Is Nitrogen Use Efficiency Compatible with High Corn Yields?

Stories such as “Fixing the Global Nitrogen Problem” are common in science-oriented media (see Townshed and Howarth, Scientific American Feb 2010) and often may suggest that agriculture is a leading cause of the problem.

It’s currently estimated that twice as much nitrogen is now being fixed into reactive forms by humans through fertilizer production and fossil fuel use as is being fixed naturally through biological fixation and lightning. Reactive forms include ammonium and nitrate resulting from fixation of di-nitrogen (N2) which is abundant in the atmosphere but non-reactive.

These increased levels of nitrogen fixation — much of it from human use — are greatly exceeding the amount lost through denitrification. That means that reactive N is accumulating around the world. These higher levels of reactive nitrogen affect natural terrestrial and marine ecosystems, and water and air quality.

When trying to identify contributing factors, often concern is focused on agricultural uses such as for corn production. This is due to the large amount of N required for production and the speculation that if yields are to increase, even more N will be required for each bushel of corn produced.

UNL Research Tests Economically Optimal N Rates

The results of 32 N rate trials for high yield corn conducted in Nebraska show that we can achieve high yields with high N use efficiency, provided N is applied at the most profitable rate and precautions are taken to minimize N loss. The average maximum treatment yield in these trials was 240 bu/ac.

Table 1. Corn yield, economically optimal N rate, and N use and recovery efficiency when the mean maximum yield was 240 bu/ac over 32 trials.

	Corn-corn	Soybean-corn
Yield, bu/ac	237	231
N rate, lb/ac	155	110
Grain:fertilizer NUE, lb/lb	85	115
Recovery efficiency, %	62	76

When N was applied at the economically optimal N rate (EONR), on average, about 1 lb of N was needed for each 100 lb of grain produced (*Table 1*). Another way to say this is < 0.6 lb of fertilizer N was required per bushel. On the other hand, the Nebraska average is 1 lb of N is applied to corn for about every 60 lb of grain harvested. These numbers indicate that we do have potential for high N use efficiency with high yield corn.

In these trials, our recovery efficiency was 70% of the applied N, while the national average is about 40%. This high efficiency contributed to the low EONR required for these high yields (*Table 1*) with only modest levels of residual soil nitrate-N after harvest (*Figure 1*). These efficiencies were achieved with:

- good crop and irrigation management,
- application of the economically optimal N rate (EONR), and
- split application of fertilizer N with 40% or more applied in-season.

With such management, it is not surprising that N use efficiency is high with a high yield crop. Such a crop is expected to have a healthy, vigorous, and extensive root system, and therefore capable of efficient recovery of N and other nutrients. A high yield crop typically has fewer constraints on growth, allowing for efficient conversion of plant carbohydrates and nutrients to grain.

Researchers Hone in on Corn-on-Corn Variations

Achieving such high N use efficiency requires an accurate estimate of EONR before N application and the use of practices to minimize N losses, such as with in-season N application. For our study, we examined the results and determined the EONRs. However, EONR varied widely, especially for corn following corn.

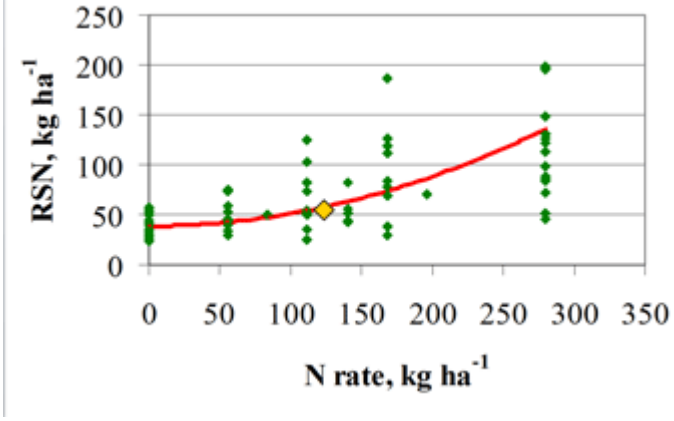

Figure 1. Residual soil nitrate N remaining after corn harvest. The golden diamond indicates the most profitable N application rate. The scatter of green diamonds show the actual measurements of residual soil nitrate for the different trials.

The UNL recommendation estimated EONR very well, on average, for corn following soybean and over-estimated for corn following corn or drybean. However, the UNL recommendation did not account for much of the great variation in EONR across site years for corn after corn, often over- or under-estimating EONR. Not being able to accurately predict corn after corn application rates showed up in a lower dollar return on the fertilizer used. We are continuing our analysis of the data to improve UNL recommendations for predicting field-specific EONR.

Taking the Research to Your Field

In summary, high nitrogen use efficiency is compatible with high yield corn. To achieve this efficiency, producers often can lower their N application rates and adopt science-based N management practices to minimize N losses.

Producers who are doubtful about seeing these efficiencies on their farm are encouraged to properly conduct on-farm trials to obtain their own information.

Taking steps to achieve high nitrogen use efficiency in commercial crop production may help slow the build-up of reactive nitrogen in our environment and reduce the potential for increased regulation of this input.

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