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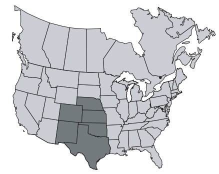

Soil Testing for Nitrate-N: Is It Still An Appropriate Tool for Wheat Production?

Background

University extension, crop consultants, and other ag professionals have traditionally recognized the value of soil testing for nitrate-nitrogen (nitrate-N) in crop production, particularly in relatively dry environments where nitrate leaching potential is low. Analysis of soil profile samples (0 to 24 in. depth) for fall nitrate-N provides a measure of residual N that will likely be available to the coming crop. This information can prove to be of particular value when it comes to making N fertilizer recommendations, as accumulated nitrate-N in the soil profile may reduce the need for input from external sources. Unfortunately, few farmers actually utilize this tool.

Taking fall soil profile samples for nitrate-N analysis has been a recommended practice for N management of winter wheat on the Great Plains for many years. However, due to the mobility of nitrate-N in the soil, soil test values observed in the fall may be different than values observed in the spring. Because many producers wait until spring green-up to make their N application, does deep soil sampling for nitrate-N in the fall really provide useful information for N management in wheat? That is certainly a legitimate question.

The driving force behind the study discussed in this publication is the growing interest in improving N management in winter wheat production. Recent efforts have been focused on improving nitrogen use efficiency (NUE), or increasing the portion of the applied fertilizer N that the plant uses. These efforts have resulted in the development of N fertilizer products designed to enhance use efficiency and reduce N loss, optical sensors that can evaluate wheat's N status, and changes in methods and timing of N application. With so many new practices incorporated into N management systems, older practices are in jeopardy of being seen as outdated, and even discarded.

Scientists at Kansas State University (KSU) recently conducted studies to evaluate the relationship between winter wheat yield and fall soil nitrate-N level, and to determine whether fall sampling for nitrate-N is still a viable practice.

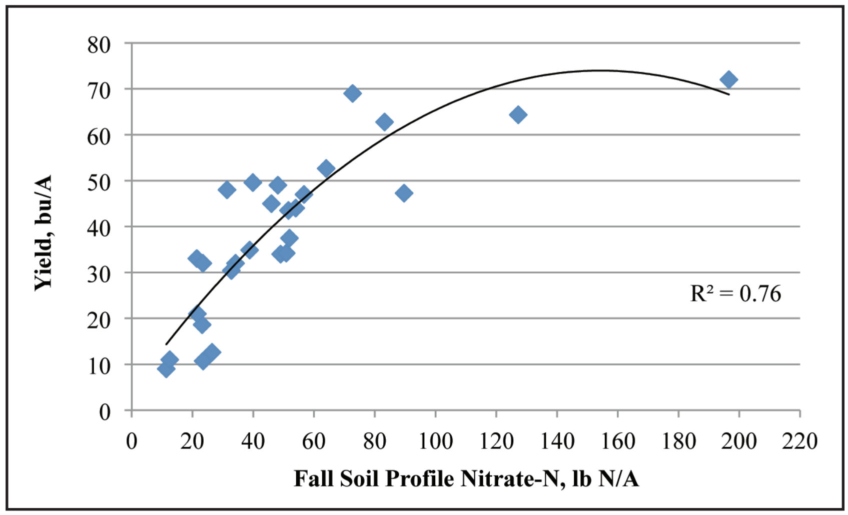

Figure 1. Relationship between fall soil profile nitrate-N level and wheat yield with no N fertilizer applied.

Procedures

Data were drawn from 26 dryland wheat experiments conducted in 2007 through 2013—most from 2010-2013—throughout Kansas in cooperation with producers and KSU experiment stations. Locations included Manhattan, Tribune, Partridge, Johnson, Randolph, Rossville, Ottawa, Sterling, Pittsburg, Silver Lake, Solomon, and Gypsum. Crop rotations were those commonly used by farmers in the specific areas, and previous crops prior to the wheat crop were primarily corn in southeastern KS, soybeans in the balance of eastern KS, and fallow in western KS.

Soil samples to a depth of 24 in. were taken in the fall prior to planting and fertilization. These samples were analyzed for nitrate-N (NO_3^--N), chloride (Cl^-), and sulfate (SO_4^{2-}), and were taken near planting time since these three anions are subject to movement and leaching in the soil. Samples from 0 to 6 in. were analyzed separately for soil organic matter, phosphorus (P), potassium (K), pH, and zinc (Zn). Fertilizer needs other than N were applied in the fall at or near seeding.

Results

Analysis from plots that received no N fertilizer showed a strong positive relationship between yield and fall soil profile nitrate-N level (**Figure 1**). Wheat yields increased

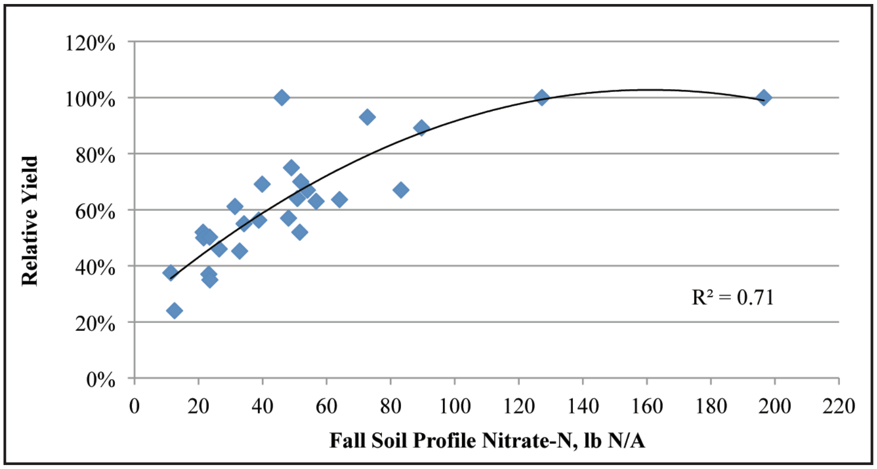

Figure 2. Relationship between fall soil profile nitrate-N and relative yield, or percent check plot yield of the maximum obtained with fertilizer at each site.

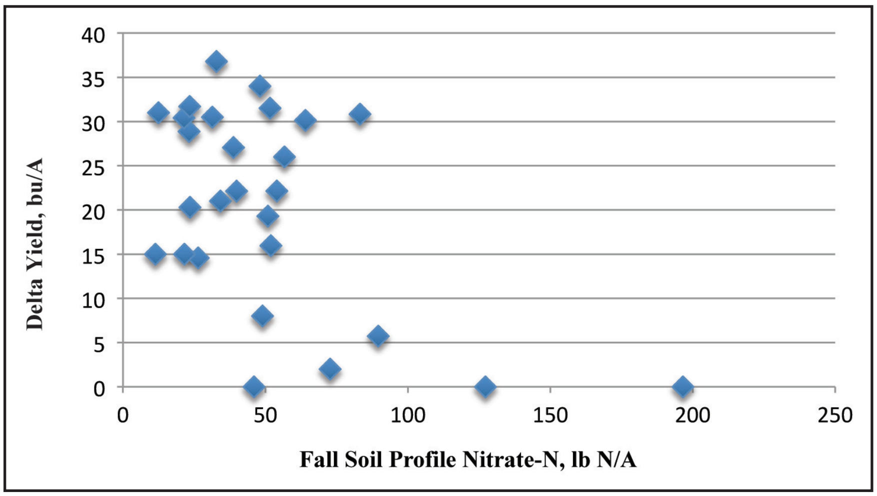

Figure 3. Increase in yield due to N fertilization, delta yield (ΔY), as a function of soil nitrate-N level.

rapidly as soil nitrate-N levels increased to about 80 lb soil N per acre, and then leveled off. The check plots were used to calculate relative yield, or percentage of the maximum fertilized yield obtained at each location (**Figure 2**). These data show that when fall soil profile nitrate-N levels are greater than 80 to 100 lb/A, relative yield approaches 100%, and it is unlikely the site will respond to additional fertilizer N applied in the spring.

An alternative way to evaluate the relationship between fall soil nitrate-N and N response is to calculate the delta yield (ΔY), or the yield change due to the addition of fertilizer N at each site. This is a good measure of N responsiveness of an individual site and year. The relationship between fall soil profile nitrate-N level and ΔY is shown in **Figure 3**. It is clear from this graph that at low soil nitrate-N levels in the profile, sites respond well to applied N fertilizer as indicated by high ΔY. However, as the profile nitrate-N level increases beyond 75 to 80 lb N/A, little or no N fertilizer response was observed.

A commonly used way to measure the efficiency of N use is to determine the amount of N fertilizer required to produce one additional bushel of yield. This relationship is shown in **Figure 4**. On highly N responsive sites, those with a large ΔY, the amount of N required to increase yield by 1 bu/A is relatively low—less than the 2.4 lb N/bu used in the KSU fertilizer recommendations. However, as the yield response decreases, the amount of N required to achieve the same response increases dramatically. This relationship explains why fertilizer recommendations are generally not made for the maximum yield, but rather the economic optimum yield, which is generally less than the maximum yield. The efficiency of squeezing out those last few bushels to achieve maximum yield is just too low. A number of additional conditions such as drought, disease, and poor root growth can greatly influence the economic optimum yield relationship to N inputs. In addition to soil profile nitrate-N measurements, many of the new technologies designed to enhance N management and NUE should help optimize the pounds of N fertilizer required to obtain a bushel of N response.

Summary

A strong positive relationship between wheat yield with no N fertilizer applied and soil profile nitrate-N level was observed. Although new practices have been developed to improve N management in winter wheat, this study indicates that soil sampling in the fall for nitrate-N remains an important practice in managing N and can result in considerable efficiency improvement and savings for producers.

When there is no soil profile nitrate-N information available, the KSU fertilizer recommendation formula defaults to a standard value of 30 lb N/A. In this particular dataset, the average profile nitrate-N level was 39 lb N/A. But the nitrate-N level at individual sites ranged from 11 to 197 lb N/A, emphasizing the importance of nitrate-N sampling. Interestingly, the equivalent fertilizer value of the accumulated nitrate-N in the soils used in this study was as high as $98/A (assuming a value of $0.50/lb N). Most recommendation systems default to a standardized set of N recommendations based on yield goal and/or the cost of N. Without sampling for nitrate-N or using some alternative method of measuring the soil's ability to supply N to a crop, such as crop sensing, the recommendation made for N is apt to be compromised, resulting in a reduction in yield and profit, and increased potential for environmental impact.

Because of the drought of the past two years in the Central and Southern Plains, there have been many situations where large amounts of N have accumulated and are present in the soil at planting of wheat or summer crops such as corn or grain sorghum. Recent samples requesting soil nitrate-N tests from western Kansas, where

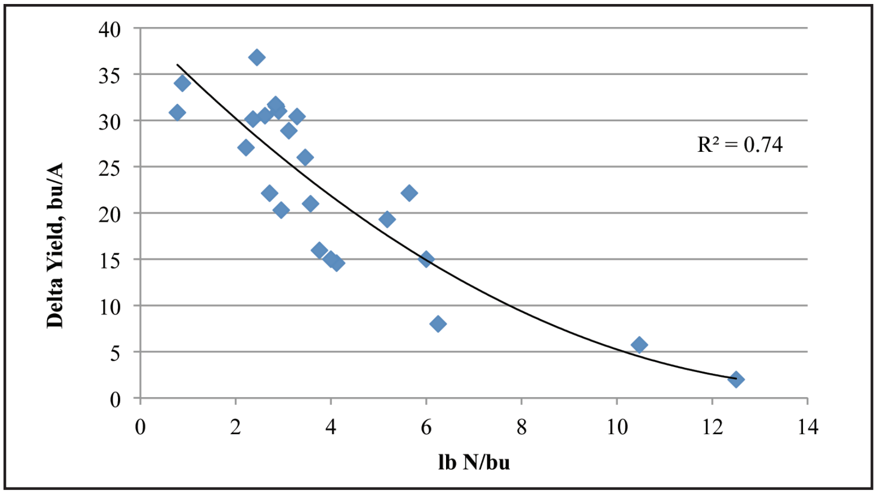

Figure 4. Pounds of N fertilizer required per bushel of yield increase at different levels of N responsiveness, or delta yield (ΔY).

drought conditions have been particularly harsh, are showing consistently high soil nitrate-N levels. Failure to account for that valuable resource can result in imbalanced nutrition and excess vegetation, increased susceptibility to plant disease, inefficient use of soil water, reduced yield, and loss of profit.

Soil sampling in the fall for nitrate-N can significantly improve N fertilizer management of winter wheat. It therefore remains a strongly recommended practice. ■

Dave Mengel

Soil Fertility Specialist
Kansas State University

3703 Throckmorton Hall
Manhattan, KS 66502
E-mail: dmengel@ksu.edu

Ray Asebedo

Agronomy Graduate (Ph.D.) Student
Kansas State University

E-mail: ara4747@ksu.edu

W.M. (Mike) Stewart, IPNI

Southern and Central Great Plains Director
International Plant Nutrition Institute (IPNI)

2423 Rogers Key
San Antonio, TX 78258
E-mail: mstewart@ipni.net
Website: http://nascgp.ipni.net/

Clifford S. Snyder

Nitrogen Program Director

International Plant Nutrition Institute (IPNI)

P.O. Drawer 10509
Conway, AR 72034
E-mail: csnyder@ipni.net