8-1-1997

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Jim Gerwing
South Dakota State University

Ron Gelderman
South Dakota State University

COOPERATIVE EXTENSION SERVICE
SDSU

Extension Extra

ExEx 8132
August 1997
Plant Science

COLLEGE OF AGRICULTURE & BIOLOGICAL SCIENCES / SOUTH DAKOTA STATE UNIVERSITY / USDA

Using Manure as a Nitrogen Fertilizer

by Jim Gerwing, Extension agronomist-soils,
and Ron Gelderman, manager-soil testing lab,
Plant Science Department

Sources of Nitrogen

Crops take nitrogen (N) from soil in the nitrate (NO_3) or the ammonium (NH_4) form. The major sources of these available N forms in soil are fertilizer, soil organic matter, crop residue including legumes, manure, and precipitation. When applying these materials to crops, the only real difference between them is the speed at which they become available to plants. Fertilizer is immediately available to plants as is any inorganic nitrogen such as ammonia (NH_3), ammonium (NH_4), or nitrate (NO_3). Manure usually contains both inorganic and organic N forms. All organic material must be broken down (mineralized) by soil microbial activity which converts it to the available N forms. The speed at which microbial activity decays organic material depends on the type of material, soil moisture, and temperature. Under normal conditions, the majority of organic material is decayed in three or four years, releasing its nitrogen into the available N forms.

Nitrogen Contained in Crops

Crops can contain large amounts of nitrogen (Table 1). In most cases only the grain is removed and the straw is returned to soil, supplying nitrogen through mineralization in subsequent years. Because of this and the other sources of N listed above, crop removal alone is not a good estimate of the amount of N to apply.

Nitrogen Rate Recommendations

The nitrogen application rate needed to reach maximum yield in South Dakota has been determined through extensive field calibration studies over the past 30 years by SDSU soil fertility researchers. This research has established a nitrogen requirement for each crop (Table 2). Crops obtain this nitrogen primarily by extracting nitrate from soil, which is in soil at the beginning of the growing season or is made available from any of the nitrogen sources during the growing season.

Table 1. Nitrogen Contained in Crops

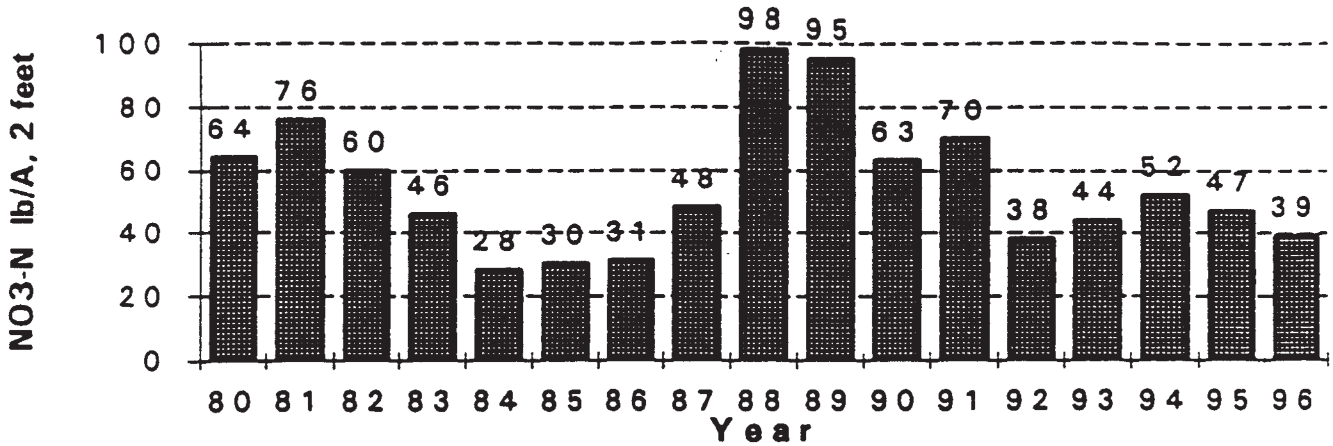
	Plant Part		
Crop (unit)	Grain	Straw	Total
	pounds N		
Corn (bu)	0.9	0.5	1.4
Soybeans (bu)	3.7	0.8	4.5
Wheat (bu)	1.6	0.8	2.4
Oats (bu)	0.9	0.4	1.3
Barley (bu)	1.1	0.4	1.5
Sunflowers (cwt)	2.8	2.4	5.2
Alfalfa (ton)	—	—	55
Grass (ton)	—	—	30

Research has shown that residual nitrate in the top 2 feet of soil prior to fertilization is used as efficiently by crops as fertilizer N or other N sources made available during the growing season. Therefore, when nitrogen fertilizer recommendations are made, the amount of nitrogen determined by the 2-foot nitrate soil test is subtracted from the total nitrogen requirement. Residual nitrate can be a large source of nitrogen for crops.

The average nitrate soil test from samples submitted to the SDSU soil testing lab over the last 17 years is 55 lb per acre. However, annual averages are lower after wet years and much higher (almost 100 lb/A) after dry years (Figure 1). Therefore, nitrogen recommendations generally go up after wet years and are reduced dramatically, sometimes to zero, after very dry years.

Legume credits must also be subtracted from the calculated nitrogen requirement since the nitrate soil test does not measure organic N. Suggested legume credits for crops following the legume are listed in Table 3.

Figure 1. Average nitrate nitrogen soil test in South Dakota recrop fields, 1979 - 1996.



Example N Recommendation

Assume

110 bu corn yield goal

40 lb 2 ft NO_3 - N Soil Test

30 bu soybean as previous crop

Calculations

110 bu x 1.2 lb N/bu = 132 lb N total required

132 lb N - 40 lb NO_3 - N test = 92 lb N recommendation

92 lb N - 30 lb N legume credit = 62 lb N needed

For the above example, the 62 pounds of nitrogen needed could be supplied as either fertilizer or manure. If manure was used, an analysis of its nitrogen content would be necessary to determine the proper rate. Since inorganic N (ammonia and ammonium) is immediately available to crops similar to fertilizer N, the analysis should determine that portion of the manure's total N that is in these forms. The remainder of the N is in organic form and must breakdown (mineralize) before it is available to the plant.

For the above example, it will be assumed there is liquid hog manure with a total N analysis of 40 lb per 1000 gallons, half of which is inorganic, immediately available N. The remaining organic N (20 lb) will decay at an estimated rate of from 30 to 50 percent per year depending on environmental conditions. For this example, a 40% decay rate will be assumed. A 40% decay rate would supply 8 lb N per year (20 lb x .4 = 8 lb N). Total available N would be 28 lb N per 1000 gallons (20 lb inorganic and 8 lb organic N). Therefore, 2,215 gallons per acre (62 lb N ÷ 28 lb available N/1000 gallons = 2,215 gallons) would be needed to fulfill the N requirement. If soybeans had not been the previous crop, 3,285 gallons (92 lb N ÷ 28 lb available N/1000 gal) would have been needed.

Most of the organic nitrogen not used the first year will become available over the subsequent 2 or 3 years. Therefore, for all practical purposes, land which is manured every year should be credited with all the N in manure after the third or fourth year. This is important when planning for total number of acres needed for proper manure utilization if land is going to receive manure every year.

It should also be recognized that if 2-foot nitrate soil test levels are very high -- such as after the dry years of 1988 and 1989 (Figure 1) -- little, if any, additional nitrogen would be needed. In these situations, other land such as pastures, hayland, alfalfa, or soybeans, which may not normally be manured, should be available for manure application. Even though nitrogen fertilizer is not needed by legumes (they can fix all the N they need from the air), manure can be applied to these crops. They will use nitrogen from the manure rather than fix N from the atmosphere. The amount of N used by legume crops would be similar to or slightly higher than non-legume crops grown under similar conditions.

Volatilization losses of ammonia in manure will decrease available N and may greatly increase the amount of manure needed per acre. This can be especially critical for hog manure which can have up to half of the total N in the ammonia form. If manure is left on the surface to dry before incorporation, almost all of the ammonia N will be lost to volatilization.

Nitrate Leaching and Role of the Nitrate Soil Test

Soil consists of many negatively charged mineral and organic particles. A measure of the total negative charge in soil is called its CEC or cation exchange capacity. Most soils have enough exchange capacity to absorb and hold like a magnet, all positively charged particles or nutrients in soils. Nitrate, however, is a negatively charged nutrient and therefore does not "stick" in soil. Nitrate is also extremely soluble in water. Water moving through soil will leave most nutrients "stuck" on the soil CEC.

Table 2. Nitrogen Requirement of Crops

Crop	Unit	Nitrogen Required[1]
Wheat	bu	2.5 x yield[2]
Oats	bu	1.3 x yield
Barley		
malting	bu	1.5 x yield
feed	bu	1.7 x yield
Rye	bu	2.5 x yield
Flax	bu	3.0 x yield
Corn (grain)	bu	1.2 x yield
Corn (silage)	ton	10.4 x yield
Sorghum (grain)	bu	1.1 x yield
Sorghum, sudan (hay)	ton	25 x yield
Grass hay	ton	25 x yield
Sunflowers	lb	0.05 x yield
Edible beans	lb	0.05 x yield
Millet	lb	0.035 x yield
Rape	cwt	6.5 x yield
Mustard	cwt	6.5 x yield
Safflower	lb	0.05 x yield
Buckwheat	bu	2.2 x yield
Potatoes	cwt	0.4 x yield

[1]Fertilizer nitrogen to apply is equal to the nitrogen requirement minus soil NO_3 - N to a 2-ft depth minus any manure or legume credits.
[2] Yield goal

Nitrate, however, is picked up by the water and carried along as it moves down through the soil. Therefore, nitrogen applied to soil in excess of crop needs, whether from fertilizer, manure or even "legume credits" will be subject to movement below the root zone. The speed of movement is determined by moisture and soil texture. Four inches of water can move as deep as four feet in sandy soil. In fine-textured soil, four inches of water may only move down 1 1/2 to 2 feet. Because all the nitrate in soil is in soil water, it is, therefore, much more likely to move nitrate below the root zone when soils are coarse-textured.

Table 3. Legume Nitrogen Credits[1]

Previous Crop	Crop to be grown	
	Short season[2]	Full season[3]
	lb N per bu (acre)	
Soybeans	0.5	1.0
Alfalfa (harvested) or Sweet clover (unharvested)		
plants/sq ft: >5	75	150
3-4	50	100
1-2	25	50
<1	0	0
Sweet clover (harvested)	10	20
Red clover (harvested)	35	70
Edible beans, Field peas	10	20

[1] Second-year credits are half of first year.
[2] Small grains.
[3] Corn, sunflower, sorghum.

Because excess nitrate in soil will likely move below the root zone, it is extremely important to soil sample for residual nitrate in the top 2 feet of soil each year. High nitrate levels in soil result from over application of manure or fertilizer, or when crop yields do not meet yield goals due to unexpected events such as hail or drought.

If accumulations of nitrate are detected by soil testing, manure or fertilizer N applications can be reduced in subsequent years allowing crops to use the excess N, greatly reducing the risk of moving large amounts of N below the root zone. If soil testing finds low levels of nitrate, larger amounts of manure or fertilizer N can be applied to prevent nitrogen deficiencies in crops.

Summary

Manure is an excellent source of nitrogen for crops and can easily fulfill the nitrogen requirement. The "slow release" organic portion is an added benefit since not all the N is available for leaching immediately. Manure also supplies organic matter which improves soil tilth, water holding capacity, and helps create a healthy rooting environment. Annual soil and manure testing can accurately predict the manure rate needed for crop production. However, like fertilizer, if manure nitrogen rates are applied in excess of crop needs, nitrates will accumulate in soil and eventually move below the root zone, threatening groundwater if it is present.

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350 copies printed by CES at a cost of 13 cents each. August 1997.