Improving Nitrogen Recommendations in Nebraska

Gary W. Hergert
University of Nebraska
West Central Research and Extension Center
North Platte, NE

ABSTRACT

Soil nitrate tests offer a unique opportunity to fine tune our nitrogen management into the 90's. Nebraska has had a long history of research and extension programs using soil nitrate levels to modify fertilizer nitrogen recommendations. Because of our climatic regime nitrate tests work well across the whole state. We have a large data base on research plots that shows the tests are very effective. A large number of farmer demonstrations conducted over the last 10 years also show that the technology is well adapted when we take it to a field scale. We began suggesting adjustments to our nitrogen recommendations for corn based on nitrate in 1974. Initially farmer acceptance of soil testing for nitrate was fairly low. As more ag consultants have come on the scene they have taken most of the deep samples. Less than 40% of the fertilizer dealers who take soil samples probably take deep samples. The total nitrate soil test correlation calibration data base from the University of Nebraska was shared with all commercial laboratories working in Nebraska in 1988. Several of the labs are routinely using this information while others have not fully incorporated it into their soil test programs. There is a continuing need to educate both farmers and fertilizer dealers to the economic and environmental benefits of wide spread adoption of soil nitrate tests. The process of change is slow, however. It has taken the last 25 years to have 50 to 60% of our farmers use these tests routinely.

INTRODUCTION

Evaluating plant available soil nitrogen by the use of mineral N tests was considered to be of limited value in crop production just 25 years ago (Bremner, 1965). Since that time there has been a great deal of research showing that nitrate tests can be used very effectively for improving N fertilizer recommendations (Geist et al, 1970; Herron et al, 1970; Maples et al, 1977; Olson et al, 1970). These tests are routinely made in the western part of the United States and, in many cases, where summer fallow is practiced. These areas typically have low winter or off-season leaching. They are also used in irrigated areas to estimate carryover nitrate nitrogen that may not have been used by the previous crop.

Recently there has been interest in using soil nitrate tests in the more humid regions of the country. At the 1989 North Central Extension-Industry Soil Fertility Conference there were numerous presentations on soil nitrate testing (NCEISFC, 1989). Nitrate testing in the drier regions has always focused on preplant sampling and samples taken from a major portion of the root zone. In the well drained deep loess and sandy soils of the western corn belt, this is usually 3 to 4 feet. Soil sampling in the more humid regions has concentrated on sampling times closer to a true V5 to V6 vegetative stage on corn. The sampling depth has been the top 1 or 2 feet of soil. Precipitation constraints of the various geographic regions suggests that both procedures are valid. There has been a tremendous amount of work done with correlation and calibration in the drier regions of the western corn belt to develop and refine nitrogen recommendations based on deep residual nitrate tests. In the

central and eastern corn belt much of the work is still in its initial stages. Correlation, as well as calibration research, is ongoing.

How readily will farmers adopt this new technology? Can the experience of the western corn belt be used as a model to predict what may go on in the eastern and central corn belt? The purpose of this paper is to review the history, development, philosophy, educational efforts and current acceptance of residual nitrate tests to improve nitrogen recommendations in Nebraska.

DISCUSSION

Early Soil Testing Research

In the 1940's the Nebraska Legislature passed legislation that established the Outstate Testing Service. Monies were provided to the University of Nebraska College of Agriculture to conduct tests to evaluate crop varieties and the new technology of fertilizer use. This was the beginning of the initial data base collected for the soil test correlation and calibration work. Most of the work centered on variety selection and fertilizer rate experiments.

In the late 1960's it became apparent that nitrogen responses were not always as consistent as what might be predicted from laboratory incubation tests to measure N production. Research reports in the Great Plains pointed to the fact that in many cases under dryland and irrigated situations fairly high levels of residual nitrate were accumulating in soils (Olsen et al, 1970; Herron et al, 1971; Geist et al, 1970). The old standard incubation tests were not always reliable predictors of N response. Excess N also depressed yields of dryland winter wheat (Olsen et al, 1964). A concerted research effort was begun in Kansas, Nebraska, Oklahoma, and Colorado at this time to look at using residual nitrate as a possible predictor to improve nitrogen recommendations. During the late 1960's and 70's a number of nitrogen rate experiments were conducted across Nebraska to evaluate the influence of soil nitrate levels on nitrogen response (Olson, 1978). This research data was incorporated into Nebraska's fertilizer recommendations in the early 1970's. The NebGuide series in Nebraska are fact sheets used for distribution to farmers and were initiated in the early 1970's. The NebGuide on nitrogen recommendations for corn was first published in 1974 and included a table which modified nitrogen fertilizer recommendations based on the amount of residual nitrate found in a cumulative 6 foot profile (Wiese and Penas, 1974). From a marketing standpoint it may have been a mistake to try to convince farmers to look at nitrate in a 6 foot sampling depth. However, this was where research guided the extension efforts and all of the research was based on the amount of nitrate found in 6 feet.

Demonstration Projects

Based on the previous 10 years of research from the mid-60's to the mid-70's there was confidence that nitrate tests could be used to improve fertilizer N recommendations. In the mid-1970's there was a growing concern in parts of the Central Platte Valley in Nebraska where groundwater levels of nitrate were showing an alarming increase. Baseline studies conducted by Knudsen (Knudsen, 1965) and Olson (Olson et al, 1962) provided an excellent data base for gauging changes in groundwater quality in many parts of Nebraska. There were many questions as to why the nitrate levels had increased, what caused it, and how could the losses be controlled? A fairly extensive state wide educational effort called, "Living With Nitrate" (NE Coop Ext. Serv. 1981) was conducted by the Nebraska Cooperative

Extension Service to include agronomists, ag engineers, civil engineers, food and nutrition specialists, and medical doctors from the Eppley Cancer Institute. The efforts main focus was to try to provide rational information about what elevated nitrate levels in drinking water really meant. The hope was to calm fears that it was a major health threat and show that is was manageable.

The outgrowth of much of the concern in the Central Platte Valley led to a fairly large project called the Hall County Project in the late 70's and early 80's (NE Coop Ext. Serv., 1984). This was primarily a field demonstration effort to show farmers how to improve nitrogen and irrigation water management on the furrow irrigated shallow sandy soils in the Hall County area. This was one of the first national demonstration projects that involved the United States Environmental Protection Agency (EPA), the Soil Conservation Service (SCS), Agricultural Stabilization and Conservation Service (ASCS), and the Nebraska Department of Environmental Control (NDEC) that showed farmers that adopting the technology that we currently had could improve their bottom line by decreasing nitrogen losses from leaching. During the late 1970's into the 1980's research work continued to add to the correlation calibration data base on soil nitrates for corn (Hergert et al, 1984). In the mid-1970's there was an energy crisis. Everyone was concerned about how much energy it took to fix nitrogen into anhydrous ammonia and how energy consumption could be reduced. The same concern related to irrigation because pumping water requires a large amount of energy whether it comes from electricity, diesel or propane. We had a ready made audience to share our ideas on improved nitrogen and water management.

Farmer Adoption of Nitrate Testing

Deep nitrate tests in Nebraska were recommended as a suggested standard practice in the mid-1970's. Initially farmer acceptance was relatively low. A few farmers that did their own sampling took some deeper samples. However, for the most part, very few if any fertilizer dealers took deep samples. As university extension specialists we hadn't done a good enough job of educating them to the importance of deep sampling as an effective management tool. There also was some reluctance to adopt the technology because dealers felt it might affect nitrogen sales, which ultimately affected their bottom line. During the 1970's, however, the ag consulting profession started to grow in Nebraska. As more ag consultants came into the picture much of the soil sampling shifted from farmer responsibility to the ag consultants and many of the ag consultants did take deep samples. In the late 1970's, and especially the early 1980's, there was a continuing increase in the number of samples submitted to the University of Nebraska Soil Test Lab that had deep samples for nitrate. By the mid-1980's approximately 40 to 50% of the samples submitted to the UNL-Lab for grain crops did have a deeper sample at least to a 2 foot depth (D. Knudsen, personal communication).

Groundwater Quality

In the mid-1980's groundwater quality concerns came to the forefront of the political arena. Again one of the most commonly referred to pollutants was nitrate nitrogen and Nebraska was one of the hot spots pointed to because some areas of groundwater that were approaching 30 ppm nitrate nitrogen. One of the primary causes of leaching in many parts of Nebraska is poor irrigation management. In the economic constraints of the early to mid-1980's very few farmers were interested in spending their own money to make improvements in irrigation management for groundwater that would show them no direct

economic benefit. The continuing high groundwater nitrate levels, however, did initiate plans of the Central Platte Natural Resources District to establish their own management area. This area encompassed about 144,000 acres and had different phases of management techniques required by farmers depending upon the nitrate groundwater level in the area (Hergert, 1987). The project is currently in its third year. Active demonstration projects has been going on in this area for the past 10 years (Ferguson et al, 1991).

An additional project to hopefully accelerate the adoption of best management practices by farmers is currently underway in Nebraska. This project is incorporating the techniques of deep sampling for residual nitrate, irrigation scheduling, and utilizes the nitrate content of the groundwater to fine tune nitrogen management in South Central Nebraska. In addition Nebraska is one of the five midwestern water quality sites selected for intensive groundwater research (MESA).

Measuring the Impact

There has been a continuing effort and interest in improving nitrogen recommendations in Nebraska. So, for all of our research and education, how have we done? Although groundwater nitrate levels have continued to increase in some areas of Nebraska on the average the amount of nitrogen fertilizer applied per bushel of grain has continued to decrease from the mid-1970's through the late 1980's (Wiese, 1989). This decrease is probably not solely due to our efforts in extension but hopefully is part of the contributing factor. The agricultural recession in the mid-1980's, high energy costs, environmental awareness, control areas and educational efforts have all heightened farmer's awareness of improving their nitrogen management. We have had good success in having more farmers take deep samples from their fields. In most situations where an ag consultant is involved probably 90% of the fields that are sampled have deep samples. Where the fertilizer dealer is the primary contact there are probably less than 40% of the fields that have been deep sampled.

There still is an element of mistrust among fertilizer dealers that nitrate at deeper depths may have little crop value. There also may be the underlying fear that wide spread nitrate testing will grossly affect nitrogen sales. Based on the research results this is not the case. If nitrate levels are high one year and farmers reduce their nitrogen recommendations and rely on a combination of residual nitrate fertilizer and improved irrigation management the nitrogen requirements the following years are similar to those normally required by corn. In Nebraska under well managed situations this is about one pound of nitrogen per bushel for yields over 100 bushels of corn per acre.

Future Challenges

Nitrogen use is important in agriculture and as we continue to fine tune our nitrogen recommendations we will start seeing problem areas that are nitrogen deficient. Why will we see them? Primarily because of applicator errors that have always been there but that have always been masked because our nitrogen applications have been 10 to 20% too high. When we fine tune our nitrogen recommendation, application errors of 20% will show up as problems. Agronomists and farmers must walk a tight rope between adequate nitrogen for maximum economic return and minimum nitrogen to influence groundwater quality. These two constraints require a much higher level of management than we needed in the past.

Soil sampling requires a lot of work, especially if you are going to a 3 or 4 foot depth. An intensive soil sampling project has been conducted in Nebraska over the last 3 years. A review of our own recommendations suggests that in most cases soil sampling to a 3 or 4 foot depth is very sufficient to estimate nitrate carryover. The current soil sampling research shows that nitrate in farmer's fields can be highly variable - the coefficient of variation often times is 50%. To improve our predicted soil nitrate levels we need to take as many samples as we do for our routine soil analyses. Twelve to 15 cores composited from a 40 acre area are probably necessary if we want to be within $\pm$20% of the mean at a confidence level of 90%. Current sampling research shows that if we take only five to eight cores per 40 acre area we are probably no better than $\pm$25% of the true mean value at a confidence level of only 75%.

As we enter the 90's we know that less farm income will be be coming from the government. The decrease in farm program income will require even more careful management for maximum profit and constraints related to environmental quality will continue to be with us. As university agronomists, we will be required to continue efforts in education to convince farmers and fertilizer dealers about the importance of soil nitrate tests as a basis for fine tuning nitrogen recommendations. In trying to develop a package of technology, it becomes a complex task because we are working with a complex system - a system of soil, plant and man. There are many aspects to manage. From an extension stand point this provides a challenge because there are a lot of basics to teach. These may not be the most popular extension meetings because they are not related to a "product" or some hot new technology. These are basic agronomic production principles. Having an enthusiastic audience for this type of program provides a challenge in adult education.

We also have the challenge of convincing more of our fertilizer dealers to adopt this technology and to alleviate their fears of large declines in nitrogen sales. Another challenge is having all commercial labs recommend and use research-based information on modifying N recommendations using soil nitrate.

We want farmers to use nitrate tests but we must also be careful not to sacrifice accuracy for ease. Our research shows that in most cases a 0 to 1 foot soil sample for nitrate is not adequate. Its a terrible predictor in terms of confidence to look at residual nitrate especially when we are thinking of a 3 to 4 foot root zone. Many of the demonstration efforts conducted in the state of Nebraska on farmer's fields over the last 10 years have shown that using residual nitrate tests is a very effective way of decreasing the nitrogen rates and leaching while maintaining the high yields the farmers have always enjoyed (Ferguson, 1991). We can do a better job than we have been doing with the technology that we have now.

More effort in the 90's will be required to improve our nitrogen management to allow for greater flexibility. The use of leaf punches or chlorophyll meters may be used to monitor plant nitrogen levels during the season. With the added flexibility of having methods to apply nitrogen in-season (a high boy and spoke injection or through irrigation water) provides farmers with the management flexibility to apply nitrogen that may be lost from unusual circumstances because we are fine tuning nitrogen rates to the point where slight nitrogen deficiency may occur. We have made great strides but there are still big challenges ahead. The challenges of farmer acceptance of soil nitrate tests that we have been through in Nebraska in the last 10 years still faces the researchers and extension specialists in the

Central and Eastern Corn Belt as they try to improve their nitrogen recommendations based on soil nitrate tests.

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