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Best Management Practices for Nitrogen on COARSE TEXTURED SOILS

BEST MANAGEMENT PRACTICES FOR NITROGEN APPLICATION

Best Management Practices for Nitrogen on Coarse Textured Soils

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Introduction

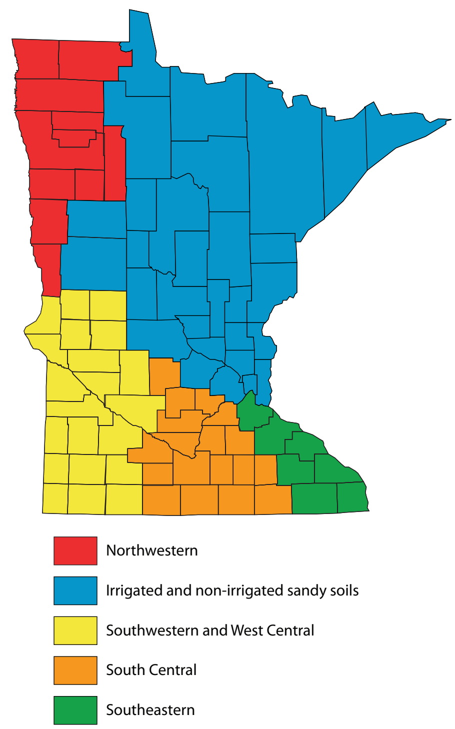
Nitrogen (N) is absorbed in large amounts by Minnesota crops. It is the major nutrient supplied in a fertilizer program. In addition, large quantities of nitrogen are part of the crop production ecosystem, including soil organic matter. Biological processes that convert nitrogen to its usable and mobile form (NO_3-N) occur continuously in the soil system. For details, see "***Understanding Nitrogen in Soils***", (**FO-3770, Minnesota Extension Service**). Nitrogen exists in several forms and conversion from one form to another can be complex.

Loss of nitrate-nitrogen (NO_3-N) from the soil system is a major environmental concern. This is especially true for irrigated sandy soils. Potential for leaching losses of NO_3-N, however, can be minimized if Best Management Practices are used. This publication describes those practices that are appropriate for corn and edible beans grown on sandy soils (see map). In Minnesota, sandy soils dominate the landscape in the central and east-central regions of the state. These coarse textured soils are also scattered throughout the remainder of the state. This publication also describes suggested Best Management Practices for corn and edible beans grown on coarse textured soils that are not irrigated.

The research-based Best Management Practices (BMP's) described in this publication are economically and environmentally sound. It is strongly suggested that they be used voluntarily.

What Are the Best Management Practices (BMP's)?

There's general agreement that BMP's are economically sound voluntary practices that, if used, are capable of minimizing contamination, of surface and ground water with NO_3-N while, at the same time, providing for profitable application of nitrogen fertilizers. The BMP's for corn and edible bean production described in this publication are based on research conducted by faculty of the University of Minnesota and other Land Grant institutions.



The BMP's relate to management of all sources of N used in crop production.

BMP's for Coarse Textured Soils

The BMP's described in this publication are appropriate for corn and edible bean production on sandy soils throughout Minnesota. While much of the discussion will focus on irrigated corn and edible beans, practices for non-irrigated crops growing on sandy soils will not be ignored. The BMP's are divided into three categories described as: 1) recommended, 2) acceptable, but with greater risk, and 3) not recommended. With respect to N management, risk can be either economic or environmental. Economic risk can be a consequence of added input costs without additional yield or reduced yield.

Environmental risk pertains to the potential for loss of nitrogen to either ground water or surface waters.

The BMP's for coarse textured soils are:

1) Recommended

- For corn, select an appropriate rate using U of M guidelines ("***Fertilizing Corn in Minnesota***" **FO-3790,** 2006 or newer) which are based on current fertilizer and corn prices, soil productivity, and economic risk.
- For edible beans, base N rate on expected yield and previous crop.
- Total N rate used for corn and edible beans should include any N supplied in a starter, in a weed and feed program, and contributions from phosphate fertilizers such as MAP and DAP.
- Use split applications of fertilizer N for both corn and edible beans.
- Use a nitrogen stabilizer (N-Serve) on labeled crops when early sidedress N is used.
- Take appropriate N credits for legumes and manure used in the crop rotation.
- If possible, apply N fertilizers below the soil surface or incorporate with light tillage or irrigation.

2) Acceptable, but with greater risk

- Spring preplant application with a nitrification inhibitor.
- Single sidedress application of anhydrous ammonia or urea early in the growing season without a nitrification inhibitor.
- Spring preplant application of ESN.

3) Not recommended

- Fall application of N regardless of source.
- Disregard for N supplied by legumes in rotation or the application of manure.
- Spring preplant N for corn without a nitrification inhibitor.
- N fertilizer applied to corn (fertigation) after tasseling.
- Application of ESN to edible beans after planting.

Choosing an Appropriate N Rate

Corn

Nitrogen rate guidelines for corn production in Minnesota have changed. Yield goal is no longer the major consideration. Instead, rate guidelines are based on 1) the productivity of the production environment, 2) the ratio of the cost of a pound of N divided by the value of a bushel of corn and, 3) the producer's attitude toward risk. The guidelines are the end product of numerous trials conducted by University of Minnesota faculty throughout Minnesota. The new guidelines agree with the concept for the approach to fertilizer N applications that will be used throughout the Corn Belt. This concept is described in detail in: ***"Concepts and Rationale for Regional Nitrogen Rate Guidelines for Corn."*** **Bulletin PM 2015. Iowa State University. Ames, IA**. The N rate guidelines for corn for highly productive environments are provided in Table 1. Guidelines for this crop in environments that are considered to have medium productivity are provided in Table 2. Soil texture and availability of irrigation water are two major factors that separate highly productive environments from those that have medium productivity. Certainly, a non-irrigated soil with a loamy fine sand texture would be categorized as an environment with medium productivity. There are no specific measurable criteria that separate highly productive environments from those that are medium with respect to productivity. This choice can be made on a field by field basis by the grower with or without the advice of an ag-professional.

Table 1. Guidelines for use of nitrogen fertilizer for corn grown on soils considered to be highly productive.

N Price/Crop Value Ratio	corn/corn MRTN*	corn/corn Acceptable Range	corn/soybeans MRTN	corn/soybeans Acceptable Range
Ratio	- - - -	- - - lb. N to apply /acre	- - - -	- -
0.05	165	130 to 180	120	100 to 140
0.10	140	120 to 165	110	90 to 125
0.15	130	110 to 150	100	80 to 115
0.20	120	100 to 140	85	70 to 100

*MRTN = maximum return to nitrogen

Table 2. Guidelines for use of nitrogen fertilizer for corn grown on soils considered to have medium productivity potential.

N Price/Crop Value Ratio	corn/corn	corn/soybeans
	- - - - lb. N to apply/acre	- - - -
0.05	130	100
0.10	120	90
0.15	110	80
0.20	100	70

More details about the N guidelines can be found in ***Fertilizing Corn In Minnesota*** **(FO-3790-C, revised)**.

As part of a larger study conducted in 2006, various rates of fertilizer N were applied to corn following soybeans grown on an irrigated sandy soil. The response to N is shown in Table 3.

Table 3. Corn yield from an irrigated soil as affected by rate of fertilizer N.

N Applied*	Yield
lb./acre	bu. / acre
0	149
30	179
60	200
90	217
120	218
150	219
180	215

* N applied in starter fertilizer and irrigation water was approximately 30 lb. per acre

The economic optimum N rate was about 90 lb. per acre. This rate, combined with the N in starter and irrigation water totals 120 lb. N per acre which is within the acceptable range listed in Table 1.

In east central and central Minnesota, a substantial amount of corn is grown on non-irrigated soils that have a silt loam or loam texture. With adequate rainfall, this should be considered as a highly productive environment and N rate guidelines provided in Table 1 should be used.

Nitrogen credits for various crops that might be in the rotation are important. These credits are listed in Table 4.

The N credits for 2nd year corn following plow-down of a good stand of alfalfa are not well defined. The results from a study conducted with irrigated corn at the Staples Irrigation Center are summarized in Table 5. Following rye, the highest N rate (180 lb./acre) produced the highest yield. For 2nd year corn following alfalfa, the optimum N rate was 120 lb. per acre. So, the second year credit after alfalfa at this site was at least 60 lb. per acre. Additional research is needed to provide a more precise definition of the second year credits.

Table 4. Nitrogen credits for various legume crops that might preceed corn in the rotation.

Previous Crop	1st year nitrogen credit
	lb. N / acre
Harvested alfalfa	
4 or more plants/ft^2	150
2 to 3 plants/ft^2	100
1 or less plants/ft^2	40
Red clover	75
Grass/legume pasture	75

Table 5. Corn yield as affected by N rate for the second year of corn following rye and alfalfa.

	Previous Crop	
N Applied	rye	alfalfa
lb. N/acre	- - - bu./acre	- - -
0	89	96
60	158	151
120	174	178
180	182	179

Edible Beans

Unlike corn, fertilizer N guidelines for edible beans are adjusted for expected yield with some consideration for previous crop and soil organic matter content. These rates are summarized in Table 6. Specific recommendations for management of fertilizer N are in the sections that follow.

Table 6. Guidelines for use of nitrogen fertilizer for edible beans grown on coarse textured soils.

Previous Crop	Organic Matter Level	Expected Yield (lb. / acre)			
		1401-1900	1901-2400	2401-2900	2901+
		- - N to apply (lb. / acre) - -			
alfalfa (4+plants/ft^2)	low [1]	0	0	0	0
	medium and high	0	0	0	0
alfalfa (2 to 3 plants/ft^2)	low	0	20	40	60
	medium and high	0	0	10	30
red clover	low	0	0	25	45
	medium and high	0	0	0	25
non-legume crops	low	60	80	100	120
	medium and high	30	50	70	90

[1] low = less than 3.0%; medium and high = 3.0 % or more

Use Split Applications

The impact of timing of fertilizer N application for both irrigated corn and edible beans has been the focus of considerable research. Results of these research efforts lead to the conclusion that split applications are superior for both crops. The value of the split application for the two crops is influenced by amount and frequency of rainfall during the growing season. This is illustrated by the corn yields summarized in Table 7. Rainfall was high in 1981 and more normal in 1982. Therefore, leaching of NO_3-N was a problem in 1981.

With leaching as a potential problem, either a single sidedress or four equal N applications after emergence produced the highest yields. Yields were low when either all of the N or a major part of it was applied before planting.

In another study conducted in 1977, corn yields were higher when split applications of 46-0-0 were used (Table 8). For the split application situations, two applications were made after corn emergence. This is an indication that less N was lost when split applications were used.

Table 7. Yield of irrigated corn grown on sandy soil as affected by timing of the nitrogen application.

Method of Application	Year 1981	1982
	- - - bu./acre	- - -
all preplant	92	197
all at the 12 leaf stage (sidedress)	168	192
4 equal applications prior to silking	159	202
1/3 preplant; 2/3 sidedress	134	194
2/3 preplant; 1/3 sidedress	105	194

N rate = 150 lb. /acre as 46-0-0

Based on the results from these and similar trials conducted over the years, preplant applications of N for corn production without a nitrification inhibitor are not recommended. There are several options for split applications on irrigated sands. These are:

- N in the starter plus sidedress N
- N in the starter plus split sidedress N
- N in the starter plus sidedress N plus N injected in the irrigation water
- N in the starter plus N injected in the irrigation water
- N in the starter plus preemergence herbicide applied with UAN
- N in the starter plus preemergence herbicide applied with UAN plus sidedress N
- N in the starter plus preemergence herbicide applied with UAN plus N injected with the irrigation water

From both an agronomic and environmental perspective, split application of fertilizer N is a good management practice. There are many choices and the grower can choose the one that fits the farming enterprise. When planning a system for split application for corn, the last application of N should take place before the silks turn brown.

Compared to corn, the edible bean crop has a shallow root system. Therefore, loss of NO_3-N below the root zone is a serious concern. This places even more importance on the use of split applications of N fertilizer.

Preplant applications of fertilizer N are not recommended for edible bean production. Recent trials to study N application frequency have shown three applications are not necessary; two are adequate (Table 9). The first application should take place following seedling emergence. For ease of field operation, the second should be made before bloom.

Table 8. Yield of corn grown on an irrigated sandy soil as affected by time of nitrogen application.

	Time of Application	
N Applied	preplant	split sidedress
lb. / acre	- - - bu. / acre	- - -
60	93	122
120	144	162
180	160	175

Yield of control (no N applied) = 37 bu. / acre
N Source = 46-0-0

Table 9. Yield of irrigated edible beans (red kidney) as affected by split application of fertilizer N.

N Applied At			Yield
post emergence	pre-bloom	post-bloom	
- - - - - -	lb. N / acre	- - - - - -	lb./acre
0	0	0	2608
30	30	30	2951
45	45	0	3042
45	0	45	3159
0	45	45	3088

It is doubtful if split applications of fertilizer N are beneficial for corn and edible bean production on non-irrigated sandy soils. A sidedress application would be the preferred timing. There is a fairly long window for completing this application beginning within a few days after emergence. The sidedress timing has several advantages. It is applied prior to the time of rapid N uptake by the corn or edible bean plant and usually after the time of heavy rains and subsequent greatest leaching potential.

Potential Helpful Products

Responding to the recognition that loss of NO_3-N due to leaching is a rather universal concern, products have been developed that, when used, could reduce the potential for loss. N-Serve is a nitrification inhibitor and will be described later. Agrotain is a urease inhibitor designed to be used in no-till or other production systems where urea remains on the soil surface without incorporation. ESN is urea coated with a polymer intended as a slow release product. Because of higher cost, use of this product falls into the category of "acceptable, but with greater risk."

Application of nitrification inhibitors, those products that delay the conversion of ammonium-N to nitrate-N, can be an important management practice in the production of corn on irrigated sandy soils. Trials have been conducted for the purpose of evaluating the effectiveness of this input.

In a comprehensive study, 46-0-0 was applied at rates to supply 60, 120,180, and 240 lb. N per acre. The 46-0-0 was applied with and without the inhibitor, N-Serve. In addition a single preplant was compared to split applications.

Use of the nitrification inhibitor produced a substantial increase in yield when the N was applied before planting (Table 10). Also, the split sidedress use of N without the inhibitor produced higher yields than the preplant application with the inhibitor. At the lower rates of applied N, the use of the inhibitor in the split application system was important.

Based on these results as well as results from other studies, the practice of applying N before planting with a nitrification inhibitor, and the practice of using a single sidedress application with a nitrification inhibitor are defined as acceptable, but with a greater risk.

Table 10. Corn yield as affected by time of nitrogen application with and without the use of a nitrification inhibitor.

	All Preplant		Split Application	
N Applied	no inhibitor	N-Serve used	no inhibitor	N-Serve used
lb. / acre	- - - - - - -	- bu. / acre	- - - - - - -	
0	59	--	59	--
60	89	119	117	127
120	105	150	147	181
180	136	169	191	191
240	170	181	191	190

N Source = 46-0-0

Appropriate Credit For Legumes and Manure

The importance of N supplied by either legume crops or manure used in the crop rotation cannot be ignored. The N credit for soybeans is 40 lb. per acre. The credits for other legumes are listed in Table 4 for corn production and are shown for edible beans in Table 6.

The N credits for manure will not be described in detail in this publication.

Application Below The Soil Surface

Although the risk is minimal with acid sandy soils there can be some loss of N via volatilization if fertilizer N is placed on the soil surface and not incorporated. Therefore, it is a good practice to incorporate any N (28-0-0, 46-0-0 etc.) that is applied to the soil surface. Cultivation or irrigation water can be used for this incorporation. Application just prior to rain would also be acceptable. Studies conducted in other states in the Corn Belt have shown that 0.25 in. of irrigation water or rainfall is necessary to incorporate either 46-0-0 or 28-0-0 that has not been previously incorporated.

Summary

Management of fertilizer nitrogen is a special challenge for crops grown on coarse textured soils, both irrigated and dryland. The research-based Best Management Practices (BMP's) described in this publication are agronomically, economically, and environmentally sound. They are voluntary. If these practices are followed, agriculture can be more profitable without the threat of regulation.

Related Publications

08560 (revised, 2008) - Best Management Practices for Nitrogen Use in Minnesota

08557 (revised, 2008) - Best Management Practices for Nitrogen Use in Southeastern Minnesota

08554 (revised, 2008) - Best Management Practices for Nitrogen Use in South-Central Minnesota

08558 (revised, 2008) - Best Management Practices for Nitrogen Use in Southwestern and West-Central Minnesota

08555 (revised, 2008) - Best Management Practices for Nitrogen Use in Northwestern Minnesota

AG-FO-5880 - Fertilizing Cropland with Dairy Manure

AG-FO-5879 - Fertilizing Cropland with Swine Manure

AG-FO-5881 - Fertilizing Cropland with Poultry Manure

AG-FO-5882 - Fertilizing Cropland with Beef Manure

AG-FO-3790 - Fertilizing Corn in Minnesota

AG-FO-3770 - Understanding Nitrogen in Soils

AG-FO-3774 - Nitrification inhibitors and Use in Minnesota

AG-FO-2274 -Using the Soil Nitrate Test for Corn in Minnesota

AG-FO-2392 - Managing Nitrogen for Corn Production on Irrigated Sandy Soils

AG-FO-0636 - Fertilizer Urea

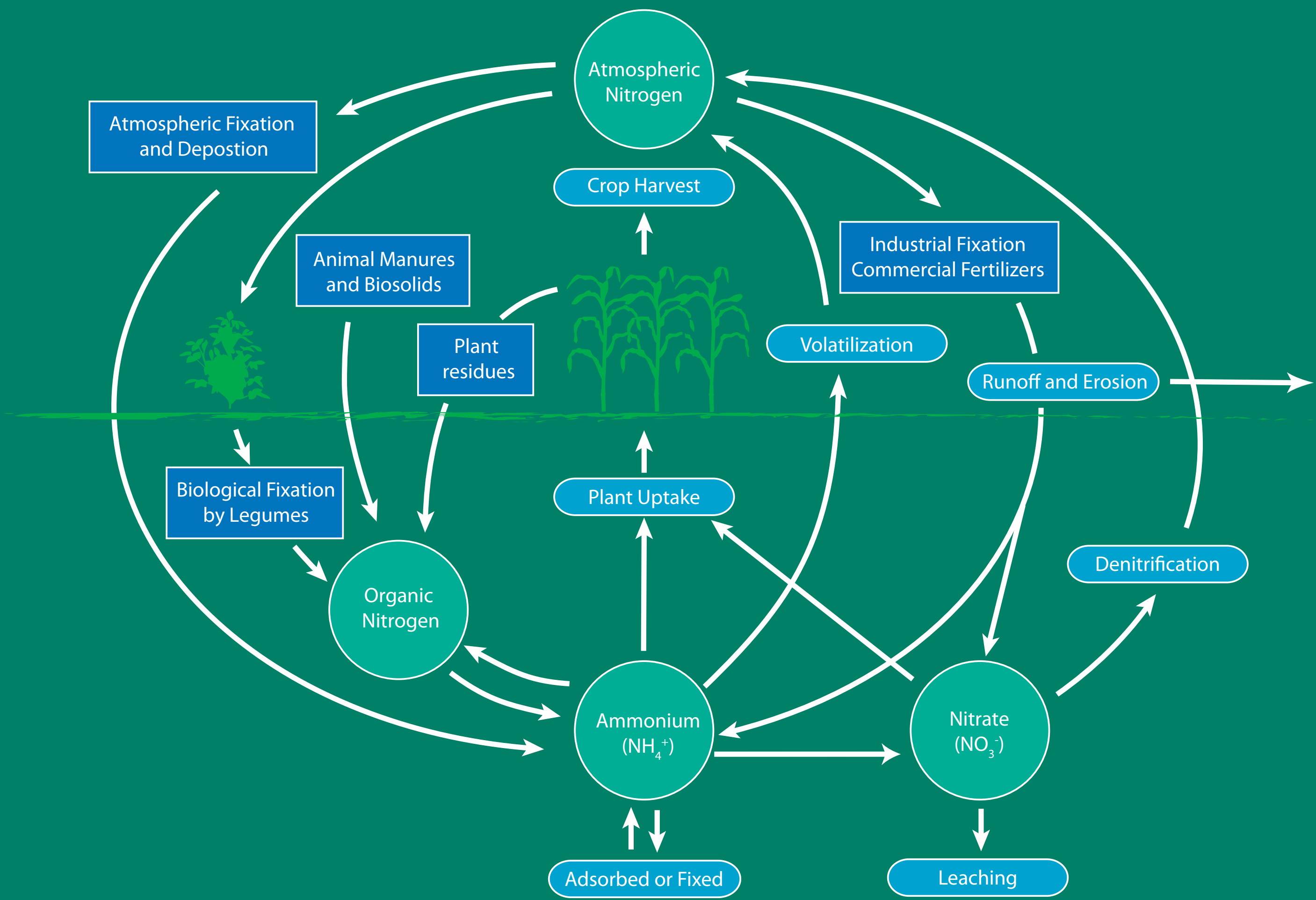
AG-FO-3073 - Using Anhydrous Ammonia in Minnesota

AG-FO-6074 - Fertilizer Management for Corn Planted in Ridge-till or No-till Systems

AG-FO-3553 - Manure Management in Minnesota

BU-07936 - Validating N Rates for Corn

Iowa State Univ. PM2015 - Concepts and Rationale for Regional Nitrogen Rate Guidelines for Corn



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