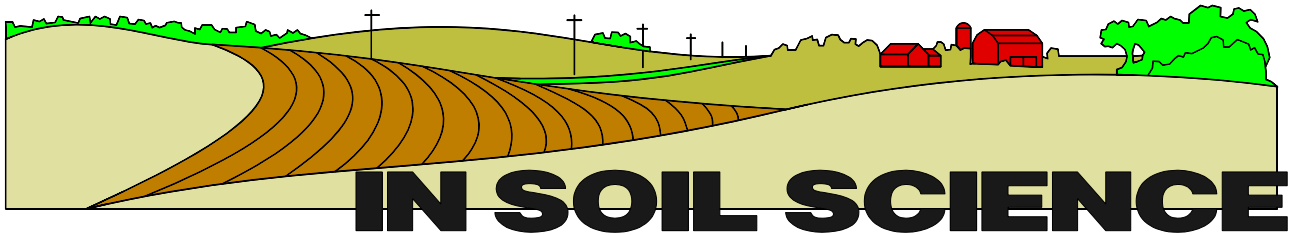


# NEW HORIZONS



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## New Nitrogen Rate Guidelines for Corn in Wisconsin Using a Regional Approach

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### Background

In the Corn Belt region, nitrogen (N) application rate guidelines, and the approach used to produce the guidelines, have varied by state in the past. Illinois, Indiana, Michigan, Minnesota, and Ohio used yield goal (or proven yield) methods that took on slightly different forms in some of the states. Iowa had a range of N rates for different cropping systems: corn following corn and corn following soybean. Wisconsin used a soil yield potential approach that was based on field N response data. The variety of methods that exist to determine N application rates have often led to producer confusion as to what the “right rate” is.

Soil fertility specialists have known for a while that using yield goal as a means to determine N application rates is faulty. The yield goal method appeared to work in the 1970s when yield levels were lower than today. However, with corn yields getting higher every year, this method has broken down. Figure 1 highlights this fact for data collected from 101 sites in Wisconsin from 1989-1999. It can be seen that an economic optimum N application rate near 160 lb N/a on

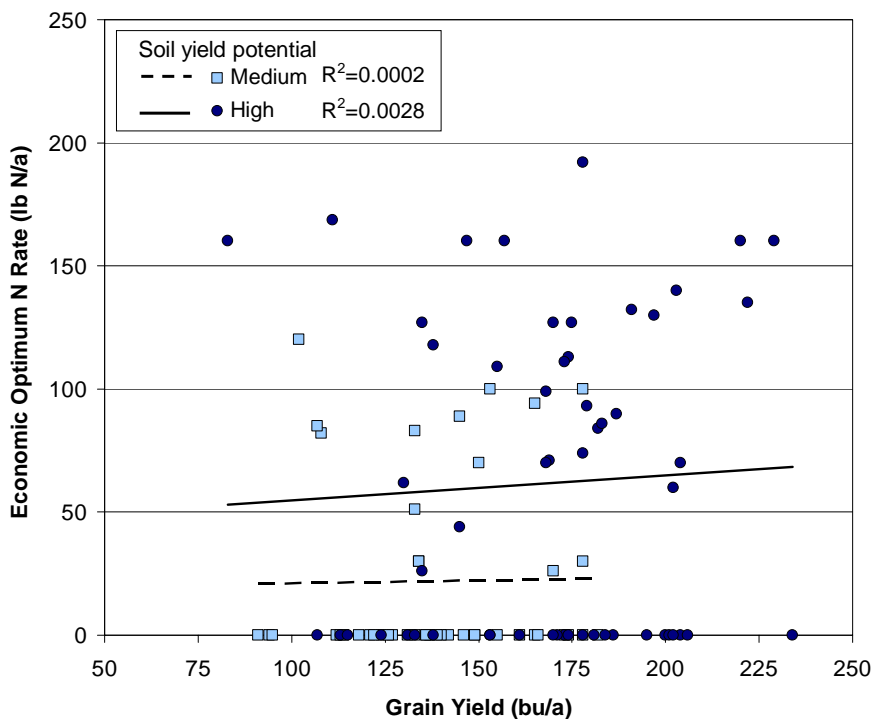


Figure 1. Relationship between the economic optimum N rate and grain yield obtained at the economic optimum N rate for 101 sites in Wisconsin from 1989-1999. Economic optimum N rates were calculated at a N:corn price ratio of 0.06. For example \$0.15/lb N and \$2.50/bu corn.

a high yield potential soil can produce anywhere from 80 to 230 bu/a of corn. Additionally, 0 lb N/a was the most profitable N rate at several sites with yield ranging from 90 to 230 bu/a. Thus, there is no relationship between the yield obtained and the amount of N needed to obtain that yield.

### **Maximum Return to Nitrogen – The Concept**

Recently, soil fertility specialists in the region have agreed upon and developed a new philosophy for N rate guidelines. The new approach is based on analyzing field N response data with the goal of providing a range of N rates that produces maximum or near maximum economic return on the fertilizer N investment. The approach is called maximum return to N (MRTN).

MRTN is calculated in the following manner:

- 1.) Compile data sets of corn yield response to applied fertilizer N for various rotations; e.g., corn after corn (CC) and corn after soybean (SC).
- 2.) At each site, a response model (or curve) is fit to the data. This model describes mathematically how yield responds to applied fertilizer N.
- 3.) N application rate, in one pound increments is entered into the response model for each site and the yield obtained at that N rate is calculated. This is done for N rates from 0 to 240 lb N/a.
- 4.) For each site, at each N rate, the yield increase over the yield at zero N applied is calculated and multiplied by the price of corn. The result is income in \$/a. The cost of N at each N rate is subtracted from the income at that N rate to arrive at the return to N.
- 5.) For each previous crop (e.g. corn), the average return to N at each N rate is determined. Thus, if 40 sites in the data set had a previous crop of corn, then the average return to N at a given N rate is calculated using these 40 sites.
- 6.) The MRTN is determined to be the N rate where the average return to N for a given previous crop is the largest (maximized).
- 7.) A range in profitable N rates can be determined as the N rates that produce a return to N that is within \$1/a of the MRTN. The ends of this range are designated as LOW and HIGH.
- 8.) Steps 4 through 7 can be repeated for various N and corn prices to obtain a range of profitable N rates as economic conditions vary.

All states participating in this regional approach have agreed to analyze their data in the same way to arrive at N rate guidelines. However, each state will use data that is specific to their state; that is taking into account local soil and climate variability. This means that N rate guidelines between states may still be a little different, but the approach is the same. Ultimately this approach will make nutrient management easier particularly when N rate questions arise in watersheds that cross state boundaries.

## Maximum Return to Nitrogen – Wisconsin Nitrogen Rate Guidelines

For Wisconsin, before the MRTN was calculated, the CC and SC databases were further subdivided based on the soil yield potential. Soil yield potential has already been determined for each soil in Wisconsin and can be found in the bulletin UWEX A2809 “Soil test recommendations for field, vegetable, and fruit crops.” A soil is classified into a yield potential category based on its rooting depth, water holding capacity, drainage, and length of growing season. Thus, a Withee soil in Central Wisconsin has a medium yield potential because it does not drain well and it has a shorter growing season while a Plano soil in Southern Wisconsin has a very high yield potential because it has large rooting depth and water holding capacity, drains well, and has a longer growing season. For the purposes of N rate guidelines, high and very high yield potential soils are grouped together, medium and low yield potential soils are grouped together, and irrigated sands are a third category.

The MRTN was calculated for CC and SC rotations on high/very high yield potential soils, for CC and SC rotations on medium/low yield potential soil, and on irrigated sands. On irrigated sands, corn is highly responsive to N and previous crop (all except forage legumes and green manures) does not impact that relationship the way it does on non-sandy soils. Tables 1 and 2 provide the MRTN along with the low and high end of the profitability range for several N:corn price ratios. To use these tables, one must first determine the N:corn price ratio that is appropriate for their farm. Then the previous crop and soil yield potential category must be identified to determine the range. For example if a field had a previous crop of corn on a high yield potential soil and the appropriate N:corn price ratio was determined to be 0.10, then the MRTN is 135 lb N/a with a range of profitability from 120 to 155 lb N/a.

Table 1. Profitable nitrogen rates for corn on high/very high and medium/low yield potential soils. MRTN is the maximum return to N. Low and high are the limits of nitrogen rates that produce a return to N within \$1/a of the MRTN. These rates include N in starter fertilizer.

N:Corn Price Ratio \$/lb:\$/bu	Previous Crop = Corn			Previous Crop = Soybean		
	Low	MRTN	High	Low	MRTN	High
	lb N/a			lb N/a		
<b>High/Very High Yield Potential Soils</b>						
0.05	135	165	190	110	140	160
0.10	120	135	155	100	115	130
0.15	100	120	135	85	100	115
0.20	90	105	120	70	90	100
<b>Medium/Low Yield Potential Soils</b>						
0.05	90	110	135	75	90	110
0.10	80	100	110	45	60	70
0.15	70	85	100	40	50	60
0.20	60	75	90	35	45	55

Table 2. Profitable nitrogen rates for corn on irrigated sandy soils (group E soils). MRTN is the maximum return to N. Low and high are the limits of nitrogen rates that produce a return to N within \$1/a of the MRTN. These rates include N in starter fertilizer.

N:Corn Price Ratio	Previous Crop = All crops except forage legumes & green manures		
	Low	MRTN	High
\$/lb:\$/bu	lb N/a		
0.05	200	215	230
0.10	190	205	220
0.15	180	195	210
0.20	175	190	200

Close examination of Tables 1 and 2 shows that there is significant overlap in profitable N rates between price ratios. This means that for producers who don't want to spend a lot of time adjusting N rates for each field each year, they don't have to. For example, for CC on a high yield potential soil, a producer may choose an N rate somewhere between 120 and 135 lb N/a and know that they will be near the most profitable N rate over a variety of economic conditions. Figure 2 provides a graphical depiction of this. At favorable price ratios (smaller numbers; e.g., 0.05) the range in profitability is larger than at less favorable price ratios. This is largely because the penalty for over application of N at favorable price ratios is not as severe when the price of N is low and the price of corn is high. Additionally at favorable price ratios (0.05) the penalty of lost return caused by under application of N is not as great either because few bushels of yield are lost and a relatively large amount of N is required to attain those last few bushels. As the price ratio becomes less favorable (gets larger; e.g., 0.20), the range of profitability becomes smaller because the penalty for over application of expensive N is much greater than at favorable price ratios largely because corn prices tend to be low in these situations. The penalty for under application of N at unfavorable prices ratios is more dramatic because the price of N is so high and price of corn so low that the small increase in yield is not large enough to pay for the cost of the N.

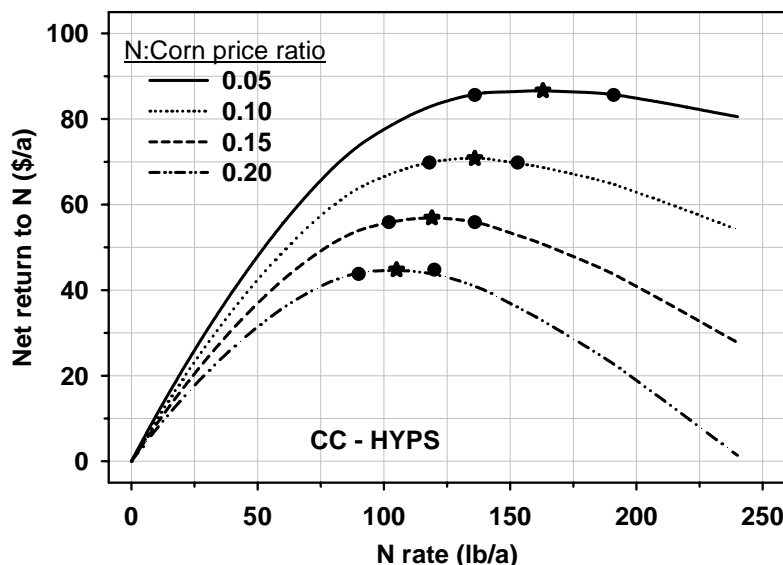


Figure 2. Profitable N rates for corn following corn on high/very high yield potential sites for N: corn price ratios of 0.05, 0.10, 0.15, and 0.20. Stars represent the MRTN and circles the low and high ends of the range of profitability (within \$1/a of MRTN) at each N:corn price ratio.

## Further Guidance on Using the New Nitrogen Rate Guidelines

While having a range of profitable N application rates for producers to follow provides them flexibility to deal with economic changes, guidance on determining which part of the range to be in is necessary for many cases. Below are some further guidelines for determining N application rates:

- If > 50% residue cover at planting, use the upper end of the range.
- When corn follows small grains, use the mid to lower end of the range for corn following soybean using the appropriate soil yield potential.
- For non-irrigated sands regardless of previous crop, use the mid to lower end of the range for a previous crop of corn on medium yield potential soils. Use sidedress N applications.
- For irrigated sands with > 2.0 % organic matter, use the lower end of the range. Use sidedress N applications.
- For non-sandy soils: 1) if organic matter is < 2.0 %, use the upper end of the range; 2) if organic matter is > 10% use the lower end of the range.
- If you think there may be carry over (residual) N from last year: 1) Use the lower end of the range; or 2) Use the upper end of the range and take preplant nitrate test (PPNT) credits.
- When corn follows a forage legume, green manure, or leguminous vegetable, use the table for corn following corn and take the appropriate N credits.
- Starter N counts towards total N applied.
- Consider using the lower end of the range to improve environmental quality, particularly on irrigated sandy soils.

## Determining Price Ratios

One question many producers may have is related to how to determine the appropriate price ratio for their situation. The first thing to do is determine how much N costs on a \$/lb basis. The next thing to do is to determine the price or value of the corn in \$/bu. Then the price ratio can be calculated as the price of N divided by the price of corn. Table 3 was developed to help producers with this. In Table 3 the price of N ranges from \$0.20 to \$0.50/lb and the price of corn ranges from \$1.80 to \$3.60/bu. This provides a fairly large range of N and corn prices to at which to look. However, attention should be focused on the price ratios outlined in black. This box highlights the price ratios when N is \$0.30 to \$0.40/lb and corn is \$2.00 to \$2.60/bu. These are likely very reasonable price ranges that producers will be working with in 2006. It can be seen that the price ratio varies from 0.12 (top right) to 0.20 (bottom left). These ratios are nowhere near the very favorable price ratio of 0.05 at the top of Tables 1 and 2. Many of the ratios are near 0.15.

Table 3. Price ratio of N:corn (ie. \$/lb N ÷ \$/bu corn).

Price of N <sup>†</sup> \$/lb N	Price of Corn (\$/bu corn)									
	1.80	2.00	2.20	2.40	2.60	2.80	3.00	3.20	3.40	3.60
0.20	0.11	0.10	0.09	0.08	0.08	0.07	0.07	0.06	0.06	0.06
0.22	0.12	0.11	0.10	0.09	0.08	0.08	0.07	0.07	0.06	0.06
0.24	0.13	0.12	0.11	0.10	0.09	0.09	0.08	0.08	0.07	0.07
0.26	0.14	0.13	0.12	0.11	0.10	0.09	0.09	0.08	0.08	0.07
0.28	0.16	0.14	0.13	0.12	0.11	0.10	0.09	0.09	0.08	0.08
0.30	0.17	0.15	0.14	0.13	0.12	0.11	0.10	0.09	0.09	0.08
0.32	0.18	0.16	0.15	0.13	0.12	0.11	0.11	0.10	0.09	0.09
0.34	0.19	0.17	0.15	0.14	0.13	0.12	0.11	0.11	0.10	0.09
0.36	0.20	0.18	0.16	0.15	0.14	0.13	0.12	0.11	0.11	0.10
0.38	0.21	0.19	0.17	0.16	0.15	0.14	0.13	0.12	0.11	0.11
0.40	0.22	0.20	0.18	0.17	0.15	0.14	0.13	0.13	0.12	0.11
0.42	0.23	0.21	0.19	0.18	0.16	0.15	0.14	0.13	0.12	0.12
0.44	0.24	0.22	0.20	0.18	0.17	0.16	0.15	0.14	0.13	0.12
0.46	0.26	0.23	0.21	0.19	0.18	0.16	0.15	0.14	0.14	0.13
0.48	0.27	0.24	0.22	0.20	0.18	0.17	0.16	0.15	0.14	0.13
0.50	0.28	0.25	0.23	0.21	0.19	0.18	0.17	0.16	0.15	0.14

<sup>†</sup> Price of N (\$/lb N) = \$/ton fertilizer x (100 / % N in fertilizer) ÷ 2000

### New Nitrogen Rate Guidelines Compared to Old Guidelines

The previous University of Wisconsin N rate guidelines were also based on corn yield response to N data sets. In developing the “old” guidelines, the data was analyzed differently than the present MRTN approach. However, the analysis did take into consideration the N:corn price ratio. The old guidelines used a fixed price ratio of 0.06 (\$0.15/ lb N and \$2.50/ bu corn) that reflected economics that had been previously considered typical. This price ratio does not reflect current economics. Thus, the MRTN approach is more robust in that annually changing economics or economics that vary between farms can be taken into consideration when determining a N application rate. It is important to point out that for CC on high yield potential soils the old guideline was to apply 160 lb N/a with up to an additional 20 lb N/a in starter fertilizer; or a total 180 lb N/a. If we look at Table 1, the MRTN for CC at a 0.05 price ratio (very close to 0.06) is 165 lb N/a and includes the N starter fertilizer. The upper end of the range of profitability at this price ratio is 190 lb N/a or slightly more than the total N that was suggested in the old guidelines. Overall, the new MRTN approach supports the previous guidelines that were established in 1990. This relationship between the old and new guidelines holds for all soil yield potential categories. *The advantage of the MRTN approach is that it provides producers the flexibility to manage N to best meet his/her economic situation.*

## Profitability and Potential Yield Loss

The price ratios in Table 3 show that current economics are not similar to the price ratio that was used to develop the old guidelines. Thus, using a price ratio of 0.05 to determine N application rates in 2006 is likely not appropriate for most producers. To maintain profitability, producers should reduce N rates to a level determined by current economics. One concern that many producers have is that reducing N rates will greatly reduce yield. Figure 3 shows the percent of maximum yield obtained for CC and SC on high/very high yield potential soils, along with irrigated sands. It can be seen that for CC, reducing N rates to 120 lb N/a will result in yield being about 97% of maximum yield. Or stated another way, will result on average in a 3% yield reduction. At a 200 bu/a yield level, this is a loss of approximately 6 bu/a from maximum yield. It must be remembered that producing maximum yield is not economical. So reducing N rates will reduce yield, but improve overall profitability. In this example, when N rates are reduced to 120 lb N/a, it is likely that some firing of the lower leaves on the stalk will be seen. It is acknowledged that most producers generally consider late season firing to be undesirable. However, it must be noted that supplying enough N to keep plants dark green through physiological maturity (black layer) means that N fertilizer has been over supplied from an economics standpoint.

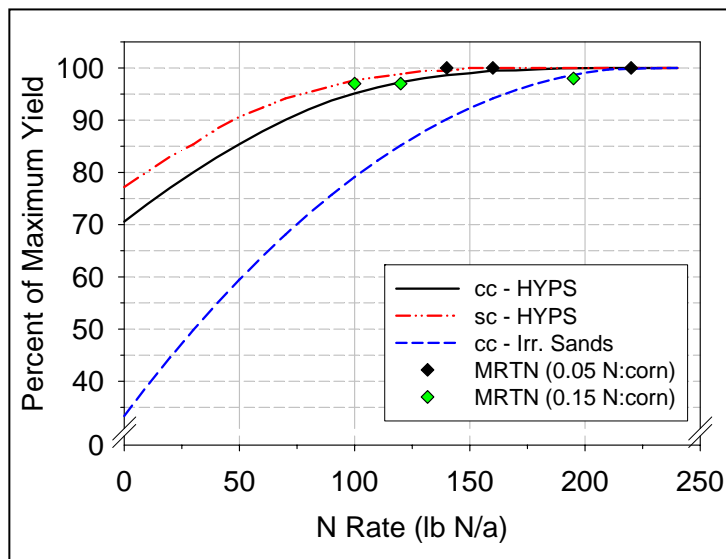


Figure 3. Percent of maximum yield obtained on average at each N rate for corn after corn and corn after soybean on high/very high yield potential soils and for all previous crops on irrigated sands with the exception of forage legumes and green manures. Dots represent the MRTN for each situation at price ratios of 0.05 and 0.15.

## Nitrogen Crediting

Nitrogen crediting is largely unchanged in the new N rate guideline system. The N credits for forage legumes, leguminous vegetables, green manures, and animal manures remain the same. A key change is that soybean N credits are no longer taken. The N credit effect observed when corn is grown after soybean compared to corn is really a rotational effect. As such, separate tables have been developed for corn after soybean. It should be noted that there is usually not a

40 lb N/a difference between the MRTN for CC vs. SC. This is because different sites make up the CC and SC data sets.

Soil N testing will remain as a tool for better N management in the new guidelines. The preplant nitrate test (PPNT) is only changed in that the N credit from the PPNT is subtracted from the N rate determined using the tables and will change based on price ratio used. In the old system, the N rate that the PPNT credit was subtracted from did not change with price ratio. For the presidedress nitrate test (PSNT), the test results are now used to determine an N credit that is to be subtracted from a previously determined N rate. Table 4 provides the PSNT N credit interpretation.

Table 4. Presidedress nitrogen test (PSNT) nitrogen credit.

PSNT	Soil Yield Potential	
	High/Very High	Medium/Low
ppm	Nitrogen Credit	
	lb N/a	
≥ 21	*	*
18 – 20	100	80
15 – 17	60	80
13 – 14	35	40
11 – 12	10	40
≤ 10	0	0

\* No additional N is needed.

## Summary

In summary the advantages of the regional MRTN approach to N rate guidelines are several. First, it is solidly based on economics. The new guidelines provide a range of N rates that will result in profitability. This means that producers have greater flexibility in adjusting N rates to match current economic climates or management levels. Second, the new guidelines confirm that our old guidelines were valid for economic conditions that had previously existed. Third, this approach provides the ability to adjust for environmental costs and show profit losses when certain environmental quality criteria must be met. And lastly, the new guidelines provide a consistent approach to N rate recommendations across state borders.