RESIDUAL SOIL NO_3-N: VARIABILITY, SAMPLING, INTERPRETATION and EFFECT ON CORN YIELD

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Residual nitrate-N (NO_3-N) in the soil profile (crop root zone) is seldom uniformly distributed. There is lateral as well as vertical variability. Numerous factors influence variability. Some of them are: 1) any factor that influences water movement through the soil such as - soil texture, compacted zone, topography and water distribution under irrigation - 2) previous crop, 3) fertilizer history (organic and inorganic sources) and 4) sampling time - caused primarily by factors influencing mineralization and leaching.

NO_3-N variability is seldom the result of a single factor. Some of the factors that have an influence on practical management and use of residual NO_3-N will be examined.

Table 1. Mean, STD and CV of residual NO_3-N by increments to four feet from a 150 acre field in Dawson Co. Ne. and suggested N recommendation adjusted for residual soil NO_3-N. Data Courtesy D. Krull 1989.

NO_3-N Information

Depth Inches	Loc. in Field	Field Strip 1	Field Strip 2	Mean	STD	CV
		NO_3-N lb/A				
0-12	Top[1]	41	38	39.5	1.5	4
12-24		14	21	17.5	3.5	20
24-36		12	41	26.5	14.5	55
36-48		12	38	25.0	13.0	52
0-12	Middle	57	108	82.5	25.5	31
12-24		34	91	62.5	28.5	46
24-36		27	57	42.0	15.0	36
36-48		32	31	31.5	0.5	2
0-12	Bottom	72	39	55.5	16.5	30
12-24		55	34	44.5	10.5	24
24-36		51	80	65.5	14.5	22
36-48		38	240	139.0	101.0	73

Summary total NO_3-N in 0-48 in. depth across locations by strips.

				Mean	STD	CV
0-48	Top	79	138	108.5	29.5	27
	Middle	150	287	218.5	68.5	31
	Bottom	216	393	304.5	88.5	29
Overall mean, STD and CV =				211	104	50

N Recommendation Information

Soil Type:	Hord Silt Loam
Field Size:	150 Acres
Irrigation method:	Gravity
Row Length:	Half Mile
Yield Goal:	195 bu per Acre
Nitrate-N in water:	zero

<u>N recommendation using Mean from 6 field sites</u>

N Required for Yield Goal:	258 lb/A
N from Soil:	211 lb/A
N from Water:	0
N Recommended from Fertilizer:	47 lb/A

<u>N recommendation using Mean from 4 field sites</u>

<u>(discarding two highest locations)</u>

N Required for Yield Goal:	258 lb/A
N from Water:	0
N from Soil:	146 lb/A
N Recommended from fertilizer	112 lb/A

1/ Top refers to where irrigation water enters the field flows to bottom (end of field).

Table 2. Mean and CV for residual NO_3-N for a Wood River silt loam, gravity irrigated, with one-half mile rows. Buffalo Co., Nebraska Data Courtesy D. Krull, 1989.

		NO_3-N lb/A				
		Field Strips			Across Strips	
Loc. in Field	Depth	1	2	3	Mean	CV
Top	0-12"	32	25	32	30	11
	12-24"	29	36	32	32	9
	24-36"	54	25	36	38	31
	36-48"	40	18	18	25	40
Middle	0-12"	36	29	36	34	10
	12-24"	40	29	32	34	13
	24-36"	36	29	32	32	9
	36-48"	25	18	29	24	19
Bottom	0-12"	47	32	36	38	16
	12-24"	40	43	29	37	16
	24-36"	22	40	29	30	25
	36-48"	22	22	25	23	7

Summary of total lb/A NO_3-N in 0-48" depth across locations x sites

				Mean	CV
Top	155	104	119	126	17
Middle	137	104	130	124	11
Bottom	130	137	119	129	6
Over-all mean and CV				126	12

FACTORS INFLUENCING VARIABILITY

Water movement.

Available data on residual NO_3-N would indicate there is variability within variability. That is, conditions that cause variability in one situation may not produce the same result at different locations. For example, under gravity irrigation there usually is more water moving through the soil profile at the top of the field than the bottom, thus, usually the residual NO_3-N increases from top to the bottom of the field. However, data for two gravity irrigated silt loam fields with half-mile runs (Tables 1 and 2.) shows the NO_3-N uniformly distributed vertically and laterally for the field in Table 2 and not in Table 1. A possible reason for more uniformity for the field in Table 2 was the irrigation water contained 48 ppm NO_3-N compared to less than 1 ppm for field 1.

The cumulative effect of water movement (over 20 years) on NO_3-N content under gravity irrigated corn can be seen from a field in Hamilton Co., Ne. (courtesy Darrell Watts, Dept. Ag. Eng. and Andrew Christiansen, Co. Ext.

Agent Univ. of Ne.) where the NO_3-N to 80 feet was 900 and 2,400 lbs/A for the head and bottom ends of the field respectively.

Previous fertilizer applications.

Previous fertilizer applied can influence residual NO_3-N (Tables 3, 4 and 5). There is a trend for variability to increase with higher rates of N (higher CV's for the data in Table 3 compared to Table 5). Further, as shown in Table 5, with application of N rates adjusted for residual N, the variability tends to decrease over time (this general trend is apparent on numerous other long term N management studies associated with the University of Ne. and Central Platte Natural Resources District N Management program).

Table 3. Range, mean, and (CV) for NO_3-N content averaged across 4 replications from an experiment[1] on a Plano sl receiving two different N treatments. Data courtesy E. S. Malone, Arlington, Wisconsin.

	Treatment 1[2]			Treatment 2[3]		
Depth, cm	Range	Mean	CV	Range	Mean	CV
	NO_3-N, kg/ha			NO_3-N, kg/ha		
0-30	16-141	51	40.8	27-320	121	49.5
30-60	18-114	49	35.1	44-226	121	34.4
60-90	22-340	70	57.3	35-217	105	34.7
90-120	12-470	115	70	49-429	127	46.3
0-120	111-819	283	45.1	216-925	478	27.4

1/ Experiment dimensions, 88.5 by 109.8 m. Individual plots 3.05 by 9.15 m, each plot had 20 cores, thus the range and means represent 80 samples.
2/ 403 kg N/ha in 1983, No N in 1984.
3/ 403 kg N/ha in 1983, 235 kg N/ha in 1984.

Soil texture, time of sampling and previous crop.

General statements concerning the influence of factors such as soil texture, time of sampling and previous crop can not be made to cover situations across different geographical areas. Climatic and soil conditions that influence mineralization in turn affect the amount of residual NO_3-N (Tables 4, 6 and 7). Example, the fine sandy loam soils (Table 6) showed little change between fall and spring. These soils were located in Western Ne. where minimal moisture was received during the sampling interval. The general trend for the silt and silt loam soils was to gain N from fall to spring. The silt and silt loam soils were located in Central to East Central Ne. Higher organic matter, higher than average temperatures later in the fall and minimal leaching potential probably accounted for the increase from fall to spring. However, under Wisconsin conditions (Table 4) the sandy loam soil lost considerable NO_3-N from all N rates compared to a gain for the silt loam.

Soybean fields showed less variability by depth than the corn field for Minnesota data (Table 7). Also, the NO_3-N change between April and June was greater in corn than for the bean fields.

Table 4. Effect of applied N in 1988 on soil profile NO_3-N by foot increments and 3 foot total in the fall of 1988 and spring of 1989 on a Meridian sandy loam (Humbird, Wi.) and Withee silt loam (Marshfield, Wi.). Unpublished Data, Courtesy L. G. Bundy and T.W. Andraski.

N lb/A	Fall, 1988				Spring, 1989			
	0-1	1-2	2-3	Total	0-1	1-2	2-3	Total
	NO_3-N lb/A, Mean of 4 Replications							
	Meridian sandy loam							
0	69	53	21	143	24	20	11	55
100	176	68	24	268	44	46	30	120
200	344	76	33	453	72	131	61	264
	Withee silt loam							
0	15	4	6	25	34	19	19	72
100	36	72	8	116	59	116	30	205
200	126	153	8	287	103	200	43	346

RESIDUAL NO_3-N VARIABILITY - HOW TO COPE

The amount of variability associated with soil profile NO_3-N that can be tolerated depends on how the information will be used. In most situations, academic research work requires a higher probability that the mean value be in a prescribed range than can be tolerated from the practical standpoint of providing agricultural producers information on using residual NO_3-N.

The question that arises most often concerning field sampling for residual NO_3-N is "how many samples to take per field"? In an intensive sampling study on the treatments shown in Table 3, CV's for the NO_3-N content in the 0 to 120 cm depth reported by Malone for groups of 5 samples taken from a 90 cm square areas ranged from a low of 9.8 in replication 1 to 70 in replication 3 for treatment A. Using these data, it would take 22 cores to estimate the NO_3-N level within $\pm$ 20% of the true mean 95% of the time but would only take 2 cores per plot (3.05m by 9.15m) to estimate it within $\pm$ 30% of the true mean 60% of the time. Malone also indicated the CV's remained in the same range as plot size increased. The intensive sampled plots (Table 6.)ranged in size from 14 to 33 acres had CV's in the general range as those reported by Malone.

An example of variability on a field basis was complied by J. Schepers and is shown in Figure 1. These data are from 94 fields in the Hall County Water Quality Special Project in 1982. Similar results were obtained for 1980, 1981 and 1983. The CV's are the means from 1 core per 20 acres and are similar to those from the intensive sampled plots (Table 3 and 6).

Table 5. Residual NO_3-N means and CV in four feet averaged across four replications for a Hord silt loam gravity irrigated field as influenced by field location and applied N and grain yield as influenced by residual NO_3-N and applied N. Hall Co. Ne. 1986 to 1989. Data courtesy Dean Krull.

Year N Applied	N-Rate	Year Sampled	Location in Field: Top End Mean	Top End CV	Lower End Mean	Lower End CV	Field Average Mean	Field Average CV	Mean Grain Yield bu/A
			---------NO_3-N lb/A---						
		1986	45	20	97	15	71	40	
1986	Check	1987	23	25	65	41	44	65	168
	85		46	20	93	17	69	38	173
	135*		46	16	112	23	79	49	170
	185		54	27	105	30	80	44	174
1987	Check	1988	15	10	18	35	17	28	122
	85		19	21	31	29	25	37	182
	135*		26	15	60	17	43	44	186
	185		37	46	59	41	48	49	192
1988	Check	1989	23	16	34	18	28	26	125
	125		37	14	50	17	44	22	179
	175*		62	18	103	15	82	29	177
	225		57	26	124	12	91	40	179
1989	Check								153
	80								202
	130*								206
	180								209

* Recommended N rate based on yield goal, residual NO_3-N and an estimated 18 lbs N/A from irrigation water.

THE PRACTICAL APPROACH

Given that residual NO_3-N can vary laterally as well as vertically within the soil profile, what steps must be taken to consider residual NO_3-N when making N recommendations for crop producers?

The approach currently in use in Nebraska uses several criteria in arriving at a N recommendation using deep sampling for residual NO_3-N.
1. The primary consideration is to avoid reducing N application to a point where the producer recognizes a reduction in yield. 2. All sources of N are considered, i.e. N in irrigation water, residual NO_3-N, credit for legumes and an efficiency factor for spring preplant or sidedress over fall application.
3. Realistic yield goal. 4. How many cores to take per field. 5. How deep to sample. As stated earlier, it is suggested at least one core per 20 acres and for fields less than 20 acres, a minimum of 4 samples. The suggested sampling depth is at least 3 feet and better to 4 feet. Residual NO_3-N is not estimated if at least a 2 foot sample is not received. Initial work involving 30 field experiments over the period 1960 to 1963 as summarized by Hergert, et al. showed that of the total residual NO_3-N in a 6 foot profile, approximately 60, 70, 80 and 90 percent was contained in the top 2, 3, 4 and 5 foot depths respectively. Thus our procedure is to estimate the residual NO_3-N to 6 feet by dividing the NO_3-N found in the top 2, 3, 4, 5 feet by 0.6, 0.7, 0.8 and 0.9, respectively. Note, no estimate of the residual NO_3-N is given if samples to at least 2 feet are not received. Table 8 contains equations

relating residual NO_3-N by 30 cm (foot) increments to total NO_3-N in the 120 and 180 cm (4 and 6) foot depths. There is good support for estimating NO_3-N to 6 feet for sugar beets, wheat, corn and sorghum on non-irrigated deep loess soils. However, under irrigated conditions, observation of numerous field experiments indicates that corn roots seldom go below 4 feet. Thus, we are now using residual NO_3-N to 4 feet for N management projects in cooperation Natural Resource Districts (NRD's). With new information being added to our data base, University of Ne. Agronomists are discussing ways to up-grade our N management program.

Table 6. Mean, median and CV for lb/A NO_3-N in 0 to 4 feet based on a sampling grid of 100 feet as influenced by soil texture and time of sampling. Data courtesy G. Hergert, F. Anderson, R. Ferguson and C. Shapiro. Nebraska, 1987 and 1988.

		Fall 1987			Spring 1988		
# Cores	Soil Texture	Mean	Median	CV	Mean	Median	CV
		lb NO_3-N					
130	Fine sandy loam	74	55	67	78	66	56
81	Fine sandy loam	38	34	32	38	34	42
150	Silt loam	40	38	37	54	53	31
110	Silt loam	82	55	119	116	92	70
88	Loam	46	39	57	53	47	39
144	Silt loam	45	32	78	62	53	50
120	Silt loam	16	14	64	20	19	32
100	Silt loam	58	47	74	72	70	50
140	Silt loam	82	64	84	89	66	91
143	Silt loam	78	60	75	92	76	69

Estimating the N Requirement.

The N requirement is calculated from the current algorithm:

$$\text{N Req. lb/A} = \frac{YG * 0.9}{(1 - 0.0008*YG)} + 50 - NO_3\text{-N soil} - NO_3\text{-N water} - \text{Legume/manure}$$

Table 7. Variation in residual NO_3-N concentrations across replications by depth as influenced by previous crop and time of sampling. Waseca Co. Mn., 1989. Data courtesy G. Randall.

Location[1]	Depth Feet	Replication[2] 1	2	3	4	Mean	CV
Sampled in late April		NO_3-N, ppm					
1	0-1	9.7	5.2	8.6	10.3	8	23
	1-2	11	3.5	5.3	4	6	50
	2-3	7.6	4.2	3.1	5.6	5	33
2	0-1	14.6	11.4	10.1	13.1	12	14
	1-2	14.5	10.3	7.9	8.4	10	25
	2-3	10.5	6.7	5.1	5.3	7	31
3	0-1	9.5	16.8	33.6	18.6	20	45
	1-2	16.2	13.3	31.9	13.7	19	41
	2-3	25.1	20	23.5	16.8	21	15
Sampled in Mid June							
1	0-1	16.1	7.9	11.1	8.6	11	29
	1-2	9.1	4.7	6.4	6.1	7	24
	2-3	6.5	6	5.8	5.5	6	6
2	0-1	11.7	14	8.3	8	11	24
	1-2	7.8	10.1	6.6	6	8	21
	2-3	7.1	7.7	5.1	6	6	15
3	0-1	10.5	10.4	21.3	11.5	13	34
	1-2	8.4	15.4	18.1	10.7	13	29
	2-3	12.4	24.5	19.6	10.1	17	34

1/ Previous crop locations 1 and 2 - soybeans, location 3 - corn.
2/ Each value - average of 2 cores, each replication - 50' x 50'.

Table 8. Relationship between cumulative soil NO_3-N and NO_3-N in 120 or 180 cm depth for 81 Nebraska soils sampled during 1976 to 1982. Data courtesy G. Hergert, E. Penas, G. Rehm, D. Sander and R. Wiese.

Depth cm	0-120 cm	0-180 cm
0-30	Y = 47.3 + 2.03*(N30 cm) R^2 = .22	Y = 87.1 + 2.04*(N30 cm) R^2 = .1
0-60	Y = 14.6 + 1.67*(N60 cm) R^2 = .58	Y = 39.8 + 1.98*(N60 cm) R^2 = .38
0-90	Y = -1.0 + 1.31*(N90 cm) R^2 = .94	Y = 10.2 + 1.71*(N90 cm) R^2 = .76
0-120		Y = 4.2 + 1.38*(N120 cm) R^2 =.91
0-150		Y = 0.4 + 1.18*(N150 cm) R^2 =.98

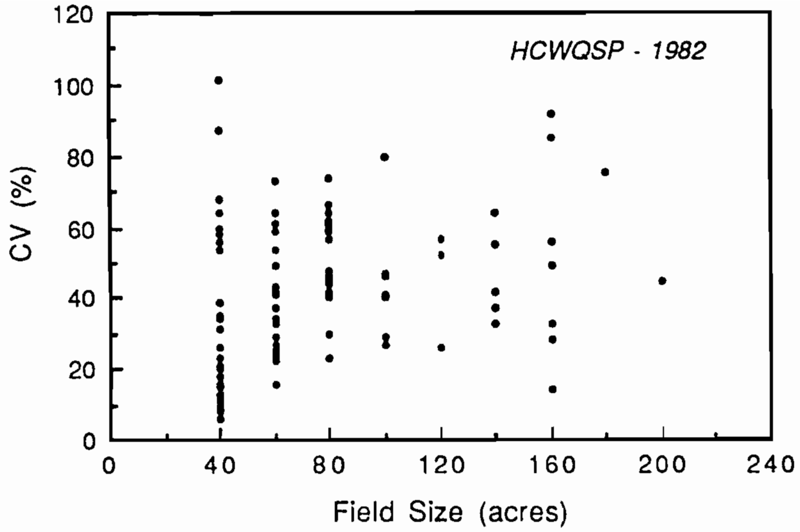

Figure 1. Coefficient of Variability (CV) for NO_3-N in 0-4 foot depth for one core per 20 acres from 94 fields. Hall Co. Water Quality Special Project (Joint project with Univ. of Nebraska and Central Platte Natural Resources District) 1982. Graph courtesy J. Schepers.

How well is the approach working?

Data shown in Tables 1 and 2 are one year N management fields conducted under a joint project between The University of Nebraska South Central Research and Extension Center and the Central Platte Natural Resources District. This project is a continuation of the Hall County Water Quality Special Project and is designed to demonstrate to crop producers that by using residual NO_3-N from the soil, NO_3-N from irrigation water plus a realistic yield goal based on their 5 year yield average, the efficient use of applied nitrogen can be increased and still produce economic corn yields. These two locations show a range in residual NO_3-N variability as well as NO_3-N available from irrigation water. Grain yields for 1989 are not available at this time, but will be provided at the November meeting.

1. Dawson Co. location information is contained in Table 1. Based on the UNL algorithm and using the mean NO_3-N from all six cores, an additional 47 pounds of fertilizer N would be required to produce 195 bu/A. However, remember the purpose of this project is to demonstrate to producers that applied N can be adjusted for residual NO_3-N. Thus, the LAST thing needed would be to suggest an N rate that may reduce yield slightly and lose the confidence of the producer. Thus a practical decision based on 10 years of experience in the area must be made, and that is to discard the two highest locations and arrive at the rate of 112 lbs N/A from fertilizer. This is the rate the producer will put over the entire 150 acre field. A replicated demonstration plot with 4 rates of N (62, 112, 162 and 212) will be placed in the farmers field.

Table 1 shows that the distribution of the residual NO_3-N across the field increases from the top to the bottom end of the field. Under the present recommendation, the amount of residual NO_3-N estimated was essentially the mean of the top and middle of the field. An obvious area for future refinement in the recommendation would be for the producer to fertilize the sections of the field according to estimated residual NO_3-N content. The bottom line here is that even though the recommendation may be excessive, a reduction of over 100 lbs N/A from what would normally been applied has been achieved.

2. Buffalo Co. location information is contained in Table 2. This 76 acre field has the residual NO_3-N uniformly distributed. The irrigation water contains 48 ppm NO_3-N. The N recommendation was arrived at by using the mean residual NO_3-N value (126 lb N/A), 97 lb N/A from the irr. water (assumes 9 inches of water will be applied) and a yield goal of 190 bu/A. Putting these numbers in the UNL algorithm results in 28 lb N/A required from fertilizer. Again, a replicated experiment with N rates of 28, 78, 128 and 178 lb N/A will be placed in the field.

3. Hall Co. location information is contained in Table 5. This is the 4th year for treatments being reapplied to the same plots. Check yields dropped the 2nd and 3rd years but increased in 1989. This is probably due to the increased potential for N mineralization due to warm temperatures late into the fall coupled with minimal rainfall. Again, under our present program we are over recommending N. But, the bottom line is we have reduced the producers normal application rate.

4. Platte Co. Ne. information on residual NO_3-N and associated grain yields are shown in Tables 9 and 10. This is an example of the type of experiment used to compiled the data base referred to in Table 8. This data is included to show (after the fact) how well the present approach to recommending N using variable residual NO_3-N data works.
Equation 1 was calculated to demonstration the error associated with N recommendations based on yield goals of 170, 180 and 190 bu/A using the mean or the lowest residual NO_3-N value observed from a field with considerable variability. Table 11 contains N rates for yield goals of 170, 180 and 190 bu/A that would have been made if residual NO_3-N had not been used as well as the adjusted rates using the mean and lowest residual NO_3-N values respectively.

The predicted N rate for maximum yield using equation 1 from Table 10 is <u>58</u> pounds of applied N if the mean residual NO_3-N of 167 lb/A is used compared to <u>77</u> pounds of applied N required if the lowest residual NO_3-N of 62 is used. Obviously, under the conditions of this experiment using the lowest value of residual NO_3-N would have resulted in an over application of from 78 to 113 lb N/A depending on the producers yield goal.

5. Table 12 shows the total residual NO_3-N for 5 foot depth for each plot from an N rate study in Winona Co. Minnesota. Observed yields are shown in Table 13. An after the fact application of the UNL algorithm would have worked well. Considering a 190 bu/A yield goal and the plot mean of 99 lb residual NO_3-N/A the recommendation would have been 153 lb N/A. The mean yield indicates approximately 100 lb N was enough for maximum yield. An over estimation of approximately 50 lb N/A BUT still a considerable reduction over what would have been applied without considering residual NO_3-N. The mean yields are curvilinear up to about 150 lb rate. Thus as shown, the quadratic

equation does not fit the data very well (Table 13).

Table 9. Mean, standard deviation and CV for NO_3-N in lb/A by increments to 72 inches deep. Each replication was 50 feet long and each strip 36 feet wide. Platte Co. Ne. 1978. Data courtesy E. J. Penas.

Rep	Depth Inches	Strips 1	2	3	Mean	Std	CV
		--- NO_3-N lb/A ---					
Rep III	0-6	7.2	5.4	4.3	5.6	1.2	21
	6-12	4.3	7.2	4	5.2	1.4	28
	12-24	50.4	14.4	4.3	23.0	19.8	86
	24-36	39.6	25.2	2.9	22.6	15.1	67
	36-48	28.8	28.8	2.9	20.2	12.2	61
	48-60	18	18	10.8	15.6	3.4	22
	60-72	18	39.6	6.1	21.2	13.9	65
Rep II	0-6	7.2	5.4	4	5.5	1.3	24
	6-12	9	9	5.4	7.8	1.7	22
	12-24	57.6	14.4	9.7	27.2	21.6	79
	24-36	115.2	25.2	14.4	51.6	45.2	88
	36-48	104.4	25.2	14.4	48.0	40.1	84
	48-60	28.8	21.6	9.7	20.0	7.9	39
	60-72	39.6	18	4.3	20.6	14.5	70
Rep I	0-6	10.8	4.3	7.2	7.4	2.7	36
	6-12	14.4	5.4	7.2	9.0	3.9	43
	12-24	86.4	46.2	18	50.2	28.1	56
	24-36	100.8	46.2	21.6	56.2	33.1	59
	36-48	100.8	36	8.6	48.5	38.7	80
	48-60	25.2	21.6	8.6	18.5	7.1	39
	60-72	28.8	14.4	9.7	17.6	8.1	46

Summary of total NO_3-N in 72" Depth

	Strips 1	2	3	Mean	STD	CV
Rep III	166.3	138.6	35.3	113.4	56.4	50
Rep II	361.8	118.8	61.9	180.8	130.1	72
Rep I	367.2	174.1	80.9	207.4	119.2	57
Total across Replications x Strips				167.2	114.0	68

The current Univ. of Ne. algorithm is providing N recommendations that allow for use of residual soil NO_3-N and NO_3-N from irrigation water. Presently as shown by these examples as well as the field sites summarized by Hergert, et al. our procedure almost always over estimates the N requirement. One probably reason for this could be the contribution of N from mineralization during the growing season. Also where irrigation water contains considerable NO_3-N the N contribution is greater because normally more than 9 inches of water is pumped. However, producers who use recommendations based on the current procedure HAVE REDUCED APPLIED N without reducing yields. Thus an economic effect has been achieved by the producer, but, more importantly, a reduction in the potential amount of NO_3-N available for leaching to the ground water has been achieved.

Table 10. Observed and predicted yield as influenced by applied rates of N. and residual N. Platte Co. Ne. 1978. Data courtesy E. J. Penas.

N rate lb/A	Grain Yield bu/A Observed				Predicted	
	Rep I	Rep II	Rep III	Mean	Eq. 1	Eq. 2
0	174	134	166	153	155	142
40	180	179	177	179	178	178
80	172	191	179	181	177	188
120	169	166	179	171	151	175
160	162	180	181	174		
200	165	171	165	167		
240	178	178	167	174		
280	153	195	157	168		

Eq. 1. $Y=135 + .1163(\text{Resid. N}) + 1.36N - .0076N^2 - .00286N*\text{Resid. N}$, $R^2 = .87$, $N \leq$ to 120 lb/A, Mean of Resid. N = 167 lb NO_3-N/A

Eq. 2: Same as Eq. 1 except Resid. N was 62 lb NO_3-N/A, the lowest value.

Table 11. Estimated N requirement for selected yield goals and adjusted N recommendation based on mean and lowest residual NO_3-N values from Table 9.

Yield Goal bu/A	N Recommendation lb/A UnAdjusted	Adjusted for Mean	Adjusted Lowest
190	252	85	190
180	239	72	177
170	227	60	155

Table 12. Mean and CV for residual NO_3-N in 0-60 inch depth by plot for an n-rate study in Winona Co., Minnesota, 1986. Each strip is 15 feet wide, each replication 60 feet long. Data courtesy G. W. Rehm.

	Strips 1	2	3	4	5	6	7		
	NO_3-N lb/A							Mean	CV
Rep IV	190	118	158	76	101	85	83	115.7	34.5
Rep III	168	121	77	95	73	45	49	89.9	44.8
Rep II	99	104	92	87	81	67	78	86.8	13.4
Rep I	128	114	136	101	92	72	81	103.5	21.4

Range across reps by strips = 44.6 to 190, Mean 99 and CV 33.4

Table 13. Grain yield as a function of applied N and predicted yield with and without profile N. Winona Co. Minnesota. Courtesy G. W. Rehm.

N Rate lb/A	Grain Yield, bu/A						
	Rep I	Rep II	Rep III	Rep IV	Mean	Eq. 1*	Eq. 2
0	183	184	152	183	176	181	180
50	203	194	179	191	192	187	188
100	206	199	232	171	202	192	193
150	191	191	194	190	192	195	196
200	199	185	181	185	188	196	197
250	195	211	204	185	199	196	195
300	192	200	183	196	193	195	191

* Eq. 1, Y=169 + .123*Soil N + .255*N - .00031*N*N - .00118*N*Soil N, R^2= .24
Soil N for calculation was mean = 99 lb/A

Eq. 2, Y=180 + .1698*N - .000444*N*N, R^2= .146

Possible ways the current UNL N recommendation procedure can/will be refined.

1. Research to relate the soil NO_3-N concentration with stem NO_3-N concentration and total leaf N at the 4 to 6 leaf stage to yield is in progress. Should this process prove reliable, it will provide the opportunity to apply additional N in cases where the present procedure did not recommend enough. Conversely, the possibility of showing excess N may lead to further refinements in the recommendation procedure so further reductions in applied fertilizer can be made.

2. Methods to estimate the amount of N mineralization during the growing season. This has greater potential under irrigation since conditions conducive to mineralization are more likely than under non-irrigation where moisture may be limiting in the top soil.

3. As previously mentioned, estimating residual NO_3-N to 4 feet rather than 6 feet will probably be changed, at least under irrigated conditions.

SUMMARY

Residual NO_3-N in the root zone is not uniformly distributed. There can be vertical and lateral variability. Predicting when and where variability occurs is risky. Some generalizations concerning residual NO_3-N are:

a. variability increases as residual NO_3-N increases
b. under irrigation, water distribution affects amount of residual NO_3-N, especially under gravity irrigation since the water is applied at the top end of the field, the movement of water through the root zone tends to decrease from the top to the bottom of the field, thus, the trend is for residual NO_3-N to increase from the top to the bottom of the field
c. variability of total residual NO_3-N in 0-4 feet from samples representing 2 to 20 acres as measured by CV's was in the range of CV's observed from different areas intensively sampled
d. because climatic and soil factors directly influence residual NO_3-N, management programs using residual NO_3-N must be flexible and tuned to local conditions.

The critical factor to remember is that research data involving distribution and utilization of residual NO_3-N must be PRACTICALLY applied to the real world of crop production. There is little doubt that residual NO_3-N can be considered when making N recommendations to crop producers. How it is used will depend on local conditions.

Promoting a N management program that uses residual NO_3-N to reduce applied N from that which producers normally apply should be done cautiously.. The program is more likely to succeed if gradual reductions in applied N are suggested so that the producer gains confidence in the program. Once the producer believes that N reductions can be made without reducing crop yields, the N management program can be refined.

The bottom line is that an accepted N management program is economically, environmental, and energy efficient.

Acknowledgements

The author appreciates the cooperation received from George Rehm, Gyles Randall, Sammuel Evans - University of Minnesota-, Larry Bundy - University of Wisconsin, Dean Krull, Gary Hergert, Jim Schepers, Ed Penas, Dick Wiese, Richard Ferguson, Frank Anderson, Don Sander and Charles Shapiro - University of Ne. for providing data for consideration for the report.

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