow fields were relatively low in the spring of 1993, so a blanket application of 52 lb N/acre was applied as preplant anhydrous ammonia without a nitrification inhibitor. In contrast, the 140 lb/acre of preplant N applied to the conventional field included N-Serve. Aerial photographs taken in early July did not reveal any N deficient areas of the fields when compared to the adequately fertilized reference strips. By late August, aerial photographs were beginning to show a few areas that were apparently N deficient. Far above normal rainfall during the growing season apparently resulted in considerable nitrate leaching. Chlorophyll meter data indicated the need to fertigate even though the soil had more than adequate water for the crop.

Grain yields for the area in 1993 were generally about 30% lower than in the previous two years. Lower air and soil temperatures, wet soils, and lower than normal solar radiation early in the growing season are probable contributing factors to the lower yields (Table 1). The increased potential for nitrate leaching and denitrification because of excess rainfall and apparent lower rates of mineralization because of the lower soil temperatures resulted in N deficient situations. Nitrate contained in the irrigation water contributed little N to the crop because of limited application. The slightly higher N fertilizer rate and/or the apparent benefit of the nitrification inhibitor on the conventional field resulted in ~10% higher yield than the other two fields.

Plot Studies:

The fertigation strategy noted above was also used on a series of small plots (8 rows at 36 inch spacing by 50 ft long) that were planted to four Pioneer brand hybrids (3394, 3379, 3162, and 3417) which covered a range in physiological characteristics. These four hybrids were fertilized at five N rates, plus one treatment which was fertilized as needed to simulate fertigation. Fertigation was initiated when the average N sufficiency index declined to a value of 0.95 as determined by chlorophyll meter readings according to the following expression:

$$\text{N Sufficiency Index} = \frac{\text{Meter reading from test area}}{\text{Meter reading from reference area}}$$

Plots receiving the highest fertilizer N rate were considered to be adequately fertilized and used as the reference. The "as needed" plots received 45 lb N/acre at planting and four applications of 27 lb N/acre each during the growing season. Yields for the various N rates followed similar trends across hybrids (Figure 1). The "as needed" treatments yielded as well or better than treatments receiving comparable rates of fertilizer at planting.

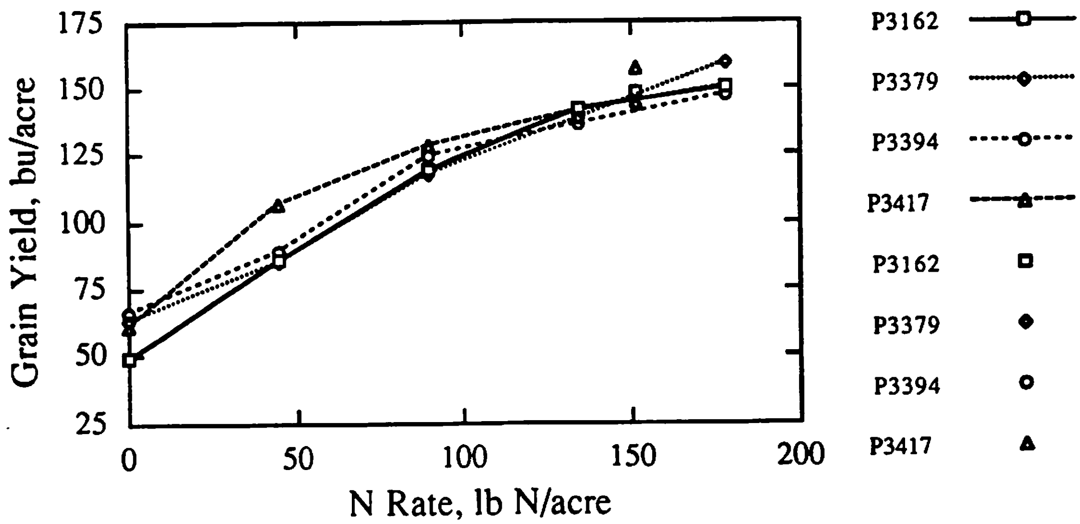

Figure 1. Grain yields of four hybrids at various planting time fertilizer N application rates compared to the fertigation strategy.

One apparent advantage of the "as needed" approach to N management is that the larger than normal application of N at planting time (UAN banded over the row and watered) was adequate to meet early season N needs of the crop without resulting in overly vigorous plants that were susceptible to wind breakage (i.e., green-snap). Plants receiving high fertilizer N rates at planting showed more stalk breakage during the July 8 wind (80 to 100 mph straight from the west). Above average stalk breakage was also observed for early planted corn and corn which followed soybeans. Highest yields for the area were recorded where modest amounts of manure were applied in the spring of 1993 and where fertigation was then used to correct for N deficiencies when they occurred.

SUMMARY

Efforts to improve fertilizer N use efficiency are likely to make variability in crop N status and yields across a field more obvious. Since most fertilizer N strategies focus on uniform applications within a field, it is inevitable that some areas will become N deficient sooner than others. Therefore, N management strategies that lend themselves to sustainability will need to involve economic and environmental compromises. Management strategies that involve variable rates of N fertilizer application offer the potential to meet crop N needs while minimizing the potential for nitrate leaching. Technologies to make variable rate N application a reality are under development for both land and water based application methods.