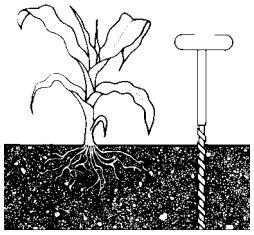

Nitrogen Fertilizer Recommendations for Corn in Iowa

This pamphlet replaces all earlier guidelines for using the late-spring test for soil nitrate and all previous nitrogen fertilizer recommendations based on corn yield goals and credits for N supplied by legumes and animal manures. Recommendations concerning applications of animal manures are provided in Pm-1596a, *Managing manure nutrients for crop production*.

Nitrogen fertilization is essential for profitable corn production. It also is a major cost of production and can contribute to degradation of the environment. The economic and environmental costs of N fertilization are more important than in the past, and they are likely to become even more important in the future. These costs provide compelling reasons for intensifying efforts to improve N management practices.

The late-spring test for soil nitrate is a new technology that enables site-specific assessments of plant-available N just before the crop begins rapid uptake of N. Use of this test should help corn producers manage N to increase their profits while reducing environmental degradation. All producers are encouraged to use this test, but the way the test is used depends on whether or not the producer exercises the option for in-season fertilization (i.e., N applications after corn plants are 6 inches tall).

Producers who apply all their N before emergence of the crop (i.e., before planting, at planting, soon after planting) should apply N at rates indicated in Table 1 and use the late-spring test to evaluate their N management. Select rates within the ranges given by considering price for fertilizer, expected price for grain, supply of subsoil moisture, and feedback given by the end-of-season cornstalk test in previous years. If price and yield outlook are favorable, select the upper part of the range; if unfavorable, select the lower part of the range.

Table 1. Rates of N usually needed if all N is applied preplant or before crop emergence (option for in-season application of N not exercised).

Crop category	N rate (lb. N/acre)
Corn on recently manured soils	0-90
Corn after established alfalfa	0-30
2nd-year corn after alfalfa	0-60
Other corn after corn	150-200
Corn after soybean (no manure)	100-150

Additional information is provided on page 4.

Producers who use the option for in-season fertilization (i.e., split applications or all applied after corn plants are 6 inches tall) should apply N at rates indicated in Table 2 and then use the late-spring test to estimate additional amounts of N needed. Rates within the range given should be selected based on the extent to which the producer wants to rely on in-season fertilization, amounts of rainfall during the previous six months, and feedback given by the end-of-season cornstalk test in previous years.

Application of some N before crop emergence is desirable to avoid the possibility of early-season deficiencies and to reduce risks associated with weather conditions that prevent in-season fertilization. Application of all N before planting, however, reduces the ability to adjust N rates for the effects of spring weather on amounts of N supplied by the soil or the amounts lost during spring rainfall. Use of the late-spring test over a period of years provides information that can be used to optimize pre-emergence applications of N.

Table 2. Rates of N to apply before crop emergence if the option for in-season fertilization is exercised.

Category	N rate (lb. N/acre)
Corn on recently manured soils	0-30
Corn after established alfalfa	0-30
2nd-year corn after alfalfa	0-30
Other corn after corn	50-125
Corn after soybean (no manure)	0-75

The 30-lb. rates could be applied as a starter.

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Soil Sampling and Testing

Time of Soil Sampling

Soil samples should be collected when corn plants are 6 to 12 inches tall (measured from the ground surface to the center of the whorl).

Selecting Test Areas

Soil samples should be collected within several test areas that are 1 to 10 acres and seemingly uniform with respect to soil characteristics and management histories. Care should be taken to avoid unusual spots (e.g., sites of old barnyards, feedlots, or manure piles, field edges or ends where fertilizer applicators may have made skips or double applications, abnormal patches of growing weeds or plant residues, or small areas where corn plants suggest differences in N availability).

The optimal number of test areas per farm should be expected to vary with many factors. First-year users of the test should consider testing about five areas for the first 100 acres and two more areas for each additional 100 acres. Information gathered in the first year can be used to help select future sampling strategies that are appropriate for a particular farm.

Depth of Soil Sampling

Samples collected for the late-spring soil test must be representative of the surface foot of soil.

Number of Cores per Sample

Soil samples analyzed for this test should be derived from at least 16 to 24 cores. Care should be taken to ensure that the soil samples are collected in a manner that is not biased by the presence of corn rows or bands of fertilizer. At least 24 cores should be collected if anhydrous ammonia was applied for the present crop.

Sampling bias can be minimized by collecting soil samples in "sets of eight" cores that have various assigned positions relative to corn rows. By this method, the person doing the sampling moves in a random pattern within the test area to select approximate positions for collecting cores. Each time a core is collected, however, its exact position is selected relative to the two nearest corn rows. The first core is collected in a row. The second is collected one-eighth of the distance between any two rows after moving to another part of the test area. The third is collected one-quarter of the distance between any two corn rows after moving to another part of the test area. The process is continued until the eighth core is collected seven-eighths of the distance between any two corn rows.

The soil from all cores should be crushed and thoroughly mixed before a subsample is removed for analysis.

Handling and Shipping Soil Samples

Moist soil samples should be protected from temperatures above 75°F and should be refrigerated if they cannot be analyzed within two days. Mailing usually poses no problem if the samples are without refrigeration for no more than two days. Assume that soil testing laboratories will protect the samples as soon as they are received.

Soil samples expected to be without refrigeration for more than two days should be dried as soon as possible. Samples can be air-dried by spreading in a thin layer on paper — a fan will accelerate drying. Samples can be dried in an oven provided the temperature does not exceed 250° F.

Soils that are extremely wet or muddy should not be sampled. Incorrect results will be obtained if water "drips" from the samples.

Soil Analysis

The late-spring test is based on concentrations of nitrate-nitrogen (NO^-_3-N) in the soil sample. Most soil testing laboratories can perform this analysis. Nitrate concentrations also can be measured on the farm by using commercially available kits.

This pamphlet expresses nitrate concentrations in terms of ppm nitrate-N (parts of N per million parts of dry soil), which is the same as ppm N as nitrate. Concentrations expressed as ppm nitrate must be multiplied by 0.23 to be converted to ppm nitrate-N.

Users of the soil test should be alert to the possibility of incorrect results on individual samples. Errors can occur during collection, handling, and analysis of samples. The impact of such errors can be substantially reduced by observing trends in soil test results and using caution when making recommendations on results that deviate from these trends.

Soil Test-based N Recommendations

Manured Soils, First-year Corn After Alfalfa, and Second-year Corn After Alfalfa

Soils that have received recent applications of animal manures or have decaying sods with alfalfa roots seem to mineralize more plant-available N after the time of soil sampling than do other soils. These soils, therefore, are treated as a separate category when making N fertilizer recommendations. These recommendations are given in Table 3.

The first step for making recommendations from Table 3 is to decide whether the top half of the table or the lower half of the table best describes the current prices for grain and fertilizer.

Table 3. Nitrogen fertilizer recommendations for manured soils[a] and corn after alfalfa.

Grain and fertilizer prices	Soil test nitrate	Recommended N rate	
		Excess[b] Rainfall	Normal Rainfall
	ppm N	-------- lb. N/acre---------	
Unfavorable	0-10	90	90
(1 bu buys	11-15	0	60
7 lb. of N)	16-20	0	0[c]
	> 20	0	0
Favorable	0-10	90	90
(1 bu buys	11-15	60	60
15 lb. of N)	16-25	0	30
	> 25	0	0

[a] A field should be considered manured if animal manures were applied with a reasonable degree of uniformity since harvest of the previous crop or in 2 of the past 4 years.
[b] Rainfall should be considered excess if rainfall in May exceeded 5 inches.
[c] Addition of 30 lb. N/acre may have no detectable effects on profits, but producers could reasonably elect to apply this rate.

The second step is to decide whether the "excess rainfall" column or the "normal rainfall" column of the table best describes weather conditions before the soils were sampled.

The third step is to use the results of the soil test to select the appropriate N rate specified. Interpolation between specified N rates is appropriate when site conditions fall between those given.

Corn After Soybean and Corn After Corn

The first step in making a fertilizer recommendation for this crop category is to select a critical concentration for nitrate (i.e., the concentration that distinguishes between adequate and inadequate supplies of available N). A critical concentration of 25 ppm-N is appropriate in absence of additional information.

The second step is to adjust the critical concentration if excess rainfall occurred at the site shortly before the soils were sampled. Reducing the critical concentration by 3 to 5 ppm is advised if rainfall is more than 20 percent above normal amounts between April 1 and time of soil sampling.

The third step is to estimate fertilizer needs by subtracting the concentration of soil-test nitrate (ppm-N) from the chosen critical concentration (ppm-N). This value is then multiplied by 8. A factor of 8 is used because studies have shown that it usually takes about 8 lb. of N/acre before planting to increase soil-test nitrate-N by 1 ppm.

Examples: A soil test of 15 ppm and a critical concentration of 25 ppm results in a recommendation of 80 lb. of N per acre to be applied.

(25 ppm - 15 ppm) x 8 = 80 lb. N/acre needed

A soil test of 35 ppm and a critical concentration of 25 ppm indicates that the soil already has approximately 80 lb. of N more than needed.

(25 ppm - 35 ppm) x 8 = -80 lb. N/acre needed.

Additional Information

Yield Goals and Nitrogen Credits

Yield goals (or potentials) are no longer used when making N fertilizer recommendations because research has shown no relationship between optimal rates of N fertilization and yields at these optimal rates.

The use of legume and(or) manure credits has been eliminated. The effects of those sources of N are addressed by giving recommendations for separate categories.

Addressing Variability

The best rate of N fertilization for corn varies greatly with year and location. This variability is caused by complex interactions of soil factors, management practices, and weather. Time and method of N application are important because they influence amounts of N lost before it can be used by the corn.

Great variability in optimal rates of N fertilization is a problem because the best rates across a wide range of conditions usually are not best for most individual sites in a given year. This problem was unavoidable in the past, but advances in technology offer new opportunities for site-specific management of N.

Users of the soil test should expect much greater variability in amounts of N supplied by animal manures and legumes than would be expected from commonly used methods to calculate N credits. Research has shown that this variability should be considered a reason for using the soil test rather than evidence that the test is not reliable.

Reliability of the Soil Test

The soil test should be considered only a tool for estimating availability of N in soils. Like any tool, the usefulness of this test varies with the skill of the user. First-time users are encouraged to experiment with the test in small areas before using it to guide fertilization on all their fields.

Recommendations for using the soil test are intended to maximize profits for the producer when used across many sites and years. Because many factors that influence fertilizer needs at a specific site and year happen after the soils are tested, the soil test should not be expected to be a perfect predictor of fertilizer needs. Use of the soil test is recommended because it is more reliable than other methods of estimating N fertilizer needs. Moreover, it is likely that the reliability of the soil test can be improved as new knowledge is acquired.

Where Caution is Required

The soil test may underestimate amounts of plant-available N when (1) nitrification inhibitors or urease inhibitors are applied with fertilizers, (2) more than 150 lb. N/acre are applied as anhydrous ammonia, and (3) more than 150 lb. N/acre are applied as injected manure.

Use of the soil test on sandy soils may require deeper sampling if fertilizers are applied before crop emergence and unusually large amounts of rainfall occur between fertilization and sampling. There are relatively few sandy soils in Iowa.

End-of-season Cornstalk Testing

Users of the late-spring test are encouraged to use the end-of-season cornstalk test, which is described in ISU Extension factsheet, *Cornstalk Testing to Evaluate Nitrogen Management,* Pm-1584. The end-of-season test essentially asks if the corn crop had too little, too much, or optimal amounts of N. The resulting information can be used to evaluate the reliability of the soil test or any other system of making N recommendations. When used over a period of several years, information provided by the cornstalk test can be used to help select rates of N application that are most appropriate for the soil factors and management practices that make sites differ in N fertilizer requirements.

Prepared by A.M. Blackmer and R.D. Voss, professors; and A. P. Mallarino, assistant professor, ISU Department of Agronomy.

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