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NITROGEN MANAGEMENT TO ADDRESS LOW GRAIN PRICES

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Nitrogen fertilizer is an essential but costly input into corn production. The recent decrease in corn grain prices has prompted questions about how N management practices can be adjusted to address this problem. This paper summarizes relevant information that has been learned during the past decade of intensive research in Iowa. The information is presented as a series of observations with a brief explanation of each.

1. Optimal rates of N fertilization vary with prices for grain and fertilizer.

An example of the amount of variation that should be expected is illustrated in Figure 1, which shows mean net returns to N fertilization across 35 pairs of trials that were conducted over a period of several years. Fertilizer N was broadcast and incorporated immediately before planting in each trial. Observed yield increases were transformed to net returns to fertilization by assuming two price scenarios that represent the normal range of prices found in Iowa. The transformation was made by subtracting the costs of N from the value of additional grain produced by additions of the N. To distinguish between the profitability of production and of marketing, grain prices should be considered equal to the market value of grain at harvest (before drying and storage costs).

![Figure 1 Relationship between various rates of N fertilization and mean net returns to fertilization in price scenarios utilizing yield-response data from 35 pairs of trials in Iowa.](image-url)
The rates of N application that maximized net returns to fertilization within a given price scenario should be considered optimal for that scenario. The most profitable rate for corn after corn changed from 150 to 200 lb N/acre as prices changed so that one bushel of corn bought only 4 lb N instead of 25 lb of N. The optimal rate of N fertilization for corn after soybean changed from 100 to 150 lb N/acre with the same change in prices.

The price differences considered are not extreme given the normal difference in prices of N in various fertilizer materials at any given time and the extent to which grain and N prices vary with time. The extent to which optimal rates of N vary with common fluctuations in prices makes it inappropriate to recommend a single rate of N for all years and forms of N. This is one reason why Iowa State University’s recommendations (Pm 1714) for early season applications of N (before planting, at planting, or before emergence) are presented as ranges. It is noteworthy that information presented in Figure 1 indicates that, especially in corn after soybean, the profits are not decreased more by applying N at rates that are a little less than optimal than by applying N at rates that are a little more than optimal.

2. Corn after soybean and corn after corn should be considered different crops when selecting N rates.

Data presented in Figure 1 show that mean net returns to N fertilization were much higher for corn after corn than for corn after soybean. This difference can be explained by the greater responsiveness of the corn after corn to N fertilization. Failure to appreciate this important difference should be expected to promote unnecessary fertilization after soybean. Part of the problem comes when risk-averse producers estimate how much extra N they should apply as insurance against possible loss of yield due to N deficiencies. The unnecessary fertilization can be costly when prices are unfavorable for producers and rates optimal for more favorable prices are applied.

Producers and environmentalists should question N fertilizer recommendations that focus on corn after corn and merely apply an adjustment for corn after soybeans. The adjustments usually made are based on questionable assumptions, and they ignore many important benefits of rotating crops. Corn after soybean is now much more important than corn after corn in Iowa, and it makes no sense to base N recommendations for a major crop on the N fertilizer needs of a minor crop.

Iowa State University’s new nitrogen fertilizer recommendations for corn (Pm 1714) consider corn after corn and corn after soybean to be totally different crops. This change should help keep Iowa corn and soybean production profitable and competitive when grain and(or) fertilizer prices are unfavorable for producers.
3. **Optimal concentrations of nitrate in cornstalks at the end of the season tend to vary with prices of fertilizer and grain.**

Current interpretations of the end-of-season test for cornstalk nitrate (described in Pm 1584) are based on the use of four categories (low, marginal, optimal, and excessive). Ongoing studies to enable more quantitative interpretations of this test have shown that the “marginal” category should be considered optimal when prices are such that one bushel of corn buys less than 9 pounds of N. This refinement in interpretation of the test would not have had significant impact on interpretations during the past few years, but it could be important when results of the test are used to adjust rates of N fertilization for next year.

4. **Non-uniform application of fertilizer N is a serious problem that reduces profits for producers.**

Recent studies using remote sensing to characterize spatial patterns in N sufficiency (N availability relative to crop needs) within Iowa cornfields has provided compelling evidence that non-uniform application of N is a serious problem in Iowa (Blackmer and White, 1998). The problem is especially severe with anhydrous ammonia. A primary cause of the problem is manifolds and hoses that deliver different amounts of N to individual knives. The observed spatial patterns of N-deficient corn as revealed by remote sensing leave no doubt concerning the cause of the problem. Remote sensing often reveals important problems that are not detected by merely driving past or walking through cornfields.

When optimal amounts of N are applied to a field, poorly adjusted applicators result in some corn having too much N and some having too little. This problem often can be hidden by addition of extra N, but this solution is costly for producers. Many applicators are so poorly adjusted that adding extra N does not prevent strips of N-deficient corn. This problem can be reduced greatly by modest efforts to adjust applicators to deliver N uniformly. Increasing effort to adjust applicators would increase profits for corn producers.

Non-uniform applications of N also pose serious problems when soil nitrate testing or cornstalk nitrate testing is used to evaluate and improve N management. When a soil or stalk sample is collected from a mixture of low- and high-testing areas, and the average for the sample represents neither area. Non-uniform application of N should be suspected anywhere where the soil or the stalk test seems to give erratic results. Correcting non-uniform applications of N should be considered a first essential step in moving toward precision farming.

5. **Routine application of commercial fertilizer to manured cornfields is unprofitable when fertilizer and grain prices are unfavorable for producers.**

Data collected in 148 on-farm trials (see Table 1) show that routine (same rate to all fields) fertilization at rates of 30, 60, or 90 lb N/acre would have resulted in economic losses in price scenarios with corn and fertilizer prices relatively unfavorable for producers. Each increase in
rate of application resulted in greater losses. Some sites did show substantial yield responses to the commercial fertilizer, but these responses were not great enough to offset economic losses that occurred at the majority of sites. At prices relatively favorable for producers, routine application of 60 lbN/acre was more profitable than not fertilizing or than applying commercial fertilizer at rates of 30 or 90 lb N/acre. Because most producers cooperating in the study applied more than 90 lb N/acre to the portion of the field that surrounded the experimental area, the study indicates that producers could increase their profits by improving N management on manured cornfields.

<table>
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<tr>
<th>Recommendation system</th>
<th>Mean net returns to added N</th>
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<tbody>
<tr>
<td></td>
<td>Poor prices†</td>
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<tr>
<td></td>
<td>Good prices‡</td>
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<td>------------------------------</td>
<td>---------------------------------------------</td>
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<tr>
<td>0 lb N/acre at all sites</td>
<td>0.0</td>
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<tr>
<td>30 lb N/acre at all sites</td>
<td>-2.1</td>
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<tr>
<td>60 lb N/acre at all sites</td>
<td>-5.3</td>
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<tr>
<td>90 lb N/acre at all sites</td>
<td>-12.6</td>
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<tr>
<td>Soil nitrate test as in Pm 1714§</td>
<td>4.8</td>
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</tbody>
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† Corn at $2.00/bu and N at $0.30/lb (1 bu buys 7 lb N).
‡ Corn at $2.50/bu and N at $0.15/lb (1 bu buys 17 lb N).
§ The mean rate of fertilization was 25 lb N/ac for poor prices and 39 lb N/ac for favorable prices.

Analysis showed that use of the late-spring test to guide fertilization as specified in Pm 1714 would have been more profitable than routine fertilization whether prices are favorable or unfavorable. If normal practice were considered to be routine application of 90 lb N/acre, then use of the soil test to guide fertilization with the unfavorable prices would have increased profits by an average of $17.4/acre (from $12.6/acre loss to $4.6/acre profit) across all fields. This average includes the consideration of zero net returns to fertilization on all fields not fertilized, so the mean profits across the fields actually fertilized would have been much higher. The soil test was able to increase profits by showing where fertilizer N was needed and where it was not needed.

Analyses also showed that knowledge concerning amounts of manure-N applied did not enable reliable predictions of plant-available N in cornfields (Hansen and Blackmer, 1997). A major problem seemed to be great variability in amounts of the manure-N lost soon after application. The late-spring test for soil nitrate addresses this problem by assessing N availability after these losses have occurred.
6. Fall application of N carries high risks.

It has been long recognized that amount of fertilizer N lost before it can be used by crop tends to increase with increasing time between application and plant uptake. The important question, therefore, is whether the benefits of fall applications outweigh the costs associated with losses of the extra N. The popularity of fall-applied N during the past few years indicates a commonly held viewpoint that the extra losses of N are relatively unimportant to producers and the fertilizer industry.

Studies during the past decade suggest that the costs associated with fall applications of N are probably greater than believed by those who use or recommend this practice. Some of these studies used soil nitrate testing, remote sensing, end-of-season cornstalk testing, on-the-go yield monitoring, global positioning, and geographic information systems to characterize responses of corn to fertilizer applied in strips within fields. These studies have revealed a surprising number of situations in which most of the fall-applied N was lost before it was needed by the crop. Perhaps even more revealing, these losses often would not have been detected by using more traditional methods. The results suggest that losses of fall-applied may have be underestimated in the past and that yield-limiting deficiencies of N should be considered a major cost of fall-applied N.

Soil samples collected in late April of 1998 provided additional evidence for substantial losses of fall-applied N in many fields in West Central Iowa (Blackmer, 1998). Results indicated that the N was largely converted to nitrate before the crop was planted. In many fields, less than half of the N applied could be accounted for as nitrate, exchangeable ammonium, or readily mineralizable N in the surface 2-foot layer of soil. The fertilizer N present as nitrate was extremely vulnerable to loss by leaching or denitrification during the large amounts of rainfall that occurred during June.

A hypoxic zone, or “dead zone”, has been identified in the Gulf of Mexico during the past few years. Although the cause of this problem is not known with certainty, N that moves down the Mississippi River from the upper mid-west is suspected to be a major factor. More intensive monitoring of nitrogen loads in Iowa rivers should be expected.

Given what has been learned in the past few years, Iowa farmers and fertilizer dealers are well advised to start moving away from fall application of N. Moving toward in-season fertilization would tend to increase profits for producers while minimizing losses of N to the environment. Efforts spent selecting the most desirable alternative to fall-applied N probably will be more fruitful than efforts to defend this practice.

7. Optimal rates of N fertilization tend not to vary in proportion to soil yield potentials or measured yields.

This conclusion is supported by data collected in many conventional plot experiments (Blackmer et al., 1993) and precision farming field studies (Blackmer and White, 1996, 1998; White and Blackmer 1998) in Iowa. The obvious fact that crop uptake of N tends to increase with yield
level is irrelevant for several reasons. One is great variability in amounts of plant-available N supplied by soils. Another is the tendency for soils with the highest yield potential to supply the most plant-available N. A third is that the percentage of fertilizer N lost before it can be taken up by the crop is highly variable and depends largely on an interaction of weather and time and method of fertilizer application. Existing evidence indicates that variable-rate applications of N based on soil yield potentials or measured yields are more likely to decrease than to increase profits for crop producers.

Recommendations based on corn yields should be questioned because they tend to distract attention from the most important factors affecting optimal rates of N fertilization. Also, recommendations that build strong associations between rates of N fertilization and yield levels should be expected to encourage producers to apply more N than is needed. In addition, oversimplification of the problems associated with selecting optimal N rates invites ineffective and costly regulations designed to protect the environment.

8. The late-spring test for soil nitrate and the end-of-season test for cornstalk nitrate should be used to evaluate and improve N management.

Testing a few sites within each of several fields each year provides producers with site-specific feedback that can be used to adjust their N management practices toward optimal. The basic idea of on-farm optimization of N management through annual cycles of evaluation and adjustment is new, but implementation is less expensive and less complicated than many of the other new innovations often described as precision farming technologies. Relatively small investments are required to learn whether greater efforts are needed to improve N management.

REFERENCES


