NITROGEN MANAGEMENT FOR SPRINKLER IRRIGATION

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Nitrogen (N) fertilizer management and irrigation practices have been implicated as major factors contributing to the increasing nitrate-nitrogen concentrations in streams and rivers, as well as the groundwater. These charges are not totally unfounded in that percolation of water through soil is a natural process and as such some leaching of nitrates through the root zone is probably inevitable. It is unfortunate however, that many people assume such leaching losses are proportional to the amounts of N fertilizer and irrigation water applied. Numerous studies over the past several decades have contributed to our understanding of the various processes controlling nitrate leaching and have shown that these losses can be minimized when good N fertilizer management and irrigation scheduling practices are implemented.

Nitrogen management alone will not effectively reduce the potential for nitrate leaching because excess water from either irrigation or precipitation will result in percolation which can carry plant available nitrate deeper into the soil profile. Proper irrigation scheduling during the growing season can minimize percolation during the summer months, but precipitation during the fall and spring, when plant demand for water is low, can result in large amounts of percolation. It therefore becomes critical to carefully manage the amount of nitrates in the root zone at all times if leaching losses are to be minimized. Before soil N can be managed, one must characterize the different sources of N and understand how the various biological, chemical and physical processes interact to supply the plant with nitrate. Although these processes and fertilizer practices identify sources of plant available N, plants do not discriminate between the various N sources as they take up nitrate.

N SOURCES

Common sources of plant N include the residual nitrate remaining in the root zone from previous crops, N released upon decomposition of past and recent organic residues and manure (mineralization), nitrates in irrigation water and precipitation, and fertilizer N. Fertilizer N recommendations are typically based on crop removal and adjusted downward to account for residual N found in the surface 8 to 12 inches.

A "rule of thumb" frequently quoted is that it takes between 1.0 and 1.4 lb of N to produce a bushel of corn, depending on the relative importance of unquantified N sources other than fertilizers. Residual soil N is then subtracted from this value to obtain the fertilizer N recommendation, however subsoil residual N, mineralized N or nitrate in irrigation water may not be considered in the recommendation. It should be noted that unrealistic yield goals can result in excessive fertilizer N recommendations. A 4 year study (1980-84) of irrigated corn production in Nebraska revealed that yield projections provided by producers exceeded their yields by an average 23% (32 bu/A), which translated into an excess 37 lb/A N recommendation. A more recent summarization (1988) of data collected by the Central Platte Natural Resource District (CPNRD) in Nebraska showed that yield goals in a larger area, but including the former area, averaged only 9% (14 bu/A) over harvested yields. Overestimation of yield goal in 1988 only translated into an excess 17 lb/A N recommendation, however producers applied an average of 43 lb/A above recommendations One can only speculate why excess N was applied, but reasons include inexpensive cost of N fertilizer, compensation for anticipated leaching losses, and realization of field heterogeneity.

RESIDUAL N

Residual soil N is relatively easy to quantify by routine soil testing procedures. The depth to which samples should be taken depends on the rooting depth and uniformity of soil texture within the root zone. Several studies in Colorado and Nebraska indicate that sampling to a depth of 2 ft provides an adequate base from which to predict the total residual N within the root zone. In Colorado, 50% of the residual N to a depth of 4 ft was located in the surface foot, while in Nebraska the residual N was more uniformly distributed within the root zone and only 32% was located in the surface foot. These data and others indicate that prediction of total residual N within the root zone from residual N in surface samples is somewhat site and soil type specific. Once this relationship is established for a given soil type or field, surface samples should permit a reasonable assessment of the residual N within the root zone.

IRRIGATION N

Nitrates in irrigation water may represent a minimal source of plant N in some cases but a very substantial source in others. The magnitude of this source (lb N/A) can be evaluated by multiplying the depth of water (inches) by the nitrate-nitrogen concentration in the water (ppm or mg/L) by 0.227. In other words, 2 inches of water containing 10 mg/L nitrate-nitrogen would contain 4.54 lb N/A. Nitrates in the irrigation water or applied through fertigation are frequently utilized with an efficiency of 30 to 75% by corn, depending on time of application and crop N status. Similar efficiencies are reported for sidedress N applications. In contrast, most studies indicate that preplant N is only 30 to 60% efficient. The reasons for the reduced efficiency of fall applied or preplant N are associated with the increased potential for leaching and denitrification (gaseous N losses), plus the likelihood for microbial immobilization as residues are decomposed. The sometimes lower than expected utilization of N in water is because the irrigation may not be applied until near silking when 50% or more of the total N uptake has occurred.

N MINERALIZATION

Mineralized N represents a substantial source of plant N, but is frequently taken for granted or overlooked because it is hard to quantify and at any one time only represents a relatively small contribution to the total nitrate pool in the soil. In essence, the mineralization process functions as a slow release form of fertilizer. Mineralization is optimum when the soil water content is approximately at field capacity and the soil temperature is about 95 F. Microbial activity decreases about 50% as the temperature drops from 95 to 77 F, and it decreases another 50% as it declines from 77 to 59 F. Mineralization occurs predominantly in the surface foot of soil and is frequently thought to contribute an amount equivalent to between 2 and 3% of the total N found in the organic matter. A soil with 2% organic matter would then be expected to mineralize 80 to 120 lb N/A over the growing season. These values may be 30 to 50% greater under irrigation due to the more favorable soil moisture conditions and the likelihood of an abundant supply of recently incorporated residues.

CROP N UPTAKE

Nitrogen uptake by corn generally follows the same trend as dry matter accumulation. Considering a 120 day hybrid, dry matter accumulation rate during the first and last month of growth are small compared to the middle two months. By silking time which usually occurs about 60 days after emergence, many irrigated corn hybrids in Nebraska will have accumulated 50 to 60% of the total dry matter production. However, N accumulation at silking time is usually greater than 80% of the total N uptake at harvest. Therefore, N availability is very important during the 30 day period before silking. Crop N requirements after silking can frequently be met by mineralization and nitrate in the irrigation water.

N MANAGEMENT

Nitrogen management practices will certainly be different for each producer and probably somewhat different for each field, depending on previous cultural practices. Considering the various sources of N available to crops, fertilizer N is really the only component over which the producer has much control during any one growing season. The proportion of fertilizer N to the total amount of N available to the crop may by relatively small for fertile soils but very substantial for sandy soils. Never the less, soil nitrates present in quantities greater than can be used by the crop at a given time represent a potential hazard to ground water. The key to good N management then is to use fertilizer N to supplement all other sources of N while maintaining an adequate supply of N for the crop. Each producer will find the need to evaluate his own N management practices in terms of time constraints, what is physically feasible, and the economics of the various forms and times of fertilizer N application.

An example of these considerations for an irrigated corn producer in Nebraska can be seen in Figure 1. Assume the producer feels a 150 bu/A yield goal is reasonable. Total crop N requirement (using the "rule of thumb" value of 1.2 above) would be 180 lb N/A. Soil test results from a 1 ft sample indicate a residual N credit of 45 lb/A is appropriate. The difference between crop N requirement and soil test residual N in the surface ft indicates that the producer should apply 135 lb N/A (150 kg /ha). Note that a value of 100 lb/A may be more appropriate for the entire root zone. Never-the-less, the producer decides to apply 135 lb N/A as anhydrous ammonia preplant because of time and economic considerations. Further, mineralization is known to contribute about 135 lb N/A (150 kg N/ha) over the growing season. In addition, the need for about 10 inches of irrigation water (20 mg/L nitrate-nitrogen) is estimated to provide a credit of 45 lb N/A (50 kg N/ha). By harvest, crop N uptake is 180 lb/A (~200 kg N/ha) and resulted in a 150 bu/A yield. The question the producer must address is whether he could have attained the same yield with less fertilizer. Perhaps only trial and error would tell for sure, but summing all of the N sources available to the crop in May and June would suggest an excess of N at that time. Reducing the fertilizer application to 75 kg N/ha reduced the potential for nitrate leaching, but also reduced the supply of plant available N. The rapid rate of N uptake during late June, July, and early August should not have been hindered even with the reduced fertilizer rate. This conclusion has been substantiated by N rate studies which seldom give a yield response above the 50 lb N/A rate for this soil.

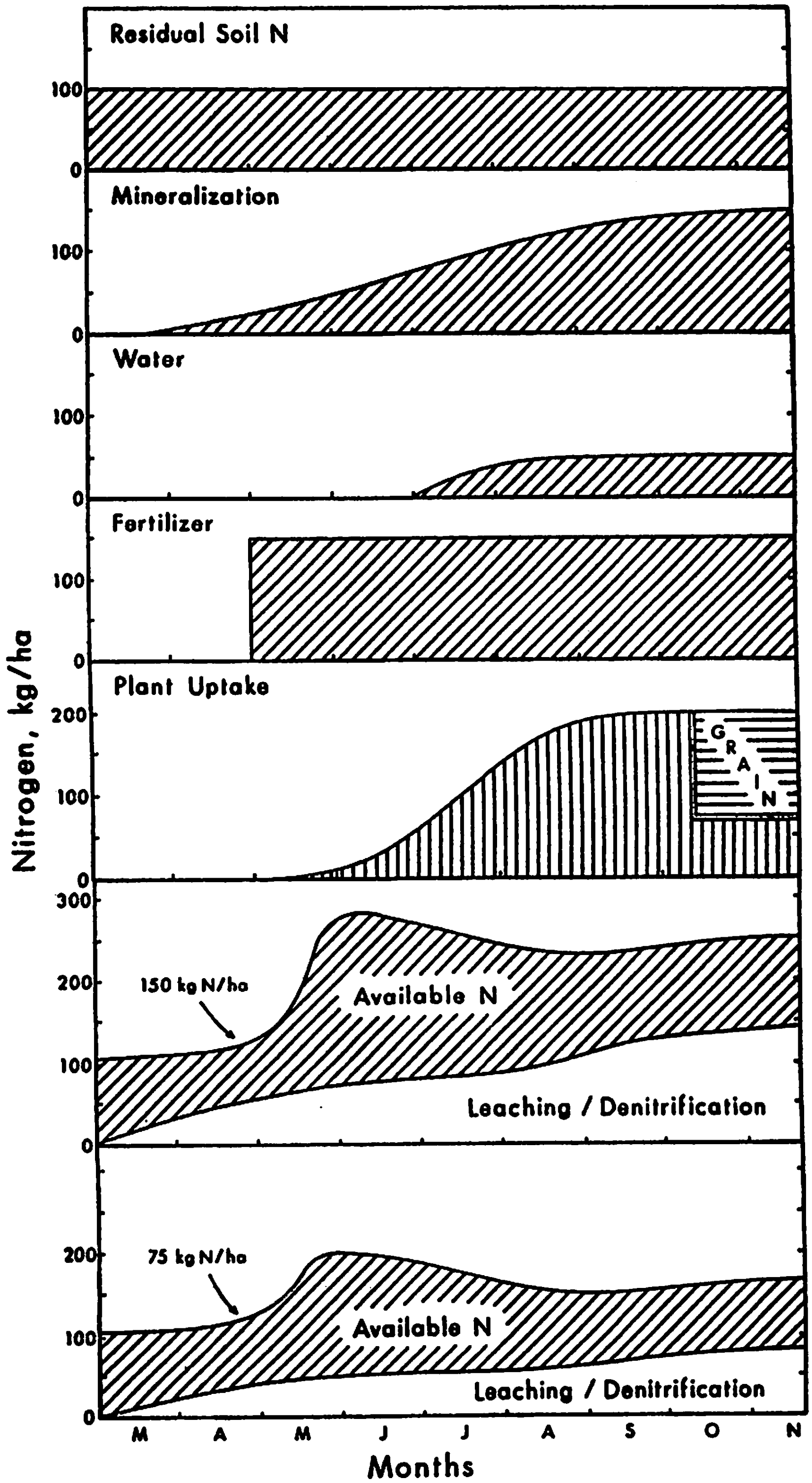

Figure 1. The amount and distribution of plant available N from various sources (100 kg/ha = 89.2 lb/A), N uptake by irrigated corn, and estimated leaching from a silt loam soil in Nebraska.

N SYNCHRONIZATION

The potential for nitrate leaching can be reduced to a minimum by applying N when crop demand is the greatest. This approach is usually restricted to situations where sidedressing is feasible or fertigation can be practiced. Where delayed N application is not possible, the use of nitrificaton inhibitors can slow the rate of N conversion from ammonium to nitrate. Yield increase to nitrification inhibitors should not be expected when N from fertilizer or other sources are in excess, but is more likely when spring precipitation is above normal.

One final consideration for producers whose soils tend to have poor drainage is that of denitrificaton. This largely microbial process can be especially important in the spring and fall when soils may be very wet. Reduced tillage or no-tillage systems which leave large amounts of residue of the soil surface of poorly drained soils may prolong the period of time when denitrification is taking place. It is difficult to separate N losses due to denitrification and leaching. Soils with a high water filtration rate and high leaching potential usually do not provide conditions conducive to denitrification, while denitrification may be the major means of N loss from soils with poor drainage. Thus, the potential for N losses may be similar for many soils receiving similar N applications, however denitrification losses do not threaten the quality of the ground water. Both leaching and denitrification represent an economical loss to the producer which can be minimized by good N management. The incentive for good N management may be somewhat negated by the relatively inexpensive cost of N fertilizer and the likelihood of a yield response from additional fertilizer. Since 1975, producers could economically justify applying an extra 18 to 22 lb N/A if they could produce one additional bushel of corn. As such, N fertilizer represents a relatively inexpensive form of insurance against environmental factors over which they have limited control.

Fertilizer practices in the past have been largely "proactive" in that much of the N fertilizer was applied prior to crop uptake (fall or preplant application). Nitrogen application at these times presents a significant hazard to the ground water because of leaching losses. Sidedress N application still permits producers to use relatively low cost anhydrous ammonia while somewhat reducing the risk of ground water contamination from excess spring precipitation. Fertigation, when coupled with plant tissue analysis, makes it possible for producers to be "reactive" to climatic conditions and thereby minimize the impact of irrigated corn production on ground water quality and still attain near maximum yields. Tissue analysis (either leaf N concentration or chlorophyll determination) makes it possible to continually monitor crop N status and adjust fertilizer N applications accordingly. Procedures currently under development should make it possible for producers to evaluate crop N status while in the field, regardless of plant growth stage, time of day, soil type, or crop cultivar.

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