AG-FO-3110
1987

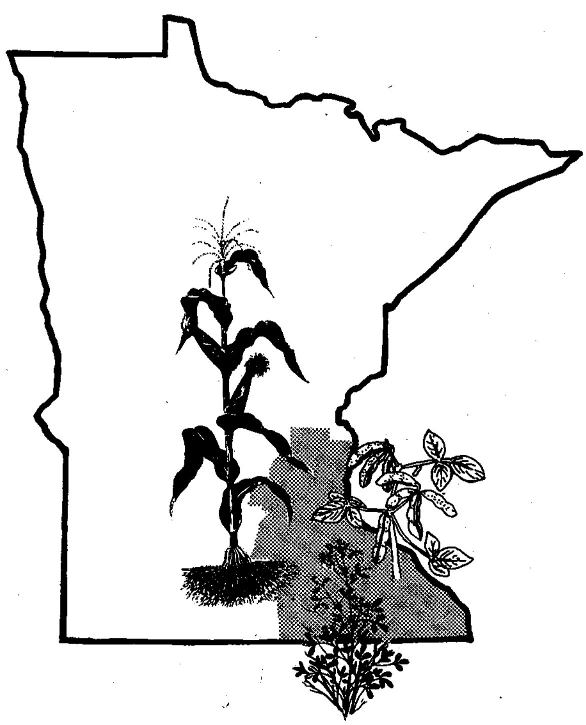
MANAGEMENT OF SOILS
IN SOUTHEASTERN MINNESOTA
A Correspondence Course

Unit 5: Nitrogen Management

John Moncrief, Gary Malzer and Curt Overdahl

Objectives

- Understand the principles of nitrogen transformations.
- Use this information to manage fertilizer nitrogen.
- Appreciate the value of nitrogen from legumes and manure.
- Understand the factors that influence nitrate (NO_3-N) entry into surface and ground water.



Minnesota Extension Service • University of Minnesota

WHAT HAPPENS TO APPLIED NITROGEN?

Nitrogen (N) is a very transient nutrient. After application it can take many different forms, some of which are not available to plants. Most of these changes are caused by soil bacteria. These bacteria are sensitive to soil aeration, temperature, pH, and the presence of carbon (organic matter) as an energy source.

Immobilization

Crop residues such as corn and small grain stover that have very little N can tie up (immobilize) applied N as the bacteria that decompose this material use N to build proteins. This is a temporary loss; as decomposition progresses the bacteria break down and release their nitrogen. However, the N may not be available when the crop needs it. For this reason, it may be beneficial to knife in N below corn or small grain residue left on the surface to control erosion.

Immobilization also is one reason why corn planted without primary tillage after alfalfa or soybeans (which have high N contents) has a high probability of equal or better yields than conventional tillage systems. There is no tie-up of applied N by crop residues but net release (mineralization) of N associated with these residues.

Mineralization

Organic N can be converted to crop-usable forms (ammonium [NH_4^+] or nitrate [NO_3^-]) from soil organic matter or crop residues. This is called mineralization. Soils high in organic matter will release a substantial amount of N when the weather is favorable for activity of the bacteria that cause this transformation (warm with adequate but not excessive moisture). For this reason nitrogen recommendations are based on soil organic matter levels.

Volatilization

Urea sources of nitrogen (granular or prilled urea and urea solutions—28% N) can be lost due to volatilization of ammonia (NH_3) after combination with water from the soil or air. Losses are greater under high temperature or soil pH. This is a potential problem with a weed and feed program since herbicides are most effective when broadcast uniformly over the soil surface, but N losses are greatest with broadcast surface applications in the presence of crop residues (Table 1). Injection or surface banding of N solutions minimizes volatilization, especially with conservation tillage. Rain within 24 to 48 hours of application or early spring applications with low temperatures will minimize losses due to volatilization.

Denitrification and Leaching

Under conditions of excessive rainfall nitrate N (NO_3-N) can be lost due to denitrification (conversion to nitrogen gases that are not available to plants) or leaching (downward movement with water beyond the root zone). Only the nitrate (NO_3) form of nitrogen is subject to these types of losses. These nitrogen losses are most probable on poorly drained or excessively well-drained soils in wet years. If

Table 1. The effect of method of nitrogen solution application (28% N at 75 lb N/A) and tillage on corn grain yields on a Mt. Carroll-Seaton silt loam soil in Goodhue County, Minnesota.[a]

Tillage	1984 inj	1984 band	1984 brdct	1985 inj	1985 band	1985 brdct[b]
	-----	-----	----- bu/A	-----	-----	-----
No-till	146	141	128	112	83	90
Ridge-till	152	146	144	135	124	128
Chisel	149	141	144	134	135	139

[a]Malzer, G.L., J.F. Moncrief, and G.W. Rehm. 1985. *Placement of nitrogen solutions under differing tillage systems.* In: A Report on Field Research in Soils. Minn. Agr. Exp. Sta. Misc. Pub. 2 (revised) pp. 202-211.
Malzer, G.L., J.F. Moncrief, and G.W. Rehm. 1986. *Placement of nitrogen solutions under differing tillage systems.* In: A Report on Field Research in Soils. Minn. Agr. Exp. Sta. Misc. Pub. 2 (revised) pp. 239-254.

[b]Nitrogen was applied in the spring directly after planting by the following methods: inj = injected with an anhydrous applicator about 4 inches deep; band = dribbled from a 1/2-inch hose just above the soil surface; or brdct = surface broadcast over complete area. Corn was grown following corn.

these types of losses are anticipated the following two management options may prove helpful: (1) split N application (early spring and late sidedress) to prevent losses by metering out nitrogen; or (2) use a nitrification inhibitor such as N-Serve with ammoniacal nitrogen sources such as anhydrous ammonia or urea. A response to N-Serve is most probable with fall-applied N on most soils and on early-spring-applied N on fine-textured, poorly drained soils.

Soils that are moderately well-drained and with slopes greater than 4 percent are unlikely to benefit from nitrification inhibitors or late sidedress N applications. These soil conditions are characteristic of most of Goodhue, Wabasha, Olmsted, Winona, Fillmore, and Houston counties. There may be a benefit to these practices on shallow soils that don't have the capacity to store much N. The effect of sidedress nitrogen and use of nitrification inhibitor on a deep loess soil in Goodhue County is illustrated in Table 2. The rainfall was below average in 1983 and there may have been a reduction in availability with the sidedress and inhibitor treatments. This has been shown at the Waseca experiment station also.

Table 2. The effect of time of nitrogen application (75 lb/A) and nitrification inhibitor on corn grain yields on a Mt. Carroll- Seaton soil in Goodhue County.[a]

	N-Serve					
	No-till		Ridge-till		Chisel	
	no	yes	no	yes	no	yes
	-----	-----	----- bu/A	-----	-----	-----
1983						
Spring[b]	124	117	133	135	133	126
Sdress[c]	104	119	131	135	142	128
1984						
Spring	147	138	154	157	162	162
Sdress	149	147	160	157	155	147

[a]Moncrief, J.F., G.L. Malzer, G.W. Rehm, J.A. True, and J. Chaplin. 1984. *The effect of N management on corn yields-1983.* In: A Report on Field Research in Soils. Minn. Agr. Exp. Sta. Misc. Pub. 2 (revised) pp. 164-173.
Moncrief, J.F., G.L. Malzer, G.W. Rehm, and J. Chaplin. 1985. *The effect of tillage, N rate, and nitrification inhibitor on corn response on an irrigated loamy sand soil and dryland silt loam soil.* In: A Report on Field Research in Soils. Minn. Agr. Exp. Sta. Misc. Pub. 2 (revised) pp. 238-248.

[b]N was applied within two days after planting.

[c]N was applied at the eight-leaf stage of growth.

Table 3. The effect of time since alfalfa on corn yield at Lancaster, Wisconsin, 1977-1984.[a]

Sequence	Applied N (lb/A) 0	50	100	200
	-----	----- bu/A	-----	-----
Cont. Corn	34	86	103[b]	127
CCCAA[c]	131	131	139	132
CCCAA	89	114	129	130
CCCAA	72	112	125	126

[a]Higgs, R., W. Paulson, A. Peterson, J. Swan, J. Jackobs, D. Graffis, J. Webb, R. Cruse, and W. Wedin. 1985. *1977-1984 crop sequence experiment progress report (Illinois, Iowa, Minnesota, and Wisconsin).* Univ. of Wisconsin, Platteville, WI.

[b]The optimum rate of applied N for a given crop sequence falls on or between underlined yields.

[c]Corn is represented by a "C" and alfalfa by an "A." The underlined C represents the year corn was grown in the sequence.

ALFALFA AND MANURE NITROGEN

There has been much concern about nitrate pollution of surface and ground water. In some cases the problem has arisen from poor management of fertilizer, manure, or legume sources of N. This problem can be alleviated by minimizing the risk of overapplication through a good understanding of how these nitrogen sources complement each other.

The benefit of alfalfa N is illustrated in Table 3. The year following alfalfa there is no benefit to N addition. In the second and third year following alfalfa there appears to be a benefit to applying somewhere between 50 and 100 pounds of N per acre. The N requirement of continuous corn is between 100 and 200 pounds per acre. Thus, farmers should apply N fertilizer at a reduced rate the second year following a good stand of alfalfa. Any N applied after alfalfa in an average year of this study was wasted and probably ended up in ground water. In an exceptional year however, higher-yielding corn would have required more N.

Manure should be managed primarily for its N and so should be applied on second- or third-year corn. Application is often made following alfalfa because there is more time than after corn. If this is a problem, apply manure after silage harvest preceding second-year corn for fall applica-

Table 4. The amount of N, phosphate, and potash applied as liquid dairy manure.[a]

	1983	1984	1985
		lb/A	
NH_3-N	132	158	122
Total N	232	310	261
Phosphate	124	136	112
Potash	224	263	217
Rate (gal/A)	9,100	10,700	9,300

[a]Burford, P.M., J.F. Moncrief, J.B. Swan, and B. Schrieber. 1986. *The effect of tillage and manure application frequency on corn growth.* In: A Report on Field Research in Soils, Minn. Agr. Exp. Sta. Misc. Pub. 2 (revised) pp. 286-301.

Table 5. The effect of manure and tillage on corn yields.

Treatment	1984 No-Till	1984 Chisel	1985 No-Till	1985 Chisel
		bu/A		
Fertilizer (ammonium nitrate, 200 lb N/A)	148	151	130	143
Manure 1982, 1984	156	158	104	112
Manure 1983, 1985	101	134	132	142
Control	67	86	59	74

[a]Burford, P.M., J.F. Moncrief, J.B. Swan, and B. Schrieber. 1986. *The effect of tillage and manure application frequency on corn growth.* In: A Report on Field Research in Soils, Minn. Agr. Exp. Sta. Misc. Pub. 2 (revised) pp. 286-301.

tions. The fertilizer savings from applying manure in the spring before planting can offset slight yield reductions due to delayed planting if the weather allows corn planting by the middle of May.

Tillage can affect residual N from manure (Tables 4 and 5). These data suggest that yield benefits can be anticipated following manure application, but they may be lower if corn is planted no-till.

REDUCING NITRATE LOSSES TO THE GROUND WATER

Losses of nitrogen under any circumstances are costly to farmers. There is evidence that some of these losses are reaching the ground water. In southeastern Minnesota, the loess soils, chiefly silt loams, permit a downward movement of unused nitrates. In addition, special geologic features in this area may conduct nutrients rapidly to underground aquifers.

In a Wisconsin study on a deep loess this downward movement averaged two feet per year. This relatively slow movement fortunately can allow a farmer to use this residual nitrogen by reducing the N additions for the subsequent crop. Leaching losses can thus be significantly reduced if it is known that excesses from the previous crop are still in the root zone. This is determined by soil nitrate testing usually down to two feet.

Within the last decade there have been several studies of profile nitrate buildup and potential losses through leaching. Dr. Chuck Simkins at the University of Minnesota made 57 field observations from 1977 to 1979 relating corn yield, added N, and the soil profile nitrate content. Of the 57 fields, 29 showed a corn yield response of 10 or more bushels per acre from added N. Nitrate soil tests taken 0 to 2 feet showed that 24 of these 29 had less than 100 pounds per acre of NO_3-N. None had over 120 pounds per acre. Nine fields testing less than 100 pounds per acre failed to produce 10 or more bushels per acre yield increase.

These results are not a clear indication that the nitrate test alone can be used to predict nitrogen needs, but suggest that the test can be useful in preventing excess N treatments.

Mr. William Jokela studied the effect of residual soil nitrate and varying nitrogen additions on yield (Table 6). Only three of the six sites showed significant increases to applied N.

Table 6. Influence of nitrogen rate and soil NO_3-N test on grain yield, six locations in southeastern Minnesota, 1980.

N Rate[a]	Winona	Goodhue	Houston	Olmsted	Steele	Wabasha
(lb/A)			Yield (bu/A)			
0	121	141	110	131	107	133
50	128	157	136	144	112	147
100	135	161	127	147	130	137
150	138	163	135	148	140	152
200	134	161	138	152	135	147
250	128	161	137	151	128	144
Signif.[b]	no	yes	no	yes	yes	no
BLSD[2]	—	16	—	11	16	—
Depth (ft)			NO_3-N Soil Test[c]			
0-2	52	42	39	56	53	88
0-3	66	54	61	94	72	164
0-4	80	67	76	123	92	262
0-5	92	83	87	141	110	348

[a]All plots received an additional 10 to 20 lb/A N as a starter.
[b]Statistical significance with 95 percent or greater level of confidence.
[c]Sampled in spring where no N was applied.

Leaching can best be minimized on deep loess soils by carefully considering nitrogen rates and amounts of residual nitrates in the soil profile. Research shows that nitrate testing is somewhat inconsistent in predicting nitrogen needs. However, measured quantities of residual nitrates used supplementary to cropping history recommendations could increase accuracy of nitrogen rates recommended. Samples should be taken as close to planting as possible to accommodate any changes in soil nitrogen in the spring. The larger the number of cores the better. Nitrate can be quite variable in a given field. The University of Minnesota Soil Science Department is currently developing guidelines to account for soil nitrate in N recommendations in the southeastern part of the state.

SUMMARY

1. Incorporate or surface band (dribble in narrow stream for solutions) urea sources of nitrogen to prevent ammonia volatilization.

2. Place nitrogen below crop residues low in N to reduce immobilization.

3. A nitrification inhibitor or sidedress nitrogen may be beneficial on poorly drained or excessively drained soils but not on the moderately well-drained soils of the counties along the Mississippi River.

4. Manure should be applied on second year corn following alfalfa and managed for its N. There is benefit the second year after application.

5. Residual N from alfalfa should be considered when applying N for first and second year corn (see AG-BU-0519, Guide to Computer Programmed Soil Test Recommendations for Field Crops in Minnesota).

6. Tillage will affect the amount of N released from manure. The release will be slower under no-till conditions.

7. Leaching on deep loess soils is best reduced by careful consideration of N rates and taking adequate credit for manure and legume N.

Issued in furtherance of cooperative extension work in agriculture and home economics, acts of May 8 and June 30, 1914, in cooperation with the U.S. Department of Agriculture. Patrick J. Borich, Dean and Director of Minnesota Extension Service, University of Minnesota, St. Paul, Minnesota 55108. The University of Minnesota, including the Minnesota Extension Service, is committed to the policy that all persons shall have equal access to its programs, facilities, and employment without regard to race, religion, color, sex, national origin, handicap, age, veteran status, or sexual orientation.