The Nitrate Soil Test in South Dakota

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The nitrate nitrogen soil test has been used for more than 15 years for making nitrogen fertilizer recommendations in South Dakota. Minimal leaching and denitrification due to a relatively dry climate has helped make this test a good predictor of nitrogen fertilizer needs. The test and nitrogen recommendation system is based on a two foot deep soil sample and a calibrated nitrogen requirement for common crops grown in South Dakota (Table 1). Extensive field plot data shows that the two foot deep sample generally correlates better to crop response than does samples taken to a shallower depth and that NO_3-N in the top two feet of soil is normally used as efficiently by crops as fertilizer nitrogen.

Table 1. South Dakota Nitrogen Recommendations Using the two foot NO_3-N Soil Test

Crop	Nitrogen Required[1] lb/bu
Wheat	2.4
Oats	1.3
Barley	1.5
Corn	(1.45 x yld) - 20
Sorghum	1.1

[1] Fertilizer N to apply is equal to the N requirement x yield goal minus soil NO_3-N to a 2-ft. depth.

Nitrogen fertilizer recommendations are made by subtracting the NO_3-N soil test level in the top 2 feet of soil from the calculated nitrogen requirement for a given yield goal. For example, a 50 bu wheat yield goal on a field with a 45 lb NO_3-N soil test would receive a 75 lb N/A fertilizer recommendation (50 bu x 2.4 lb N/bu = 120 lb N requirement - 45 lb soil test = 75 lb N/A). A 130 bu corn yield goal with the same soil test would receive a 124 lb N fertilizer recommendation (130 bu x 1.45 lb N/bu = 189 lb N - 20 = 169 lb N requirement - 45 lb soil test = 124 lb N/A). As these examples indicate, the nitrate soil test has a direct influence on the amount of nitrogen fertilizer recommended in South Dakota.

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The average nitrate soil test level has varied widely in South Dakota over the last ten years (Fig. 1). During the relatively wet years of 1984 to 1986 the average soil received at the SDSU soil testing lab from recrop fields tested as low as 27 lb/A 2 feet. That contrasts with the dry year of 1988 when the average test for recrop fields averaged 98 lb/A. The year to year variability in NO_3-N soil test results in an equally large difference in nitrogen fertilizer recommendation over the years.

There is a good relationship (r^2=0.75) between state wide annual relative spring wheat yields and fall NO_3-N soil test levels (Fig. 2). In years when spring wheat yields were above average, fall NO_3-N levels were low and years when spring wheat yields were low, NO_3-N levels were high. The extremes were a year when yield was 150% of the 20 year average with a fall NO_3-N level of 27 lb/A and a year when the yield was only 55% of average with resulting fall NO_3-N levels of 98 lb/A 2 feet. The relationship between average corn yields and fall NO_3-N soil test levels was not as good as for wheat (Fig. 3). This may be due to the longer growing season for corn allowing more opportunity for variability in mineralization rates of organic N, weather patterns, and possible leaching of NO_3-N, especially with irrigation.

In South Dakota, high yield years are usually years with above normal precipitation. The low soil tests after the wet years may be due to some losses by leaching and denitrification in addition to larger crop removal. The dry years have little or no crop removal and leaching and appreciable denitrification are unlikely.

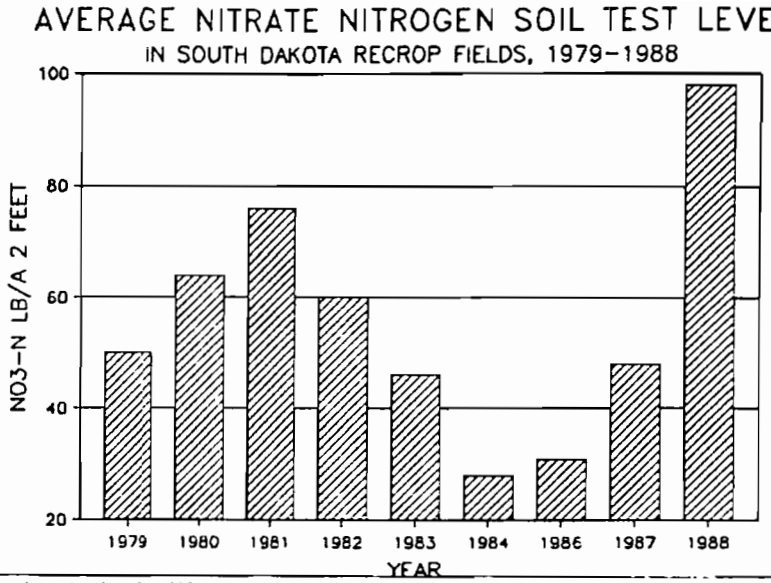
In addition to large differences between years, nitrate soil tests also vary widely within a given year in South Dakota. Even though samples taken for the 1989 crop year averaged 98 lb/A, 53 lb over the long term average, 29% of the samples tested less than 60 lb/A (Table 2) and would be considered near the long term average of 45 lb/A. Some of the variability in NO_3-N levels between fields in any given year is undoubtedly due to differences in soils, crop species, yield, and management factors such as fertilizer applications and tillage.

Table 2. Distribution of NO_3-N Soil Test Levels, SD, Fall 1989

Soil test level, lb/A 2 feet[1]					
0-20	21-40	41-60	61-80	81-100	>100
----------% of samples----------					
2	12	15	16	13	36

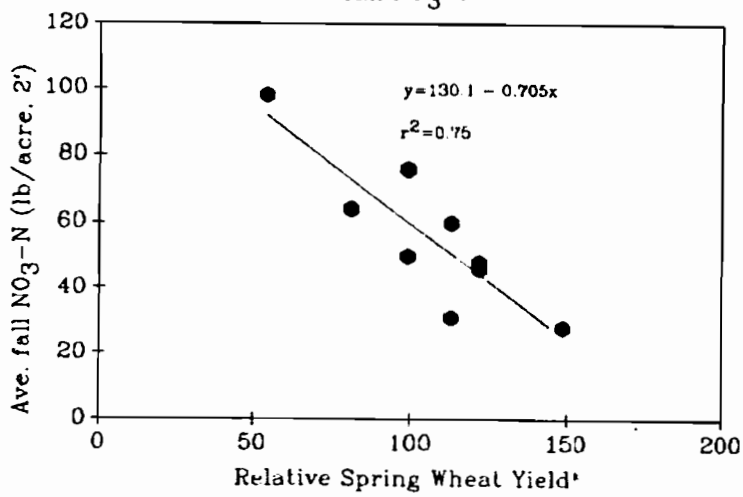
[1] average test: 98 lb/A 2 feet

Fig. 1



Correlation of relative spring wheat yield with average fall NO_3-N.

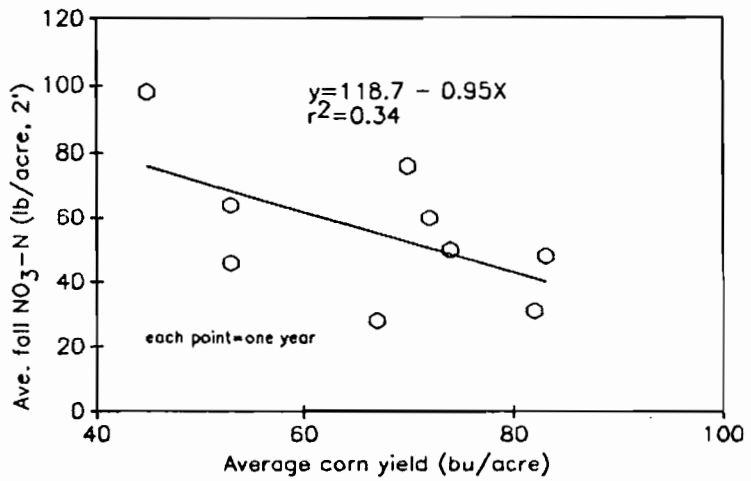
Fig. 2



Relative sp. wht. yld.= harvested ave. yld./20 yr. ave. yld. (22.2 bu/a)

Fig. 3

Correlation of average corn yield with average fall NO_3-N, 1979 - 1988.



The nitrate test is measuring the amount of available NO_3-N at the time of sampling. In addition to this source, available nitrogen can be mineralized from organic material during the growing season. Studies at SDSU indicate the amount of N becoming available from mineralization varies widely between locations within a year and between years (Tables 3 and 4). During the dry year of 1988, mineralization was estimated by adding Total N uptake and post season soil NO_3-N to five feet and subtracting preseason NO_3-N at eleven locations in South Dakota. Mineralization rate ranged from a low of 33 lb/A to a high of over 100 lb/A with an average of 72 lb/A. Another study in South Dakota showed mineralization rate varied between years at an individual site and that tillage had an influence on the rate (Table 4). Over a period of 3 years, the average mineralization rate for no till was 70 lb/A but increased to 82 lb for chisel plowing and 100 lbs/A for moldboard plow treatments. This variability in mineralization rate during the growing season decreases the soil tests ability to predict the amount of fertilizer N which is needed for efficient crop production because it is not known how much other nitrogen will be available. Efforts to find tests to predict rates of mineralization have not been completely successful.

Table 3. Estimated Nitrogen Mineralization, South Dakota, 1988

Site	Spring NO_3-N 0-5 ft	Fall NO_3-N 0-5 ft	Crop N uptake	Estimated Mineralization[1]
	lb N/A			
Rob 2	68	43	97	72
Spk	53	39	95	81
High	86	91	101	106
Jer 2	54	74	98	118
Jer 1	88	99	63	74
Dav 2	58	39	67	48
Dav 1	137	156	62	81
Brk	78	53	85	60
Cod	162	141	54	33
Rob 1	138	111	76	49
Moo	129	116	206	193
Avg				72

[1] N uptake of check and post season NO_3-N - preseason NO_3-N

Table 4. Net Nitrogen Mineralization Rates[1], Bruce, SD[2]

Tillage System	Year 83	84	85	Avg
	----------lb N/A----------			
MP	93	45	163	100
CH	75	41	128	82
NT	61	44	106	70

[1] N uptake of check and post season NO_3-N - preseason NO_3-N
[2] P. Fixen

SDSU soil testing lab summaries of residual NO_3-N indicate mineralization of organic N continues into late fall (Table 5). Samples analyzed in July and August of 1988 averaged 74 lb/A 2 feet while samples analyzed in November averaged 98 lbs. Samples taken over the winter months showed no further increases in NO_3-N level indicating mineralization had stopped. If fall soil sampling is used, for the NO_3-N test to make an accurate prediction of the next year's fertilizer needs, samples must be taken late enough such that fall mineralization is nearly complete.

Table 5. Nitrate Soil Test Summary by Month, Recrop Fields, 1988-89

Month:	July/Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr
lb N/A:	74	87	93	98	109	96	99	98	96

Nitrogen fertilizer applications made in excess of crop needs are normally measured with the nitrate test. In a study near Beresford in SE South Dakota, nitrogen rates up to 400 lbs/A were applied for corn in the spring of 1988. The drought of 1988 caused near total crop failure (<25 bu/A). The nitrate soil test in the spring of 1989 measured a nitrate level of 378 lb/A 2 feet where the 400 lb rate had been applied (Table 6). The check plot (0 N rate) had a nitrate test of 69 lb/A.

Table 6. Influence of Nitrogen Fertilizer on NO_3-N Soil Test, Beresford, South Dakota

Nitrogen rate[1]	NO_3-N Soil test, 0-2 feet June 88	April 89
lb/A	----------lb/A----------	
0	66	69
123	--	163
200	--	195
400	--	378

[1] applied April, 1988

Summary

1) The deep (0-2 foot) nitrate soil test has proven a valuable tool in measuring available nitrogen in South Dakota soils and in predicting fertilizer nitrogen needs.

2) The success of the nitrate soil test is due in part to the relatively dry climate of South Dakota, minimizing leaching and denitrification losses and ensuring what is measured will be available for subsequent crops.

3) The accuracy of the nitrate test in predicting nitrogen fertilizer needs could be improved if the mineralization rate of soil organic N during the growing season could be predicted.

4) The nitrate soil test is an important tool in preventing potential nitrate contamination of groundwater by improving the accuracy of predicting nitrogen fertilizer needs of crops.

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