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Nitrogen Management Guide for Connecticut

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Nitrogen Management Guide For Connecticut

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1. Obtain (and report to services making N fertilizer recommendations) accurate information about all aspects of manure management. Especially important are application rates, time elapsed between spreading and incorporation, and application times.

See *Previous Cow Manure Applications*, p 2, *Manures and Other Waste Products*, p 3, and *Manure Application Rates*; p 5.

2. Use realistic yield goals for corn

See *Crop Removal of N*, p 4.

3. Do not overapply manures and/or N fertilizers:
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   b. Do not apply extra N as an insurance policy.

See *Nitrogen Management–N Fertilizer Rates Based on a Balance Approach*, p 5 and *Worksheet for Determining N Fertilizer Rates Using a Balance Approach*, Table 1, p 7.

4. Apply most of the fertilizer N recommended as a sidedressing or topdressing.

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5. For corn, apply no preplant fertilizer N on fields which have received manure within eight months or on fields which will receive any N in fertilizer applied through the planter (starter fertilizer). If manure and starter are not used, do not apply more than 40 lbs N per acre preplant.

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See *Manure Application Rates*, p 5.

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11. Learn the names of soils and their location on the farm. Be especially careful in managing N on well drained to excessively-drained soils underlain by sands or sands and gravel.

Nitrogen Management Guide for Connecticut

Nitrogen (N) has a pronounced and often dramatic influence on the growth and yield of crops. Management of soil and fertilizer N is difficult because N undergoes numerous transformations and is easily lost from the soil. These losses concern growers for two principal reasons: 1) the losses can and often do adversely affect plant growth and crop yield, and 2) when N is lost in the nitrate form, there is a chance for contamination of groundwater and drinking water supplies. The purpose of this management guide is to describe the behavior of soil and fertilizer N and to suggest management practices that minimize the potential for contamination of groundwater with nitrate without sacrificing crop yield.

The maximum contaminant level (MCL) permissible for nitrate in Connecticut drinking water is 10 mg per liter nitrate-N (10 ppm nitrate-N). When drinking water contains more than 10 ppm nitrate-N, the Connecticut State Department of Health considers the water unfit for infants and pregnant women to drink. For additional information on nitrates in drinking water, including human health concerns, see *Water and Nitrates*, p 11 in the Appendix.

The Nitrogen Cycle

The N cycle (p 3) illustrates N inputs, losses and transformations. When inputs exceed plant needs, nitrate can accumulate in the soil and pose a threat to groundwater. Conversely, when plant-available forms of N from the soil and any inputs are too low, crop growth suffers. The key to successful management of N is to find the relatively "thin line" region between too much and too little N. It is not an easy task, because N transformations and losses are affected by soil conditions and the vagaries of the weather and because the rates of most N inputs are difficult to estimate accurately.

Nitrogen Inputs

As can be seen from the N cycle, there are several different sources of the N used by plants:

The Soil Itself (soil humus): The total amount of N in the plow layer of agricultural soils is surprisingly large. (One can estimate the total N in lbs per acre in the surface 6 to 7 inches of soil by multiplying the soil's organic matter content by 1,000. Thus, a soil with 4% organic matter contains about 4,000 lbs N per acre.)

The amount of this total N available to plants in any one year, however, is relatively small. Research has shown that for most soils, only 1% to 3% of the total N is converted annually to forms plants can use. For the soil with a total of 4,000 lbs N per acre, a 1% to 3% conversion would produce 40 to 120 lbs N per acre annually for plant use. If the crop needs 200 lbs N per acre for adequate growth and development, additional N must come from nonsoil sources. Manure and/or commercial fertilizer are the most likely candidates to furnish this supplemental N.

Previous Cow Manure Applications: Only a fraction of the total N in cow manure is available to crops in the year of application. Some of the N in the manure, usually between 5% and 10% of the total applied, is released the year after the manure is added. Smaller amounts are furnished in subsequent years. The quantity of N released the year after a single application of 20 tons per acre of cow manure is small (about 15 lbs N per acre). However, in cases where manure has been applied at high rates (30-40 tons per acre) for several years, the N furnished from previous manure increases substantially (see Appendix Tables A1 and A2, pp 11 and 12).

The buildup of a soil's N-supplying capacity resulting from previous applications of cow manure has important consequences for efficient N management, two of which are:

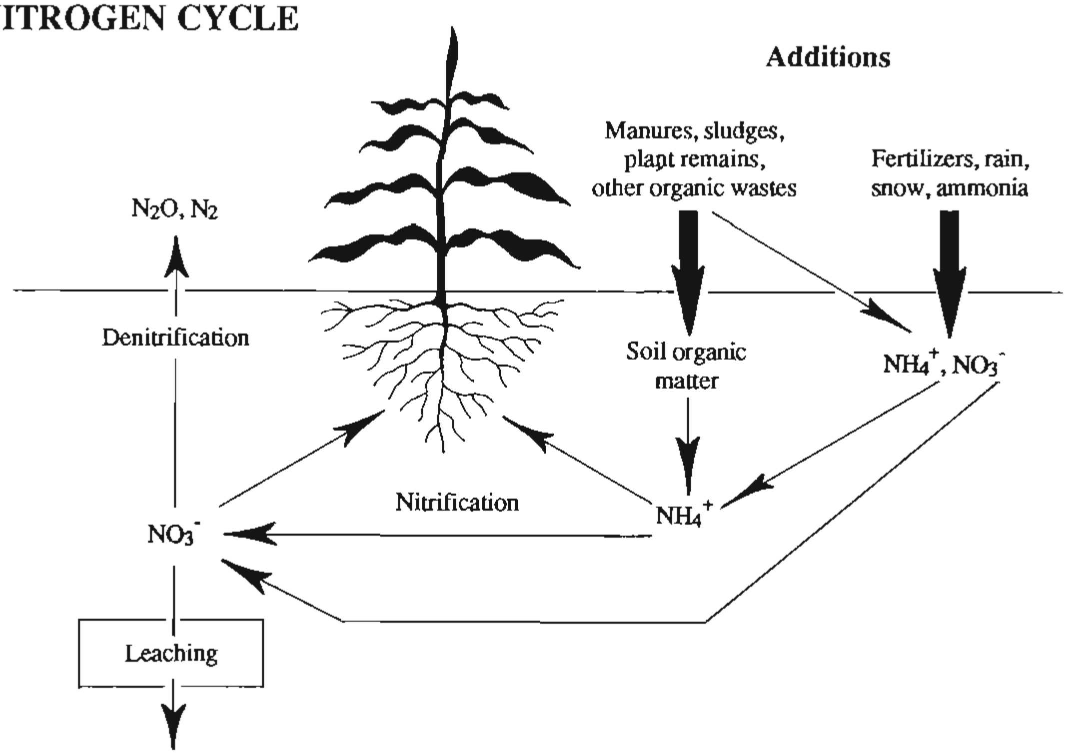
1) The amount of fertilizer N needed for the crop decreases annually;
2) If all of the crop's N needs are being supplied by the cow manure, the rate of cow manure needed decreases yearly.

Appendix Table A3, p 12, illustrates how the N fertilizer requirement decreases annually. Table A4, p 13, shows how cow manure rates decrease each year to furnish the N needed annually for 20-, 24- and 28-ton-per-acre silage corn yields.

In cage layer poultry manure, a higher percentage of the total N in the manure is converted to plant-available forms in the year of application. Consequently, there is relatively little carryover of N to crops in succeeding years. This is due to the nature of the organic N compounds in poultry manure. This does not mean, however, that there is never any carryover of N from poultry manure applications. If excessive rates of poultry manure (or commercial N fertilizers) are used, high levels of residual inorganic N, including nitrate, may be in the soil the following spring. High levels of soil nitrate in the fall, winter and spring have the potential to pollute groundwater.

Previous Crops: Previous crops can supply appreciable amounts of N to succeeding crops. Legumes such as alfalfa and red clover furnish 100 lbs or more of N to

THE NITROGEN CYCLE



crops that follow. Other legumes, mixed grass-legume stands and grass sods supply less N to succeeding crops. For N credits given previous crops by the Cooperative Extension System, see Appendix Table A5, p 13.

Manures and Other Waste Products: Manures supply important amounts of N to crops. The N credits (N fertilizer equivalent) given these materials is always less than their total N contents. For example, we credit cow manure with between 2 and 6 lbs of N per ton even though the total N in the manure is typically 10-12 lbs N per ton. The relatively low figure (2-6 lbs N per ton) reflects losses of N that occur during handling, storage and residence on the soil surface. The low figure is also due to the fact that only a fraction (about one third) of the "stable" organic N in cow manure is made available to crops in the year of application (Klausner et al, 1984).

The N content of manures and their N fertilizer equivalents are highly variable. Differences in N content are due to the species of animal, the animal's age and diet, the moisture content of the manure, handling and storage, and the amount of bedding in the manure. The N fertilizer equivalent of a given manure varies not only with animal species and the total N content of the manure, but also with time of application and time elapsed between spreading and incorporation.

Nitrogen credits given at The University of Connecticut for different manures applied at various times are given in Appendix Table A6, p 13. The values in this table are based on numerous analyses of Connecticut manures as well as published data from other states. If specific manure analysis data for the farm are not available, growers should estimate N credits by using Table A6.

Manure Analysis

Most laboratories that analyze manure samples provide results for both total N and ammonium N. (Total N is the sum of ammonium N and organic N.) The N credit assigned to the manure that was analyzed depends on its ammonium content, its organic N content, when the manure is applied and how quickly it is incorporated after application. Good results from manure analysis require submitting a good, representative sample. The labs that perform the analyses provide sampling instructions and directions for packaging and submitting the samples. Most of these labs also provide estimates of N credits for the year of application based upon results of the analysis. The Cooperative Extension System also provides assistance with interpretation of the results.

Synthetic Chemical Fertilizers: Fertilizers used to supply N include urea (46-0-0), diammonium phosphate (DAP: 18-46-0), monoammonium phosphate (MAP: 11-48-0), ammonium nitrate (34-0-0), urea-ammonium nitrate solution (UAN: 32-0-0) and various "manufactured" and mixed fertilizers such as 15-8-12, 15-15-15 and 10-10-10. In "bulk blended" or "custom blended" mixes, N-containing fertilizers with almost any grade can be provided. Suggestions for rates, times and methods of application are given starting on p 8.

N from Biological N Fixation: Bacteria associated with the roots of legumes such as alfalfa and clover convert N gas in the atmosphere into forms utilizable by crops. The amounts of N so fixed can exceed 200 lbs N per acre for alfalfa and some varieties of red clover. An important consequence of this fixation is that established legume crops need no N fertilizer. Some testing services, including The University of Connecticut soil testing lab, recommend a small amount of N (usually 40 lbs N per acre or less) for legume establishment.

Nitrogen Losses

Volatilization Losses: These gaseous losses occur mainly from surface-applied manures and urea. The losses can be substantial–more than 30% of the N in topdressed urea can be volatilized if no rain falls within two or three days of application. Losses are greatest on warm, moist sandy soils with pH values above 7.0 (Nelson, 1982). Delaying the incorporation of manures after they are spread also leads to volatilization losses of N. The Pennsylvania State University estimates, for example, that only 15% of the total N in poultry manure and 20% of the total N in cow manure is available to the crop in the year of application if the manure is incorporated more than 7 days after spreading (Beegle, 1989).

Leaching Losses: Nitrogen can be lost by leaching in either the ammonium or nitrate form. Usually, much more N is leached as nitrate than as ammonium. Leaching losses are greatest on permeable, well-drained to excessively-drained soils underlain by sands or sands and gravel when water percolates through the soil. Percolation rates are generally highest when the soil surface is not frozen and evapotranspiration rates are low. Thus, October, November, early December, late March and April are the times in Connecticut that percolation rates are highest and leaching potential is greatest. This is why nitrate remaining in the soil after the harvest of annual crops such as corn in September is particularly susceptible to leaching. Of course, leaching can occur any time there is sufficient rainfall or irrigation to saturate the soil. An example is the 12 inches of rain that fell in north central and northwestern Connecticut in May 1989.

Denitrification Losses: These losses occur when nitrate is converted to gases such as nitrous oxide (N_2O) and nitrogen (N_2). The conversions occur when the soil becomes saturated with water. Poorly drained soils are particularly susceptible to such losses. In especially wet years on some soils, more than half the fertilizer N applied can be lost through denitrification.

Immobilization: Immobilization occurs when soil microorganisms absorb plant-available forms of N. The N is not really lost from the soil because it is held in the bodies of the microorganisms. Eventually, this N will be converted back to plant-available forms. In the meantime, however, plants are deprived of this N, and N shortages in the plants may develop. Immobilization takes place when highly carbonaceous materials such as straw, sawdust or woodchips are incorporated into the soil. Manure with large amounts of bedding may cause some immobilization.

Crop Removal of Nitrogen: In most cases, the greatest removal of N from the soil is via crop removal. Good corn and alfalfa crops typically remove over 200 lbs of N per acre annually. Anticipated crop removal of N is one of the factors used in making N fertilizer recommendations for corn. This is one reason that realistic yield goal estimates for corn are essential for recommendations that are neither too high nor too low. Depending on the crop, variable amounts of the N absorbed by the crop are returned to the soil after harvest by nonharvested plant parts.

Nitrogen Management:
N Fertilizer Rates Based on a Balance Approach

The balance approach takes into consideration the internal N requirement of the crop, N inputs (gains) and N losses. The success of this approach depends upon the accuracy of estimates of these gains, losses and crop N needs.

> For corn, fertilizer recommendations based on a presidedress soil nitrate test, which is described starting on p 6, is preferred over the balance approach.

In the procedure described below, the "Crop N requirement" provides a measure of how much N a given crop needs above and beyond that provided directly by legume bacteria and the soil itself. (See Table A7, p 14.) Incorporated into the "crop N requirement" are factors that estimate N contributions from the soil and legume bacteria as well as an estimate of the fraction of fertilizer N absorbed by the crop. The N fertilizer requirement is calculated by subtracting from the crop N requirement amounts of N from sources other than the soil itself and legume bacteria.

Procedure for the Balance Approach:

Use steps 1-4 below, which utilize the following equation:

$$\text{N Fertilizer} = \begin{matrix}\text{Crop N}\\\text{Requirement}\end{matrix} - \begin{matrix}\text{N from}\\\text{Previous}\\\text{Crop}\end{matrix} - \begin{matrix}\text{N from}\\\text{Previous}\\\text{Manure}\end{matrix} - \begin{matrix}\text{N from}\\\text{Current}\\\text{Manure}\end{matrix}$$

1. From Table A7, p 14 obtain the crop N requirement.
2. Subtract any N supplied by the previous crop (Table A5, p 13).
3. Subtract N supplied by cow manure applied for crops grown in previous years (Tables A1 and A2, pp 11 and 12).
4. Subtract N supplied by manure applied for this crop. (Usually, this is any manure applied within eight months of planting.) (Table A6, p 13)

Several worksheets to facilitate calculating N fertilizer rates by the balance approach are provided with this guide. Additional worksheets can be obtained from Extension System offices. An example of a filled-out worksheet appears in Table 1 on page 7.

Examples of N fertilizer recommendations for different crops and manure management practices are shown in Table A8, p 15.

Manure Application Rates

To obtain good estimates of amounts of N supplied from manures and other organic wastes, growers need accurate estimates of application rates. The following suggestions may help:

1. If the manure spreader's capacity is given in bushels or cubic feet, refer to Appendix Tables A9-A12, pp 16-17 to convert to tons. Count the number of spreader loads applied to known acreages and calculate the application rate in tons per acre. For liquid manures, determine how many gallons are applied to known acreages and calculate rates in gallons per acre. For additional information on estimating the volume of various manure spreaders, including volumes when the spreader is piled high, contact your Regional Dairy Extension Educator or the Extension Agronomist of the Cooperative Extension System.

2. Estimate annual manure production in tons for the dairy farm by multiplying the number of milking cows by 18 and the number of young stock by 8. For example, on a farm with 100 milking cows and 75 young stock, annual manure production would be about 2400 tons. Divide the total annual tonnage of manure by the acreage on which the manure is spread. This provides a good estimate of application rate as long as the manure is applied at about the same rate on all fields. In the example above, if the 2400 tons were spread on 110 acres, the application rate would be about 22 tons per acre.

Good record keeping enables growers to predict manure application rates more accurately. Assume, for example, that fields "barn lot," "home" and "big M," with a total of 25 acres, receive two applications of manure. Another 75 acres receive only one application. This means, assuming that the spreader is applying the manure at the same rate with each pass, that one application was made to 125 acres (75 + (2x25) = 125). If 2400 tons were spread, the application rate for a single application would be 2400 divided by 125 or 19.2 tons per acre. Thus, the 75 acres would receive 19.2 tons per acre, while "barn lot," "home" and "big M" would receive 38.4 tons per acre.

On many dairy farms, a disproportionately large percentage of the manure is spread on fields close to the barn. As a result, these fields usually have high N supplying capacities as well as high levels of available phosphorus and potassium. Most of these fields need little or no additional phosphorus and potassium and relatively little N from manure and/or fertilizer for good crop yields. The phosphorus and potassium in the manure are, in effect, wasted on these highly fertile fields. Also, the N supplied from continued high rates of manure applied to these fields increases the potential for contamination of groundwater with nitrate. The manure might better be transported to more distant, less fertile fields. These longer trips may not appear at first glance to be cost-effective on the basis of time spent and fuel costs. However, the savings in all fertilizer costs and avoidance of potential costs associated with liabilities related to contamination of drinking water with nitrate may make trips to more distant fields worthwhile.

For additional information on manure application rates, see *Important Information on Soil and Fertilizer Nitrogen* on p 18 in the Appendix.

Nitrogen Management: Nitrogen Fertilizer Rates For Corn Based On A Presidedress Soil Nitrate Test

The presidedress or "June" soil nitrate test is the recommended procedure for estimating N fertilizer needs for corn. As described below, this test has definite advantages over the balance approach. Unfortunately, corn is the only crop for which test calibration data are available at this time.

The presidedress soil nitrate test, which was originally developed in Vermont (Magdoff and et al, 1984) provides a measure of N available to the corn crop over the course of the growing season. The soil is sampled to a depth of one foot when corn is 6 to 12 inches tall. The nitrate in the soil at this time is derived from several sources: soil organic matter, previous crops, previous manure, manure applied for the current crop and previous fertilizer N. Because it measures the amount of nitrate in the soil from these sources, the test usually eliminates much of the uncertainty and variability associated with the balance approach described in the previous section. For example, the N lost from manures during handling and storage, that lost from the soil surface by volatilization and N not released from the more resistant organic N compounds in the manure is not in the soil and is therefore not measured by the nitrate test.

Research involving the test has been conducted in Connecticut, Vermont, Pennsylvania and Iowa. Good results have been obtained in each region. Growers who have used the test have reported that in the great majority of cases, it has worked well. Because the corn is 6 to 12 inches tall when the soil is tested, any N fertilizer recommended on the basis of test results must be applied as a sidedressing or topdressing.

Procedure for the Presidedress Soil Nitrate Test

Examples of soil sampling instructions and the questionnaire used for the soil nitrate test in Connecticut appear on pages 18 and 19 in the Appendix. It is especially important to place the samples in coolers with ice packs as they are being taken from the field. The samples should then be kept refrigerated or, if to be held for more than one day before pick-up, frozen. This handling is required to minimize biological activity that could increase nitrate levels in the samples.

This test differs from conventional soil testing in that sampling to a 12-inch depth is recommended. Every effort should be made to sample to this depth even though it is often a difficult task on stony soils. It is also important to avoid sampling close to the row in fields where starter fertilizer was applied.

In 1988 and 1989, a courier from The University of Connecticut's Soil Testing Lab collected soil samples for the nitrate test from designated pick-up points around the state. The day after the pick-up, analysis results and N fertilizer recommendations were telephoned to growers. The one-day turnaround allowed growers to order and apply any recommended fertilizer in a timely fashion.

Table 1. Worksheet for Determining N Fertilizer Rates Using a Balance Approach (Example, using silage corn as the crop)

Entry No.

1 Crop for which N fertilizer recommendation desired: SILAGE CORN

Yield goal for silage or grain corn: 22 T/A or ______ bu/A

2 Crop N requirement (Table A7, p 14): 165 **lbs N/A;**

3 Previous crop: SILAGE CORN

4 N from previous crop: (Table A5, p 13): 0 **lbs N/A;**

5 Cow manure previously applied to this field:

Number of years applied: 5 (See Table A1 or A2, p 11 or 12 including "Yrs" footnote.)

Estimated annual application rate: 20 T/A ______gal/A ______bu/A ______cu ft/A;

(If bu/A or cu ft/A, enter equivalent T/A using Table A9 or A10, p 16): ______T/A;

6 N credits for previous cow manure: (Table A1 or A2, p 11 or 12): 28 **lbs N/A;**

7 Manure/organic waste applied or to be applied for this crop:

Kind and form (e.g., liquid cow): LIQUID COW

Month(s) of application: MAY

Application rate: ______T/A 5 1000 gal/A ______bu/A ______cu ft/A

(If bu/A or cu ft/A, enter equivalent T/A using Table A9, A10, A11 or A12, pp 16-17):

______T/A;

8 N credits for manure applied for this crop:

a. Rate (from 7 above): ______T/A or 5 1000 gal/A

b. Lbs N/T or lbs N/1000 gal (Table A6, p 13) 16 :

c. N credits (a x b) 5 x 16 = 80 lbs N/A;

9 Calculate N fertilizer rate:

N fertilizer = Entry No. 2 - Entry No. 4 - Entry No. 6 - Entry No. 8c;

N fertilizer = 165 - 0 - 28 - 80 = 57 lbs N/A.

Water Nitrate Test

The levels of nitrate in water on farms can and often do reflect N management practices on the farm. Water samples can be obtained from deep wells, shallow wells and from field drainage systems. If the water sample is obtained from a well used as a source of drinking water, a nitrate-N level above 10 mg NO_3-N per liter indicates that the water is contaminated. (See *Water and Nitrates,* p 11 in the Appendix.

When nitrate levels in drinking water supplies exceed 10 ppm NO_3-N (45 ppm NO_3), growers need to alter N management practices in fields that are likely sources of nitrate to these water supplies. Such fields are usually adjacent to or upslope from contaminated wells. By comparing relative amounts of nitrate in water from different fields (e.g., water from shallow wells and from drainage systems), growers may be able to pinpoint more accurately those fields likely to be major contributors of nitrate.

Management practices to reduce soil nitrate levels include reduction in manure application rates on some fields, utilization of the presidedress soil nitrate test to help identify soils with high N supplying capacities, reduction or elimination of preplant broadcast N fertilizer, and better utilization of cover crops. Subsequent monitoring of nitrate levels in the water is advised to determine what effect changes in management practices have on nitrate concentrations in the water.

How to Test for Nitrates in Water

Using a Test Kit on the Farm: Various kits, the best known of which is the quant-strip test kit, are available from chemical supply houses.

The quant-strip test kit allows users to analyze water samples for nitrate easily and rapidly. One simply places the end of one of the strips in the water sample for two seconds. The strip is then removed and, after one minute, the intensity of the pinkish purple color that develops is compared with a series of colors on a chart. The concentration, which is given in ppm NO_3, must be divided by 4.5 to convert to ppm NO_3-N.

As of October 1989, quant-strip test kits for nitrate were available in Connecticut from the following sources:

New England Scientific, New Milford, CT
(Tel: 354-9765)
Macalaster Bicknell, New Haven, CT
(Tel: 800-468-6226)

The kits cost between $25 and $30 each for 100 strips. (No endorsement of these companies by the Cooperative Extension System is intended, nor is criticism of other companies who may sell these or similar test kits implied.)

Laboratory Water Analysis: When water nitrate levels measured by the test kit are near or above 10 ppm NO_3-N (45 ppm NO_3), a more accurate analysis may be desired. (Some individuals may wish not to use the test kit and have all samples analyzed by a lab.) A listing of state approved water testing laboratories in your area can be obtained from The University of Connecticut Cooperative Extension Center nearest you. Be sure to check with the laboratory about the kind of container to use and how the water sample should be collected and handled prior to analysis.

How to Apply N Fertilizer

Apply N Fertilizers at Recommended Rates: Follow N fertilizer recommendations that are provided with soil test results. If the soil has not been tested, follow procedures given in this guide using either the balance approach (steps 1-4, p 5) or the presidedress soil nitrate test for corn (p 6).

Method of Application: Fertilizers containing N can be broadcast before planting, applied through the planter as a "starter," or added as a topdressing or sidedressing to established plants.

Preplant Broadcast: It is unwise to apply more than 40 lbs N per acre before planting. Preplant N is more susceptible to loss through leaching and denitrification than N applied as a sidedressing. When 150 to 200 lbs N per acre is added for corn before planting, 90% of this N resides in the soil for 4 to 5 weeks "waiting" to be absorbed by the crop. This N is a "sitting duck" for spring rains of the kind that occurred in Connecticut in 1984 and 1989. As a result of leaching losses, groundwater may be contaminated with nitrate, and the lost N will need to be replaced to assure subsequent good growth. Thus, preplant applications of N can be and often are economically and environmentally unsound.

Starter fertilizers: Starter fertilizers usually contain some N and a relatively high concentration of phosphorus. Examples are 10-20-10, monoammonium phosphate (MAP; 11-48-0 or 13-52-0) and diammonium phosphate (DAP; 18-46-0). To avoid salt injury, the sum of the N and the potash (K_2O) application rates in starters should not exceed 80-100 lbs per acre (e.g. 400 lbs of 10-20-10 per acre).

Monoammonium phosphate is a better starter than DAP. Some agronomists recommend that DAP not be used as a starter and that neither DAP nor urea be used in fertilizer blends used as starters (Beegle, 1989). Other agronomists suggest that no more than 30 lbs per acre of N as urea (65 lbs per acre urea) or 65 lbs of DAP per acre be used in the starter band (Cox et al, 1988.)

Starter fertilizers are most beneficial on soils that are low in available phosphorus, acidic or cold. When starters are applied at recommended rates, they furnish enough N to meet crop needs during the first 4 to 5 weeks after planting. When starter is used for corn grown for silage or grain, all of the fertilizer N recommended should be applied as a combination of starter and topdressing. In the absence of starter, no more than 40 lbs N per acre should be broadcast before planting, and this should be done only on those fields which have not received manure within the last eight months.

Sidedressing and Topdressing N: In general, as much of the recommended fertilizer N as practicable should be sidedressed or topdressed. Corn, for example, absorbs only 8% to 10% of its total N during its first 25 days of growth. During the next 25 days, corn absorbs about 35% of its total N. Topdressing or sidedressing when the crop is 8 to 12 inches tall assures that the corn (and other crops at similar stages of growth) will be supplied N when demand for it is greatest. As mentioned previously, leaching losses are much less likely if most of the N fertilizer is topdressed or sidedressed.

"Straight" N materials commonly used for sidedressing include urea (45-0-0), ammonium nitrate (34-0-0) and UAN (urea ammonium nitrate solution, 32-0-0). Ammonium nitrate is the best of the materials in terms of volatilization losses. It is, however, the most expensive per pound of N and is often not readily available.

Volatilization losses are potentially greatest from urea. These losses are minimal if at least one-half inch of rain falls within a day or two of application.

"Dribbling" or surface banding of UAN is an alternative to the solid forms of urea or ammonium nitrate. The price of UAN is generally slightly more than that of urea per pound of N. Volatilization losses from UAN are usually intermediate between those for urea and ammonium nitrate.

Pastures and hay land usually receive topdressings of N from complete fertilizers such as 10-10-10, 15-15-15, 15-10-10 or 15-8-12. Typically, N rates range from 40 to 60 lbs N per acre topdressed in early spring and again in early June. For some grasses, a third topdressing of 40-60 lbs per acre is made after the second cutting.

Nitrification Inhibitors

Nitrification inhibitors are chemicals which slow down or delay the conversion of the ammonium form of N to the nitrate form. They do this by killing or interfering with the metabolism of Nitrosomonas bacteria, which convert ammonium to nitrite in the nitrification process. The objective of nitrification inhibitors is to maintain applied N in the ammonium form (which is available to plants) before rapid N uptake by crops occurs. This delay in conversion to nitrate can reduce both leaching and denitrification losses, especially during and after periods of heavy rainfall.

As of October 1987, three chemicals were approved by the U.S. EPA for use as nitrification inhibitors on cropland in the U.S. (Nelson and Huber, 1987). These materials are nitrapyrin (N-Serve), etradiazol (Dwell or Terrazole) and dicyandiamide (DCD, Guardian or Super-N).

Research on the effects of nitrification inhibitors has shown the following for corn (Nelson and Huber, 1987):

1. The probability of yield response is greatest on excessively drained and poorly drained soils;
2. There is no yield response in cases where N rates used are excessive;
3. The inhibitors may not work on sandy soils with very low cation exchange capacities (very few Connecticut soils fall into this category);
4. There is only a "fair" probability for yield response with spring, preplant N applied to silt loams and coarser textured soils (the great majority of Connecticut soils fall into these textural classes);
5. The probability of yield response to inhibitors with sidedress-applied N is low.

Based upon these findings, it is unlikely that Connecticut growers would save money, increase yields or minimize N losses by using nitrification inhibitors. Exceptions could be years when most of the N for corn is applied preplant and heavy spring rains follow. If, as is recommended in this guide, no more than 40 lbs N per acre is applied preplant for corn, environmental benefits from nitrification inhibitors will be negligible, and farmers may, in fact, lose money by using them.

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Appendix

Water and Nitrates

Maximum Contaminant Level (MCL) Permissible

As nitrate-nitrogen (NO_3-N)	10 mg/L
As nitrate (NO_3)	45 mg/L

mg/L = milligrams per liter
1 mg/L = 1 ppm (part per million)

Note: It is very important to know exactly what units are being used when interpreting the results of your water analysis. Results are usually reported as NO_3-N, but sometimes they are given as NO_3. If results are reported as NO_3, divide by 4.5 to obtain the concentration as nitrogen in the nitrate form. That is,

$$\frac{\text{ppm } NO_3}{4.5} = \text{ppm } NO_3\text{–N}$$

Human Health Concerns

An excessive concentration (greater than 10 ppm NO_3-N) of nitrate in drinking water is of particular concern for infants under six months of age. A condition called metheglobinemia, or "blue baby disease," can occur if an infant ingests water containing an excessive amount of nitrate. If the water condition goes undetected and is not corrected, the infant may die.

With adults, drinking water that has a concentration of NO_3-N greater than 10 ppm is not a concern unless the adult is experiencing problems with enzyme deficiency or has a deficiency in erythrocyte metabolism, suffers from anemia, has gastric diseases that reduce hydrochloric acid, is of the hemoglobic type or has had a previous diagnosis of metheglobinemia, or has a pulmonary disease where oxygen therapy is required.

Also, it is recommended that pregnant women and nursing mothers not drink water having a NO_3-N concentration greater than 10 ppm.

Animal Consumption of Nitrate in Water

In concentrations of 100 ppm NO_3-N or greater, nitrate in livestock drinking water may contribute to animal health or production problems. Fortunately, nitrate levels in Connecticut water fed to livestock are seldom, if ever, this high.

Water Analysis Information

A listing of state-approved water testing labs in your area can be obtained from the Cooperative Extension System office nearest you.

NOTE: Before collecting a water sample, check with the lab to learn what type of container to use and how the sample should be collected.

Table A1.
Estimated N Credits from Previous Applications of Solid Cow Manure

	T/A manure previously applied annually								
	10	15	20	25	30	35	40	45	50
Yrs[1]	*Credits in lbs N/A*[2]								
1	8	11	15	19	23	26	30	34	38
2	10	15	20	25	30	35	40	45	50
4	13	19	26	32	38	45	51	58	64
6	15	22	30	38	45	52	60	68	75
8	17	26	34	43	51	60	68	77	85
10	19	29	38	48	57	67	76	86	95
15	23	35	47	58	70	82	94	105	117
20	27	41	54	68	81	95	109	122	136

[1]Yrs = number of consecutive years manure previously applied, starting with the year before the current cropping year. For example, if manure was applied from 1982 through 1989, inclusive, Yrs = 8 for the 1990 cropping year.

If manure has been added in the last two years but was not added in certain years before, use the total number of years the manure was added for Yrs. Example: If manure was applied 1976-1980, 1983-85 and 1988-1989, inclusive, Yrs for 1990 = 10.

[2]Assumes that the total N in cow manure is 10 lbs N/T and that N becomes available over time as follows:

50% of the total N is available in the year of application (year 1);
15% of the N remaining after year 1 is available in year 2;
6% of the N remaining after years 1 and 2 is available in year 3;
4% of the N remaining after years 1, 2 and 3 is available in year 4;
After year 4, 3% of each year's remaining N is available the next year.

Table A2.
Estimated N Credits from Previous Applications of Liqnid Cow Manure[1]

	1000 gal/A manure previously applied annually									
	4	5	6	7	8	9	10	12	14	16
Yrs[2]	*Credits in lbs N/A*[3]									
1	10	12	14	17	19	22	24	29	34	38
2	13	16	19	23	26	29	32	39	45	52
4	16	21	25	29	33	37	41	49	57	66
6	19	24	29	34	38	43	48	58	67	77
8	22	27	33	38	44	49	55	66	77	88
10	24	31	37	43	49	55	61	73	86	98
15	30	38	45	53	60	68	75	90	105	120
20	35	44	52	61	70	78	87	105	122	140

[1] Assumes that the total N in liquid cow manure is 32 lbs N/1000 gal and that N availability follows the decay series 50%, 15%, 6%, 4% and 3% thereafter. Also, assumes a manure dry matter content of 10%.

[2] Yrs = number of consecutive years manure previously applied, starting with the year before the current cropping year. For example, if manure was applied from 1982-1989, inclusive, Yrs = 8 for the 1990 cropping year.

If manure has been added in the last two years but was not added in certain years before, use the total number of years the manure was added for Yrs. Example: If manure was applied 1976-1980, 1983-1985 and 1988-1989, inclusive, Yrs for 1990 = 10.

[3] To adjust for different dry matter contents, multiply credits by (% dry matter x 0.1). Example: If dry matter = 8%, multiply credits by 0.8.

Table A3.
Nitrogen fertilizer needed for silage corn yields of 20, 24 and 28 T/A when 20 T/A cow manure is applied each year.

Year	*N from manure for current crop*[1]	*N from previous manure*[2]	*Fertilizer N required* 20 T/A	24 T/A	28 T/A
	Lbs N per acre				
1	100	0	50	70	90
2	100	15	35	55	75
3	100	20	30	50	70
4	100	23	27	47	67
5	100	26	24	44	64
6	100	30	20	40	60
7	100	32	18	38	58
8	100	34	16	36	56
9	100	36	14	34	54
10	100	38	12	32	52
12	100	42	8	28	48
14	100	45	5	25	45
17	100	50	0	20	40

[1] Assumes spring application of manure, incorporation within 1-2 days of spreading and 5 lbs N per ton in forms available to the crop in the year of application.

[2] Assumes that release of plant-available forms of N in years after application takes place according to decay series described in Table A1.

Table A4.
Rates of solid cow manure needed to meet the N requirements of 20, 24 and 28 T/A silage corn crops when the manure is applied each year.

	Silage corn yield		
	20 T/A	24 T/A	28 T/A
Year	*T/A cow manure needed*[1]		
1	30	36	42
2	25	31	36
3	25	30	35
4	24	29	34
5	24	28	33
6	23	28	32
7	23	28	32
8	22	27	31
9	22	26	31
10	22	26	30
11	21	25	30
12	21	25	29
13	21	25	29
14	20	24	29
15	20	24	28
20	19	23	27

[1]Tons per acre solid cow manure required annually to furnish N needed by crop from nonsoil sources; assumes spring application of the manure, incorporation within 1-2 days after spreading and 5 lbs N per ton in forms available to the crop in the year of application. Also assumed is that release of plant-available forms of N in years after application takes place according to decay series described in Table A1, p 11.

Table A5.
Nitrogen Credits for Previous Crops

	Nitrogen credit
Previous Crop	*Lbs N per acre*
Grass sod	20
"Fair" clover (20-60% stand)	40
"Good" clover (60-100% stand)	60
"Fair" alfalfa (20-60% stand)	60
"Good" alfalfa (60-100% stand)	100
Corn for grain	40

Table A6.
Nitrogen Credits from Manure Incorporated Before Planting

	Time(s) of application		
	April/ May[1]	Fall only[2]	Other times[3]
Kind of manure	*Lbs N/ton or lbs N/1000 gal*		
Dairy (cow)			
solid	5	2	3
liquid	16	8	12
Poultry, cage layer			
fresh (20-40% D.M.)	16	5	8
sticky-crumbly (41-60% D.M.	22	7	11
crumbly-dry (61-85% D.M.)	32	10	16
Liquid poultry	26	7	13

[1]"April and/or May" credits are for manure applied and incorporated in April and/or May for spring-planted crops and for manure applied and incorporated within four weeks of planting at times other than spring.

[2]Use "fall only" values for manure applied in no-till or maintenance situations where the manure is not incorporated.

[3]"Other times" means times other than April and/or May or fall only for manure applied for spring-planted crops. "Other times" also means any combination of times from fall through May other than April and May for spring-planted crops. Examples: March; February, March and April; November, April and May.

Table A7.
Crop N Requirements Used for Calculating N Fertilizer Rates for Agronomic and Vegetable Crops Using the Balance Approach (p 5).

Crop	*Crop N Requirement*[1]
	Lbs. N/A
Silage Corn	
16 T/A yield goal	120
18 "	135
20 "	150
22 "	165
24 "	180
26 "	195
28 "	210
30 "	225
Corn for grain	
80 Bu/A yield goal	120
100 "	150
120 "	180
140 "	200
160 "	220
Legume seeding	40
Legume maintenance	0
Grass hay seeding	40
Grass hay maintenance	100[2]
Small grains or soybeans	40
Sudangrass, sudan-sorghum hybrid or millet	100
Orchardgrass, reed-canarygrass, tall fescue or ryegrass seeding	40
Orchardgrass, reed-canarygrass, tall fescue or ryegrass maintenance	150[3]
Legume-grass pasture maintenance	0
Grass pasture maintenance	100[4]
Horse pasture seeding	45
Horse pasture maintenance	90[4]
Sweet corn	
early-season	130
full-season	160
Tomatoes	150
Peppers	100
Cabbage, broccoli and cauliflower	150
Squash and pumpkins	105
Cucumbers and melons	130
Beans	80

[1]See text, p 5, for definition of crop N requirement. In the footnotes that follow, "N fertilizer" and "N fertilizer rate" refer to values for N fertilizer calculated from crop N requirement using the balance approach described on p 5.

[2]If no manure is applied, topdress one-half of the N fertilizer in early spring and the balance after the first cutting. If manure is applied, apply any N fertilizer after the first cutting.

[3]If the N fertilizer rate is 130-150 lbs N/A, topdress 50-60 lbs N/A in early spring, 40-50 lbs N/A after the first cutting and 40-50 lbs N/A after the second cutting. If the N fertilizer rate is 60-120 lbs N/A, topdress half of the N in the early spring and the balance after the first cutting. If the N fertilizer rate is less than 60 lbs N/A, topdress the N after the first cutting.

[4]If the N fertilizer rate is 60-100 lbs N/A, topdress half the N in early spring and the balance in early June. If the N fertilizer rate is less than 60 lbs N/A, topdress the N in early June.

Table A8.
Examples of N Fertilizer Recommendations Using the Balance Approach (See text, p 5).

	Crop N	*Previous Crop*		*Previous Cow Manure*			*Current Manure*[3]				*N Fertilizer Recommendation*[1]		
Crop	*Requirement*[1]	*Crop*	*Credit*[1]	*Rate*[2]	*Duration*[2]	*Credit*[1]	*Kind*	*Rate*	*Time*	*Credit*[1]	*Preplant*	*Starter*	*Topdress/ Sidedress*
20T/A silage corn	150	silage corn	0	20	15	50	cow	20	S	100	0	0	0
25 T/A silage corn	190	grass sod	20	—	—	0	none	—	—	0	40 0	0 or 20	130 150
25 T/A silage corn	190	silage corn	0	30	20	80	cow	30	F	60	0	0	50
Alfalfa seeding	40	silage corn	0	—	—	0	none	—	—	0	40	0	0
Grass hay maintenance	100	grass hay	0	—	—	0	none	—	—	0	0	0	40-60[4] 40-60[5]
Early sweet corn	130	sweet corn	40	—	—	0	none	—	—	0	40	0	50
Full-season sweet corn	160	peppers	0	20	10	40	cow	20	F	40	0	0	80
Summer squash	105	squash	0	—	—	0	none	—	—	0	75	0	30

[1] Values for crop N requirement, credits from previous crop, previous cow manure, current manure and N fertilizer recommendation are in lbs N per acre.
[2] Rate in tons per acre and duration in years.
[3] Manure applied for the current crop: rate in tons per acre; S=spring, F=fall.
[4] Apply in early spring
[5] Apply after first cutting.

Table A9.
Values for Conversion of Cubic Feet per Acre to Tons per Acre for Solid Cow Manure.[1]

cu ft/A	*T/A*	*cu ft/A*	*T/A*	*cu ft/A*	*T/A*
100	3	580	16	1050	29
120	3	600	16	1080	30
140	4	620	17	1100	30
160	4	640	18	1120	31
180	5	660	18	1140	31
200	6	680	19	1160	32
220	6	700	19	1180	32
240	7	720	20	1200	33
260	7	740	20	1220	34
280	8	760	21	1240	34
300	8	780	21	1260	35
320	9	800	22	1280	35
340	9	820	23	1300	36
360	10	840	23	1320	36
380	10	860	24	1340	37
400	11	880	24	1360	37
420	12	900	25	1380	38
440	12	920	25	1400	38
460	13	940	26	1420	39
480	13	960	26	1440	40
500	14	980	27	1460	40
520	14	1000	28	1480	41
540	15	1020	28	1500	41
560	15	1040	29		

[1](cu ft/A x .0275 = T/A)

Table A10.
Values for Conversion of Bushels per Acre to Tons per Acre for Solid Cow Manure.[1]

bu/A	*T/A*	*bu/A*	*T/A*	*bu/A*	*T/A*
100	3	480	16	860	30
120	4	500	17	880	30
140	5	520	18	900	31
160	6	540	19	920	32
180	6	560	19	940	32
200	7	580	20	960	33
220	8	600	21	980	34
240	8	620	21	1000	34
260	9	640	22	1020	35
280	10	660	23	1040	36
300	10	680	23	1060	36
320	11	700	24	1080	37
340	12	720	25	1100	38
360	12	740	25	1120	38
380	13	760	26	1140	39
400	14	780	27	1160	40
420	14	800	28	1180	41
440	15	820	28	1200	41
460	16	840	29		

[1]bu/A x .034375 = T/A

Table A11.
Values for Conversion of Cubic Feet per Acre to Tons per Acre for Cage Layer Poultry Manure.[1]

	T/A		
cu ft/A	*fresh*	*sticky-crumbly*	*crumbly-dry*
60	2	1	1
80	2	2	1
100	3	2	2
120	3	3	2
140	4	3	2
160	4	4	3
180	5	4	3
200	5	4	3
220	6	5	4
240	7	5	4
260	7	6	4
280	8	6	5
300	8	7	5
320	9	7	6
340	9	8	6
360	10	8	6
380	10	8	7
400	11	9	7
420	11	9	7
440	12	10	8
460	13	10	8
480	13	11	8
500	14	11	9

[1] cu ft/A x .0272 = T/A fresh;
cu ft/A x .0223 = T/A sticky-crumbly;
cu ft/A x .0173 = T/A crumbly-dry.

Table A 12.
Values for Conversion of Bushels per Acre to Tons per Acre for Cage Layer Poultry Manure.[1]

	T/A		
bu/A	*fresh*	*sticky-crumbly*	*crumbly-dry*
40	1	1	1
60	2	2	1
80	3	2	2
100	3	3	2
120	4	3	3
140	5	4	3
160	5	4	3
180	6	5	4
200	7	6	4
220	7	6	5
240	8	7	5
260	9	7	6
280	10	8	6
300	10	8	6
320	11	9	7
340	12	9	7
360	12	10	8
380	13	11	8
400	14	11	9

[1] bu/A x .034 = T/A fresh;
bu/A x .02785 = T/A sticky-crumbly;
bu/A x .02165 = T/A crumbly-dry.

Table A13.
Important Information On Soil And Fertilizer Nitrogen

The Connecticut Department of Environmental Protection (DEP) maintains that everyone has a right to clean, potable drinking water. When nitrate levels in drinking water exceed 10 ppm NO_3-N, the water does not meet drinking water standards. Farmers located close to contaminated wells may be held responsible by the DEP for elevated NO_3-N levels in these wells. The consequences for such farmers may be serious:

1. They may be issued pollution abatement orders which prohibit any N inputs (from fertilizer or manure) to certain fields;
2. They may be required to supply bottled water to residences with high NO_3-N drinking water;
3. They may be held liable in civil suits brought by affected well owners.

What Can You Do To Minimize Nitrate Additions to Groundwater From Your Fields?

1. Provide (and make sure your fertilizer salesman provides) accurate information about crops, soils and management practices.
   A) Furnish realistic yield goals for corn. If a field can produce only 20 T of silage and N is applied to the field for a 25 T/A crop, much of the extra N will enter groundwater as NO_3.
   B) Provide accurate information on manure rates, both past and present:
      a. Each cow produces 18T annually; young stock put out about 8T annually. Calculate total farm production of manure and determine the number of acres receiving it. A good estimate of tons/A can then be figured.
      b. The weight of manure (in lbs) landing on a 56" x 56" (or 48" x 65") piece of plastic is the spreading rate in tons/A. The average weight of 3-4 catches will provide a good estimate. Use a milk scale.
   C) Provide information on soils in your fields by indicating MAP symbols (e.g. PdB, AfA, NaB) on soil sample questionnaire sheets. The potential of the soil to leach nitrates and grow crops is indicated by this information.
2. Do not overapply manure. The following annual rates of application should not be exceeded on any one field when the manure is incorporated within two days of application:

Kind of Manure	*Amount not to exceed per acre*
Cow	30 T or 900 bu or 1100 cu.ft.
Liquid cow	10,000 gal
Poultry (fresh; wet-sticky, 20-40% D.M.)	8 T or 230 bu or 290 cu.ft.
Poultry (sticky-crumbly, 41-60% D.M.)	6 T or 220 bu or 270 cu.ft.
Poultry (crumbly-dry; 61-80% D.M.)	4 T or 190 bu or 240 cu.ft.

Fields close to the barn which have received large annual applications of manure for many years are the most likely to furnish NO_3 to groundwater. Distributing manure to fields further away from the home farm will decrease the chances for NO_3 pollution.

3. If There are wells downslope from your farming operations, it is especially important to minimize NO_3 additions to groundwater by following the suggestions on this sheet.

Table A14.
Sampling and Sample Handling Instructions for Presidedress Soil Nitrate Test

1. Do not sample if N fertilizer was broadcast before planting. (It is all right to sample if manure and/or starter fertilizer was applied before planting.)
2. Sample when corn is 6 to 12 inches tall:
   a. Sample to 12-inch depth;
   b. Obtain 15-20 cores per sample area;
   c. Avoid row fertilizer bands (e.g. starter) by sampling midway between rows. Avoid sampling areas where manure was piled or where manure application was unusually heavy or light.
   d. Mix cores thoroughly in clean pail. Take 1/2 cup as the sample;
   e. Place sample in plastic-lined white bag, close and immediately place in styrofoam cooler containing ice packs. (Make sure name and sample ID are written on white bag.)
3. Fill out questionnaire for each sample and submit with sample(s).
4. If samples are to be held for more than one day before delivery to pick-up point, place in freezer.
5. Transport samples in styrofoam cooler with ice packs to nearest sample pick-up point. Put samples in refrigerator.

For additional information, contact Gary Griffin, Extension Agronomist, at 486-6384 or 486-4274, or one of the regional dairy extension educators: **Western Region:** Richard Meinert - 567-9447; **Central Region:** Keith Goff - 875-3331; **Eastern Region:** Joyce Meader - 774-9600

Table A15.
University of Connecticut Soil Nitrate Test for Corn–1989 Questionnaire

Name____

MailingAddress____

City____________________State________Zip__________Phone________________

Please read and follow the accompanying instructions carefully. Improper sampling or handling of samples may result in too little or too much N fertilizer being recommended.

SampleI.D.____

Size of Field: __________acres.

1. Manure applied to this field since last September:

_____none _____cow _____liquid cow _____poultry _____liquid poultry

_____liquid cow and poultry _____other______________________________

Rate of application: _____heavy _____medium _____light

When applied:______________________________________

2. Yield expected on this field with best management: ______________T/A
3. Was a starter fertilizer used? _____yes _____no
4. How much N, if any, was broadcast before planting?__________________
5. Was this a no-till seeding? _____yes _____no
6. Soil series or soil mapping unit (if known):______________________________

FOR LAB USE

Lab No. __________________ Test Result:________________________________mg NO_3-N/kg soil