1979

Nitrogen Management

Cooperative Extension South Dakota State University

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FS 752

Nitrogen Management

COOPERATIVE EXTENSION SERVICE
SOUTH DAKOTA STATE UNIVERSITY
U.S. DEPARTMENT OF AGRICULTURE

FS 752

Nitrogen Management

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Nitrogen is the plant nutrient most universally needed for high crop yields. The most abundant source of nitrogen is the inert gas N_2, which constitutes approximately 78% of the earth's atmosphere. This gas is unusable by plants; it must be converted, either by industrial processes or by natural soil microorganisms, to forms a plant can take up.

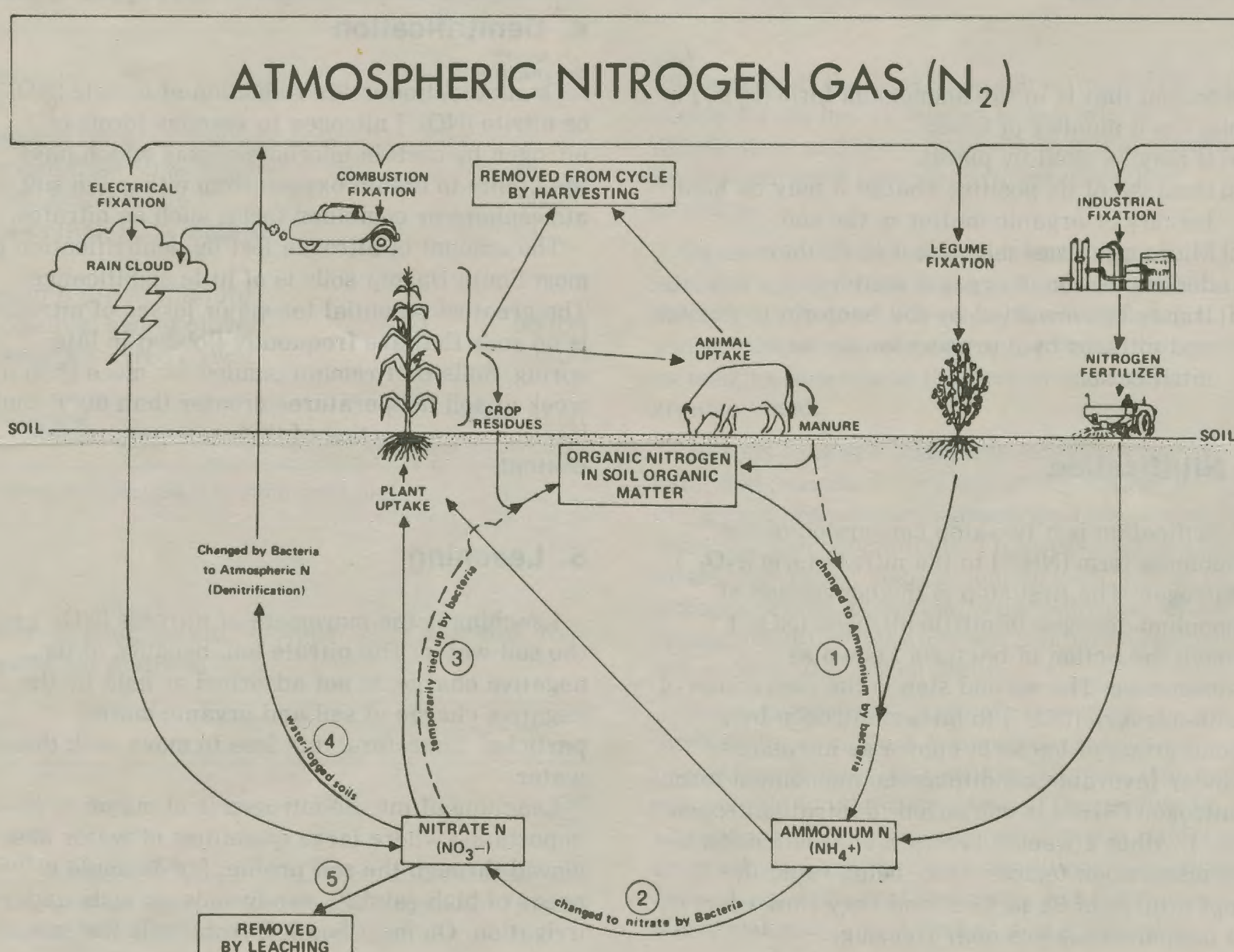
The three most common questions regarding the use of nitrogen fertilizer include the rate of application, the time of application, and the form of nitrogen fertilizer to be used.

Answers to these questions are clearer if you understand how nitrogen in plant residues and soil organic matter is changed to forms usable by plants (aminization, ammonification, and nitrification) and how available forms of nitrogen may be removed from the root zone (denitrification and leaching). These reactions govern the proper management of nitrogen fertilizers and are part of a system known as the nitrogen cycle (Fig 1).

1. Aminization and Ammonification

Plant residues and soil organic matter contain nitrogen compounds which can be broken down and recycled for use by growing plants. In

Figure 1. The nitrogen cycle: (1) aminization and ammonification, (2) nitrification, (3) immobilization, (4) denitrification, (5) leaching.



aminization, numerous groups of bacteria and fungi, each of which is responsible for one or more steps in the breakdown of organic matter, convert proteins which contain nitrogen to simpler compounds called amines and amino acids.

Ammonification is the process in which amines and amino acids are broken down to ammonia (NH_3), which is rapidly converted to ammonium (NH_4^+). Approximately 1-3% of the total organic nitrogen contained within soil is released in this manner each year (Table 1).

Table 1. Average nitrogen release expected per year due to the breakdown of organic matter.

Soil organic matter	Percent organic matter breakdown* 1	2	3
%	N release/yr		
1	13	26	40
2	26	52	78
3	40	78	120
4	52	104	156
5	66	132	198

* under normal condition the expected rate of breakdown is ½% per year for grass sod, 1 to 1½% for small grain, and 1½ to 3% for row crops.

Nitrogen that is in the ammonium form (NH_4^+) is subject to a number of fates:

a) It may be used by plants.
b) Because of its positive charge it may be held by clay or organic matter in the soil.
c) Microorganisms may use it in further decomposition of organic matter.
d) It may be converted by soil bacteria to nitrites and nitrates by a process known as nitrification.

2. Nitrification

Nitrification is a two-step conversion of the ammonium form (NH_4^+) to the nitrate form (NO_3^-) of nitrogen. The first step is the conversion of ammonium-nitrogen to nitrite-nitrogen (NO_2^-) through the action of bacteria known as nitrosomonas. The second step is the conversion of nitrite-nitrogen (NO_2^-) to nitrate-nitrogen by a second group of bacteria known as nitrobacter.

Under favorable conditions the ammonium form of nitrogen (NH_4^+) is converted to nitrate-nitrogen (NO_3^-) within 2 weeks. The rate of nitrification is dependent upon temperature, being rapid at temperatures of 65 to 85°F and very slow when soil temperatures are near freezing.

Nitrogen that is in the nitrate form (NO_3^-) can be:

a) utilized by plants,
b) immobilized by microorganisms,
c) moved downward in the soil profile by percolating water (leaching),
d) lost to the atmosphere through a process known as denitrification.

3. Immobilization

Immobilization of nitrogen occurs when microorganisms, during the process of organic matter decomposition, utilize nitrogen within their bodies, rendering it temporarily unavailable to plants. If the organic matter being decomposed contains a small amount of nitrogen in relation to carbon (such as wheat straw or corn stalks) nitrogen in either the nitrate (NO_3^-) or ammonium form (NH_4^+) will be temporarily immobilized, and a deficiency of nitrogen may develop for the growing crop. If decomposing material is high in nitrogen compared to carbon (as in alfalfa) the net effect will be an increase in the nitrogen supply.

4. Denitrification

Denitrification is the reduction of nitrate (NO_3^-) or nitrite (NO_2^-) nitrogen to gaseous forms of nitrogen by certain microorganisms which have the ability to obtain oxygen from either the soil atmosphere or combined forms such as nitrates.

The amount of nitrogen lost by denitrification in most South Dakota soils is of little significance. The greatest potential for major losses of nitrogen is on soils that are frequently flooded in late spring. Soils that remain ponded for more than a week at soil temperatures greater than 60°F could lose the major portion of their nitrate-nitrogen content.

5. Leaching

Leaching is the movement of nitrates (NO_3^-) with the soil water. The nitrate ion, because of its negative charge, is not adsorbed or held by the negative charge of soil and organic matter particles. Therefore, it is free to move with the soil water.

Leaching of nitrate-nitrogen is of major importance where large quantities of water are moved through the soil profile, for example in areas of high rainfall, sandy soils, or soils under irrigation. On most South Dakota soils the quantity of precipitation which enters the soil does not generally exceed the soil's water holding capacity; therefore, only limited movement of nitrates would be expected.

The Nitrogen Cycle and Nitrogen Management Decisions

Rate of Application

Research indicates that most soils do not have sufficient nitrogen supplying potential for satisfactory yields of nonleguminous crops. Recommendations for the amount of applied nitrogen fertilizer must balance the nitrogen requirement of each crop against nitrogen additions and losses through natural processes. Allowance is also made for the nitrogen contribution by legume fixation (Table 2) and the additions of manure (Table 3).

Two soil testing laboratory procedures are presently available which aid in the prediction of nitrogen fertilizer needs. The first test is a measurement of the amount of organic matter in the upper 6 inches of soil from which estimates of nitrogen release can be made. The second is the nitrate-nitrogen soil test. This procedure measures the nitrate concentration, also known as residual or carryover nitrogen, in the upper 2 feet of the soil profile.

A review of nitrate tests in South Dakota indicates that residual nitrogen levels are generally higher after years of drought (less nitrogen has been removed by crops) and lower after years of above average moisture. However, general adjustments based on weather or previous crop are inaccurate because of variation from field to field.

Less commercial nitrogen is needed when nitrate-nitrogen levels are high. Being aware of residual nitrate levels will mean more economical use of nitrogen fertilizers.

Table 2. Suggested nitrogen credits for legumes.

Crop	Pounds of nitrogen credit
Legume or legume-grass sods*	
more than 50% legume	100
20-50% legume	50
less than 20% legume	0
Legume green manure	
biennial sweet clover	50/ton
alfalfa and red clover	50/ton
Soybeans	1# for each bushel produced

* For stands that are 2 or more years old.

Table 3. Suggested average N, P_2O_5 and K_2O credits for manure.

Kind of manure	Credit, pounds per ton* N	P_2O_5	K_2O
Cattle or hog	10	5	10
Sheep	20	9	20
Poultry and turkey	20	25	10

* Credits shown apply to manure containing enough straw to have absorbed most of the urine.

Time of Application

The time of the year in which nitrogen fertilizers should be applied is related to the rate of nitrification and the potential loss of the nitrate form of nitrogen from denitrification and/or leaching.

On most South Dakota soils the timing of nitrogen applications is not critical. On soils that are subject to severe leaching (soils with high water infiltration rates) nitrogen should be applied as near as possible to the time of the crop's greatest need.

On soils that are commonly saturated for extended periods during the spring, losses of nitrogen due to denitrification can be reduced by following two precautions. First, use only nitrogen forms that supply the ammonium (NH_4^+) form of nitrogen (Table 4). Second, apply nitrogen in the spring, or in the fall after soil temperatures are below 50°F at a 4-inch depth.

Use of commercial products known as nitrification inhibitors temporarily reduce the population of the nitrosomonas bacteria which are responsible for the conversion of ammonium to nitrate-nitrogen in the soil. Nitrification inhibitors have shown benefits under conditions subject to heavy losses of nitrate-nitrogen; but for the bulk of South Dakota soils, their use is of little value.

Table 4. Common nitrogen fertilizer materials and their distribution of nitrogen in the ammonium and nitrate forms.

Fertilizer material	Ammonium (NH_4^+)	Nitrate (NO_3^-)
Anhydrous ammonia (82%N)	100	0
Urea (45% N)	100	0
UAN (28% N)	75	25
Ammonium nitrate (34%N)	50	50

Form of Application

All common nitrogen fertilizer materials give equivalent response if properly handled. It is necessary to weigh the cost advantage of any form of nitrogen fertilizer against cost of application and handling ease. For example, anhydrous ammonia is the least expensive nitrogen carrier, but does not lend itself as easily as UAN (28% nitrogen solution) to split applications of nitrogen on irrigated corn.

As previously mentioned, selection of nitrogen carriers becomes critical only under conditions of high nitrogen loss due to either denitrification or leaching. For further information regarding the handling and use of anhydrous ammonia or urea see South Dakota Cooperative Extension Service Fact Sheets 557 and 658.

Additional Information

FS 679, Fertilizing barley
FS 432, Fertilizing corn
FS 680, Fertilizing flax
FS 678, Fertilizing oats
FS 718, Fertilizing soybeans
FS 677, Fertilizing wheat

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