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EC93-126 Procedures for Field Demonstrations of Nitrogen Management Practices

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Extension Soils Specialists



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Nitrate-nitrogen in groundwater is a major public concern. Agriculture is often targeted as the primary source; however, crop producers are reluctant to reduce the amount of nitrogen they apply in fear of reducing crop yields and profits. Soil testing for nitrate-nitrogen is being promoted as a way to fine tune or improve nitrogen management, but adoption by producers has been slow. The availability of sampling equipment, labor and sampling costs, laboratory fees, and failure to recognize that a water quality problem exists all contribute to this slow adoption.

Properly designed field demonstrations can urge crop producers to use the practices designed to minimize nitrogen loss to the environment. Also, the data collected can be used to evaluate the calibration of the nitrate-nitrogen soil test. This publication explains how to conduct a field demonstration using scientifically acceptable methods that are practical for on-farm use.

Time Commitment

Conducting field demonstrations requires a time commitment. It takes several hours of planning time, two days to establish the demonstration strips (sample soil and apply fertilizer strips), a day to harvest and several hours to calculate yields and complete statistical analysis. Time also is needed to check the strips during the season and record observations.

Field demonstrations should be done only if a producer and those assisting are willing to commit the time and follow all the required steps. The adage, "Do it right or don't do it at all" applies to successful demonstrations since data collected from demonstration plots cannot be interpreted unless all the steps are done correctly. The steps involve selecting a field site, collecting soil samples, selecting nitrogen treatments, developing a field plan, measuring and marking plot areas, collecting data, harvesting grain at maturity, calculating grain yields and summarizing data, and analyzing and interpreting the data. These steps are discussed in detail below.

Selecting a Field Site

The area used in the demonstration should be as uniform as possible in soil texture, slope, irrigation and previous crops, as well as in manure, lime, and fertilizer applications. The uniform area must be large enough to repeat the treatments (applied rates of nitrogen) five or more times and still leave adequate border areas on the

sides. Each set of nitrogen rates is called a replicate or block (a block of treatments is illustrated in Figure 1 on page 2). Five or more replications or blocks of nitrogen rates are usually needed to detect small but economic differences in grain yields due to the rate of applied nitrogen. Three or four replications may be adequate when space is limited; however, the ability to detect small differences is greatly reduced.

The entire area of the field involved in strip trials must be treated uniformly: one hybrid or variety; same tillage, herbicide, insecticide, plant population, and irrigation. The only variable is the amount of nitrogen applied.

The width of each plot (one rate of nitrogen) will be determined by the equipment used. Minimum width should be two combine widths and may need to be wider depending on the width covered by the fertilizer applicator. Field length strips should be utilized wherever possible since this causes the least disruption of normal farm operations. See NebGuide G84-723 *Maximizing the Use of Farm Strip Plots* for general guidelines.

Collecting Soil Samples

Collect soil samples for nitrate-nitrogen tests prior to establishing the demonstration. Although one set of samples can be used to determine the average soil nitrate-nitrogen content, it is desirable to collect a set of samples from each block of applied nitrogen fertilizer rates. This will provide some information regarding the variability of nitrate levels in the field. A minimum of eight cores should be collected for each sample. See NebGuide G91-1000 *Guidelines for Soil Sampling* for more information.

Soil cores need to be taken to 48 inches deep and divided by depth: 0-8 inches, 8-24 inches, 24-36 inches, and 36-48 inches or 0-12 inches, 12-24 inches, 24-36 inches and 36-48 inches. The 0-8 inch sample is useful because it can be used for other nutrient tests.

Selecting Nitrogen Treatments

The primary treatment is the amount of nitrogen suggested for the expected yield when credit is given for all sources of nitrogen. These sources include soil nitrate-nitrogen based on soil tests, nitrate-nitrogen in the irrigation water, and nitrogen available from legumes, manure, and other organic sources. This treatment is compared

with a lower nitrogen rate and one higher rate (for example, minus 50 and plus 50 pounds nitrogen per acre from the recommended amount). Additional rates deviating more than 50 pounds nitrogen per acre from the recommended amount can be used if the cooperator is willing to apply them. The yield potential should be high enough and the soil and water nitrogen low enough so there is a need to apply fertilizer nitrogen. This will allow an evaluation of the recommended amount of nitrogen. See NebGuides G93-1178 *Fertilizer Nitrogen Best Management Practices* for more information.

There may be situations where only two rates of nitrogen are compared:

1. The field is not wide enough to accommodate at least three blocks of three nitrogen rates.
2. The soil and water nitrogen are so high that the suggested amount of fertilizer nitrogen is zero.
3. The field was in soybeans and the objective is to demonstrate that the amount can be reduced 40-50 pounds per acre following soybeans without affecting grain yield.
4. You want to compare a reduced amount of nitrogen with the amount commonly used.

If only two nitrogen rates are compared, six to eight replications of each rate should be used. Using less than five replications greatly reduces the ability to detect small differences in grain yield.

Developing a Field Plan

Two field plans are shown below. One illustrates three nitrogen rates in five blocks. The second plan shows two nitrogen rates (paired comparisons) in alternating strips.

Three nitrogen rate layout. Each treatment strip should be wide enough for at least two passes with a combine. Only the center rows are harvested for a yield check in each strip leaving at least two rows border on each side of the treatment strip. Thus, each block is equivalent to at least six combine widths. The width of each strip also must match fertilizer application equipment. Space for more than two passes with a combine may be needed, depending on fertilizer application equipment; therefore, each demonstration must be individually designed to match planting, fertilizing and harvesting equipment. Usually, producers prefer to harvest rows matched with the planter; thus, this needs to be considered when developing the field plan. Strips usually need to be wider than the suggested minimum to accommodate the equipment available.

Treatments must be randomized within each block. Divide the demonstration area into blocks with each block wide enough for three rates of nitrogen. Assign the nitrogen rates to each plot in a block at random. Drawing numbers is a good approach. Repeat the process for each block. Do not use the same randomization for each block; nor, should the same plot layout be used at several locations.

Figure 1. Example of a three nitrogen (N) rate plot layout in five blocks

(Rates randomized in each block)

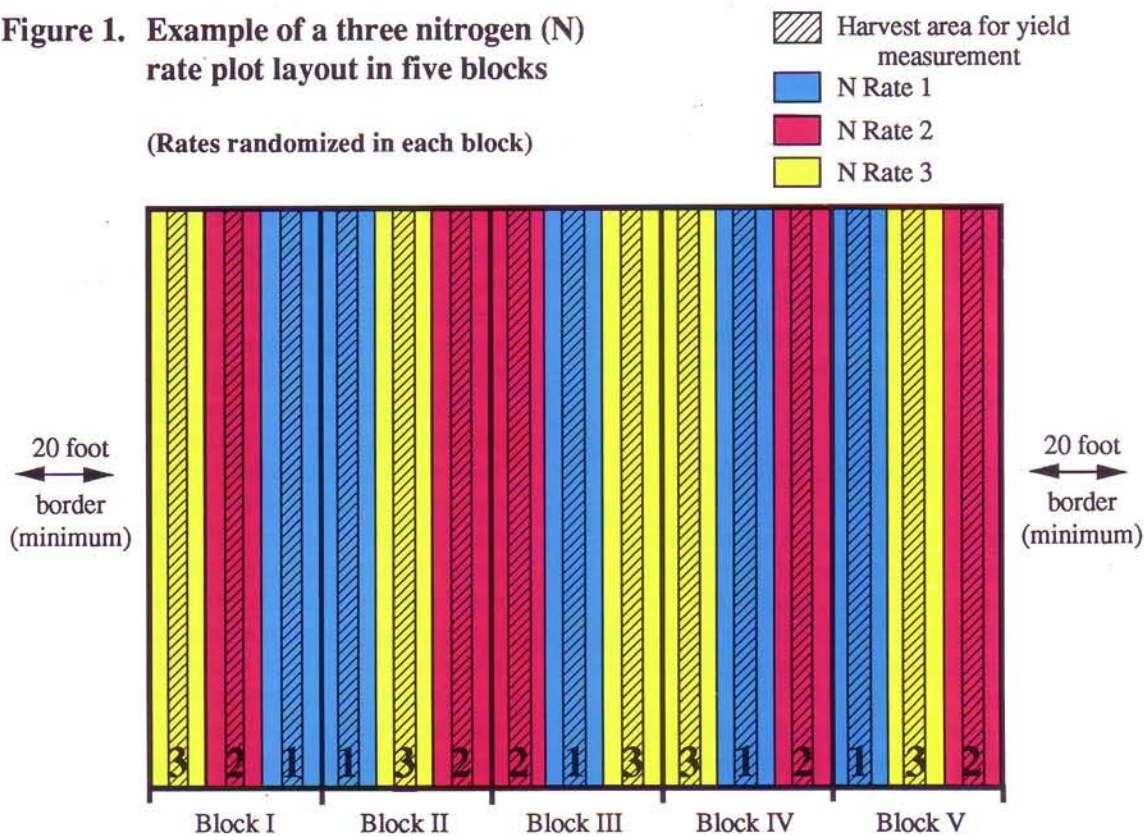
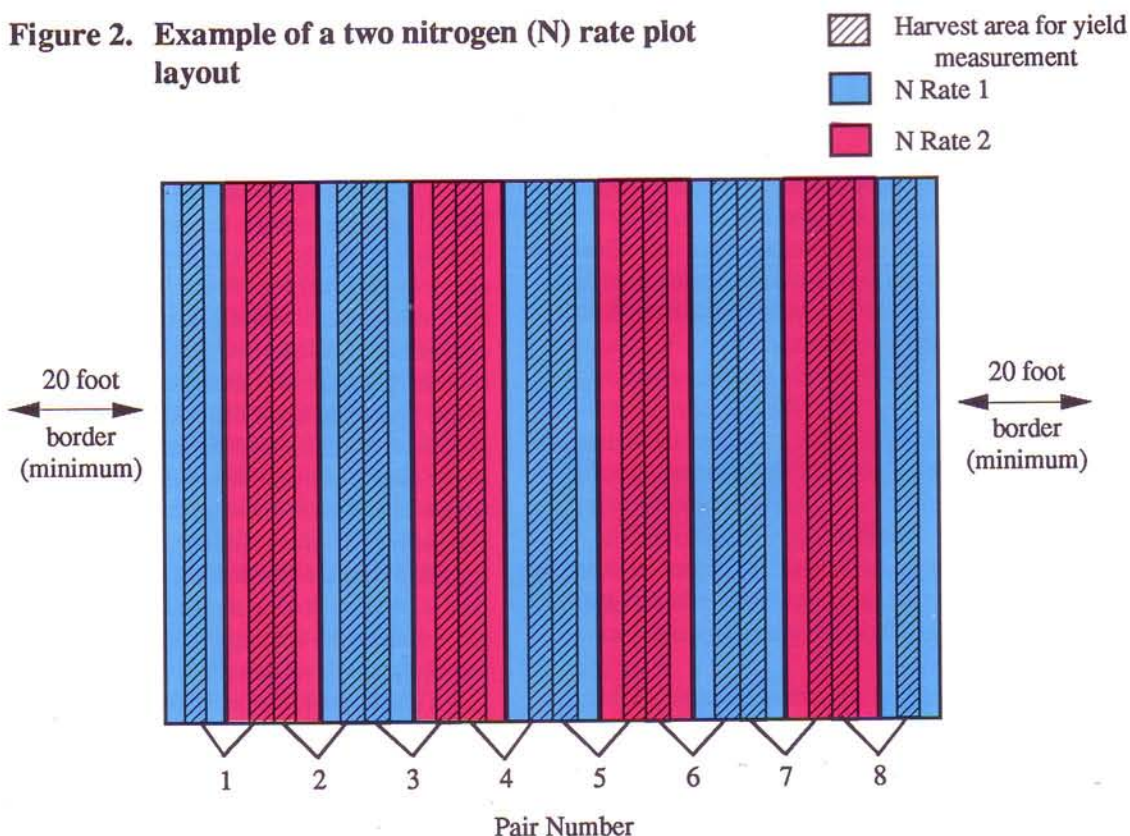


Figure 2. Example of a two nitrogen (N) rate plot layout



Two nitrogen rate layout. This plot layout utilizes alternate strips of two nitrogen rates. Statisticians call this paired comparison. Each nitrogen rate strip must be wide enough for at least three combine passes (except the first and last strips where only one harvest pass plus adequate border rows is needed).

In each nitrogen rate strip, two separate harvests are made and the outside rows serve as border. The left-hand portion of a strip is compared to the other treatment beside it on the left, and the right-hand portion is compared to the other treatment beside it on the right.

The width of each strip also must be matched to the width of the fertilizer application equipment. Establishment of this layout is simplified since treatments are alternating. Space requirements are less since less area is needed for border rows.

Measuring and Marking Plot Areas

Prior to applying the nitrogen fertilizer treatments, the individual plots need to be marked. If the nitrogen fertilizer is applied prior to planting, plots need to be measured or established according to existing rows of the previous crop. For applications after planting, count rows for each plot and mark.

Each individual plot should be marked with a plot stake or wire flag. Place the marker in the first row of each plot. Wire flags placed in the row will not interfere with field operations. Identifying the nitrogen rate on

each plot marker is an aid when applying fertilizer treatments and making observation notes.

It is a good idea to put markers (flags or stakes) on the edge of the field (fence row) where they are not likely to be moved. Measure and record the distance from the markers to the corners of the demonstration plot area.

Collecting Data

All known information for the demonstration site is recorded in the Crop Data Record (sample is shown on page 7). Information such as row width, planter rows, combine rows, and fertilizer applicator width must be known prior to layout of the demonstration. Other information needs to be recorded as it becomes available.

During the growing season, visual observation of the demonstration plots should be made at least monthly. Take notes of plant color, stage of development, differences in pollination, grain fill, stand, weeds and insects, etc. Record the date of each visit and any observations made. A photographic record of observed differences may be useful. For irrigated sites, collect an irrigation water sample for nitrate analysis making a collection after the well has been in operation for several days.

Determine the amount of water applied for the season. An irrigation flow meter is the preferred method of measuring this amount. Keeping track of the number and duration of irrigations is acceptable if the output of the well is accurately known.

Harvesting Grain at Maturity

Strips are harvested by combine, usually by the cooperating farmer, and the grain weighed either by weigh wagon or another scale. A one-pint sample of grain is collected from each strip for grain moisture. Test weight and protein also can be determined on the samples if desired. Samples must be taken from each individual plot. Without individual plot samples, analysis of the effect of the nitrogen rate on grain moisture, test weight, and protein cannot be made.

The number of rows harvested and their length must

be recorded for each strip. Yields can then be calculated and the results analyzed statistically.

Calculating Grain Yields and Summarizing the Data

During or after harvest, data are recorded on the Data Worksheet (example on page 8). This worksheet contains all the data needed to calculate grain yields and perform the statistical analysis. The grain yields can be calculated at the time the statistical analysis is performed or can be calculated using the following equation:

$$\frac{\text{Grain, lbs}}{\text{plot}} \times \frac{(100 - \text{moisture, \%})}{100} \times \frac{1}{\text{DM, lbs/bu}} \times \frac{1 \text{ row}}{\text{row width, in}} \times \frac{12 \text{ in}}{\text{ft}} \times \frac{1}{\text{rows/plot}} \times \frac{1}{\text{row length, ft}} \times \frac{43,560 \text{ ft}^2}{\text{ac}} = \text{bu/ac: where}$$

(1) $\frac{\text{Grain, lbs}}{\text{plot}}$ is the weight of grain harvested from a strip.

(2) $\frac{(100 - \text{moisture, \%})}{100}$ is the dry matter content of the harvested grain.

(3) $\frac{1}{\text{DM, lbs/bu}}$ is the weight of dry matter in a bushel at standard moisture.

DM for corn @ 15.5% moisture = 47.32 lbs/bu

DM for grain sorghum @ 14% moisture = 48.16 lbs/bu

DM for wheat and soybeans @ 13% moisture = 52.20 lbs/bu

(4) $\frac{1 \text{ row}}{\text{row width, in}}$ is the row spacing in inches.

(5) $\frac{12 \text{ in}}{\text{ft}}$ converts row spacing from inches to feet.

(6) $\frac{1}{\text{rows/plot}}$ is the number of rows harvested per strip.

(7) $\frac{1}{\text{row length, ft}}$ is the average length of rows within each strip.

(8) $\frac{43,560 \text{ ft}^2}{\text{ac}}$ is the square feet per acre.

The first three terms convert the pounds of harvested grain to bushels of grain at standard moisture. The last five terms convert the measurements for area to plots per acre.

Example calculations from Data Worksheet:

$$\frac{5065 \text{ lbs}}{\text{plot}} \times \frac{(100 - 15.2)}{100} \times \frac{1}{47.32 \text{ lbs/bu}} = 90.8 \text{ bushels/plot} \quad \text{and}$$

$$\frac{1 \text{ row}}{36 \text{ in}} \times \frac{12 \text{ in}}{\text{ft}} \times \frac{1}{4 \text{ rows/plot}} \times \frac{1}{2257 \text{ ft}} \times \frac{43560 \text{ ft}^2}{\text{acre}} = 1.61 \text{ plots/acre}$$

$$\text{thus } \frac{90.8 \text{ bu}}{\text{plot}} \times \frac{1.61 \text{ plots}}{\text{ac}} = 146 \text{ bu/ac}$$

$$\text{or } 1.61 \text{ plots per acre means } \frac{1 \text{ acre}}{1.61 \text{ plots}} = 0.62 \text{ acres per plot}$$

$$\text{thus } 90.8 \text{ bu} \div 0.62 \text{ ac} = 146 \text{ bu/ac}$$

Analyzing and Interpreting the Data

The final step is to statistically analyze the data to determine if observed differences are in fact due to the applied rate of nitrogen or occurred by chance alone. Standard analysis of variance procedures are used. Those not familiar with statistical analysis should consult EC 92-125 *On-farm Trials for Farmers Using the Randomized Complete Block Design* or seek help from the authors of this circular. An example of the statistical analysis for data from a paired comparison demonstration is shown on page 6.

Statistical analysis is necessary to determine if observed differences in grain yield or other variables are due to the applied rate of nitrogen or whether differences are due to variability in the field. Replication of treatments is necessary to calculate experimental error. Also, the analysis procedure assumes that the plots for each rate of nitrogen were selected at random. If plots are not replicated, data cannot be interpreted. If plots are not assigned at random, the statistical analysis is not valid.

Statistical analysis will give a measure of variability in the trial, and from this information one can determine the probability that differences observed are due to treatment or are a result of field variability.

Example of a paired comparison analysis

Pair Number	Nitrogen Rate		Difference (d) (H - L)	d ² (H - L) ²
	Low	High		
1	161.2	159.7	-1.5	2.25
2	156.0	158.8	2.8	7.84
3	157.9	160.2	2.3	5.29
4	158.0	161.9	3.9	15.21
5	158.7	161.3	2.6	6.76
6	160.0	158.4	-1.6	2.56
n = 6				
Sum (Σ)	951.8	960.3	8.5	39.91
Mean (x̄)	158.6	160.0	1.4	

Variance of the mean:

$$\begin{aligned}
 (S_{\bar{d}})^2 &= \frac{\Sigma d^2 - (\Sigma d)^2 / n}{n(n-1)} \\
 &= \frac{39.91 - (8.5)^2 / 6}{6(5)} = \frac{39.91 - 12.04}{30} = 0.93
 \end{aligned}$$

Standard error of the mean:

$$\begin{aligned}
 S_{\bar{d}} &= \sqrt{(S_{\bar{d}})^2} \\
 &= \sqrt{0.93} = 0.96 \\
 t &= \frac{\bar{x}_d}{S_{\bar{d}}} = \frac{1.4}{0.96} = 1.46 \\
 df &= (n-1) = (6-1) = 5
 \end{aligned}$$

From Table I, one can determine that with five degrees of freedom, a value for $t = 1.46$ means that a difference of 1.4 bushels per acre in this trial would occur about 20 percent of the time by chance alone (probability = 0.2). Thus, one would conclude that the application of a higher rate of nitrogen did not increase grain yield in this trial.

Table I. Values of t

df	Probability of a larger value of t, sign ignored							
	0.5	0.4	0.3	0.2	0.1	0.05	0.02	0.01
1	1.000	1.376	1.963	3.078	6.314	12.706	31.821	63.657
2	.816	1.061	1.386	1.886	2.920	4.303	6.965	9.925
3	.765	.978	1.250	1.638	2.353	3.182	4.541	5.841
4	.741	.941	1.190	1.533	2.132	2.776	3.747	4.604
5	.727	.920	1.156	1.476	2.015	2.571	3.365	4.032
6	.718	.906	1.134	1.440	1.943	2.447	3.143	3.707
7	.711	.896	1.119	1.415	1.895	2.365	2.998	3.499
8	.706	.889	1.108	1.397	1.860	2.306	2.896	3.355
9	.703	.883	1.100	1.383	1.833	2.262	2.821	3.250
10	.700	.879	1.093	1.372	1.812	2.228	2.764	3.169

NITROGEN DEMONSTRATION CROP DATA RECORD

County _____	Crop _____ Expected Yield _____
Legal _____ 1/4 of _____ 1/4, Sec. _____ T _____ R _____	Hybrid _{3/} _____
Cooperator _____	Date of Planting _____
Address _____	Date of N Application _____
_____	Field Operations _{4/} _____
Phone Number _____	_____
Irrigated? _____ Type _{1/} _____	_____
Irrigation Water Applied, inches _____	Planting Rate, seeds/ac _____
Irrigation Water Runoff, inches _____	Previous Crop _____ Yield _____
Irrigation Water N Content, ppm _____	Fertilizer Applied _{5/} _____
Growing Season Rainfall, inches _____	_____
N Applicator Width, inches _____	_____
Planter Rows, number _____ Width, inches _____	Starter Applied _{6/} _____
Combines Rows, number _____	_____
Soil Type Name and Texture _{2/} _____	Herbicide _{7/} _____
Soil Nitrate-N, ppm by depths _____	Insecticide _{7/} _____
_____	_____

Notes:

- 1/ Type of irrigation i.e. furrow, pivot, tow line, big gun, etc.
- 2/ Specific soil type name
i.e. Sharpsburg silty clay loam, Gibbon silt loam, etc.
- 3/ List brand and number (or name) i.e. Pioneer 3377 or Horizon Colt, etc.
- 4/ Give specific field operations
i.e. cut stalks, plant, one cultivation, etc., or
disc, field cultivate, plant, one cultivation, etc.
- 5/ List amounts and time of applications of all fertilizer materials applied.
- 6/ Give the rate of material applied, pounds or gallons per acre, exact grade, and specific placement
i.e. six gallons of 10-34-0, or 50 pounds of 18-46-0 with 1% Zn, two inches side and one inch below seed.
- 7/ Give kinds, amounts, when applied, how applied, etc.

NITROGEN DEMONSTRATION DATA WORKSHEET

Date _____ Location _____ Crop _____ Crop DM, lbs/bu _____ Row Width, inches _____

(1) Plot No.	(2) Block No.	(3) N Rate	(4) Rows, No.	(5) Width Plot, ft	(6) Length Row, ft	(7) Grain, lbs.	(8) Moisture, %	(9) Test wt., lbs/bu	(10) <u>100-Moisture</u> 100	(11) Plots/ac (43,560/5*6)	(12) Bu/plot (7*10/DM)	(13) Yield, bu/ac (11*12)
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Example:													
Date	10/1/92		Location		Butler		Crop	Corn	Crop DM, lbs/bu		47.32	Row Width, inches	36"
102	1	50	4	12	2257	5065	15.2	60.4	.848	1.61	90.8	146.0	

[illegible]

Related Publications

NebGuide G74-174 *Fertilizer Suggestions for Corn*

NebGuide G84-723 *Maximizing the Use of Farm Strip Plots.*

NebGuide G93-1178 *Fertilizer Nitrogen Best Management Practices.*

NebGuide G91-1000 *Guidelines for Soil Sampling.*

EC92-125 *On-farm Trials for Farmers Using the Randomized Complete Block Design.*