4 - Fertilization and Liming

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Soil testing is the foundation of a sound fertility program, with the goal of a soil testing program being to provide guidelines for the efficient use of lime and fertilizers. University of Arkansas fertilizer and lime recommendations are based on field research conducted under varying soil conditions, crop rotations, crop nutrient requirements and yield goals.

Soil pH

Soil pH affects the availability of nutrients to plant roots. The desirable soil pH for corn ranges from 5.8 to 7.0. Continued cultivation and the use of chemical fertilizers, especially those containing ammonium and sulfur, tends to decrease soil pH over time. Irrigation with water high in calcium carbonate, on the other hand, tends to increase soil pH.

Soil samples should be collected and checked for the degree of acidity or alkalinity in a soil. Lime is generally recommended at pH values below 5.7 (Table 4-1). If rice is in the rotation, lime is not recommended without the benefit of additional information such as irrigation water quality tests. Even then, lime is not recommended unless the soil pH is below 5.7 (Table 4-2). If lime is needed, it is better to apply it during the fall to provide enough time for it to react with the soil.

Liming materials also have different Relative Neutralizing Values (RNV). The RNV of a material is based on its fineness and Calcium Carbonate Equivalent (CCE or the amount of pure calcium carbonate to which the selected material corresponds), with finer materials reacting more quickly than coarse materials. An Ag lime material with a CCE of 110 is "stronger" than an Ag lime material with a CCE of 90, consequently less volume would be needed to increase the pH of a given soil.

Table 4-1. Lime Recommendations for Corn When Rice Is Not in the Rotation

Soil pH	Soil Test Calcium (lb/A by Mehlich 3 Extraction)			
	Below 1000	1000-3000	3000-4500	Above 4500
	Tons/A			
Above 5.7	0	0	0	0
5.2 - 5.7	1	1.5	2	2.5
5.0 - 5.2	1.5	2	2.5	3
Below 5.0	2	2.5	3	3

Table 4-2. Lime Recommendations for Corn When Rice Is in the Rotation

Soil pH	Lime (tons/acre)
Above 5.7	0
5.2 - 5.7	1
5.0 - 5.2	1.5
Below 5.0	2

Nitrogen

Nitrogen is an important component of amino acids and proteins, which are the basic building blocks of all living matter – both plant and animal. Nitrogen-deficient plants normally show a pale-yellowish color (Chlorosis), which results from a shortage of Chlorophyll in the plant's "solar collection cells." A rough rule of thumb is that, based on the yield level, 1 to 1 1/2 pounds of actual nitrogen (N) are required for each bushel of corn produced. More N is normally required per bushel on the silty clays and clays (Table 4-3) than on the sandy loams and silt loam soils (Table 4-4).

Table 4-3. Fertilizer Recommendations for Corn Grown in Sandy Loams or Silt Loams According to Yield, P and K Levels

Soil Test P (lbs/A)	Soil Test K (lbs/A)		
	Above 275	150-275	Below 150
	Recommended N-P_2O_5-K_2O, lbs/A		
Up to 125 bushels			
Above 100	120-0-0	120-0-60	120-0-90
60-100	120-50-0	120-50-50	120-60-90
Below 60	120-60-0	120-60-60	120-60-90
150 bushels			
Above 100	150-0-0	150-0-60	150-0-100
60-100	150-50-0	150-60-60	150-50-100
Below 60	150-70-0	150-70-70	150-70-100
175 bushels			
Above 100	180-0-0	180-0-70	180-0-120
60-100	180-60-0	180-70-70	180-60-120
Below 60	180-80-0	180-80-80	180-80-120
200 bushels			
Above 100	210-0-0	210-0-80	210-0-150
60-100	210-60-0	210-60-80	210-60-150
Below 60	210-90-0	210-90-90	210-90-150
225 bushels			
Above 100	240-0-60	240-0-100	240-0-200
60-100	240-60-60	240-50-100	240-50-200
Below 60	240-100-60	240-100-100	240-100-200

Table 4-4. Fertilizer Recommendations for Corn Grown in Silty Clays, Silty Clay Loams and Clays According to Yield, P and K Levels

Soil Test P (lbs/A)	Soil Test K (lbs/A)		
	Above 275	150-275	Below 150
	Recommended N-P_2O_5-K_2O, lbs/A		
Up to 100 bushels			
Above 100	125-0-0	125-0-60	125-0-90
60-100	125-50-0	125-50-50	125-50-90
Below 60	125-60-0	125-60-60	125-60-90
120 bushels			
Above 100	175-0-0	175-0-60	175-0-100
60-100	175-50-0	175-60-60	175-50-100
Below 60	175-70-0	175-70-70	175-70-100
140 bushels			
Above 100	225-0-0	225-0-60	225-0-120
60-100	225-50-0	225-60-60	225-60-120
Below 60	225-80-0	225-80-80	225-80-120
160 bushels			
Above 100	300-0-0	300-0-80	300-0-150
60-100	300-60-0	300-60-80	300-60-150
Below 60	300-80-0	300-80-80	300-80-150

In Arkansas, this is due to the tendency of clay soils to fix ammonium ions between the clay particles in an unavailable form. If high carryover N is suspected, a soil nitrate-nitrogen test may be used to refine recommended N rates. For a reliable indication of N carryover, the grower should submit at least one subsoil sample along with a topsoil sample about a month ahead of planting. The topsoil and subsoil samples should each represent at least 12 inches of soil depth. Total soil profile N in excess of 40 pounds per acre should be subtracted from the preplant rate in order to achieve a particular yield goal.

Figure 4-1, shows a typical nutrient uptake pattern for a corn plant. No more than half of the total amount of the recommended N should be applied preplant, since the root system is not yet fully developed and salt damage to the young seedlings is a possibility. Also, in the event of poor stands, there remains the option of saving the fertilizer that would have been sidedressed. The remainder of the N should be sidedressed or topdressed after a stand is obtained but before the corn gets “knee high” (six leaves). At this point the corn plant will experience a period of rapid growth, the growing point is above the soil surface and the plant is “deciding” what type of yield load it can support. Thus, it is critical that the plant has an ample supply of nutrients, and water, at this time. Preliminary results of on-going research in Arkansas have shown the potential for significant yield increases when a portion of the fertilizer is applied just before the tassel emerges.

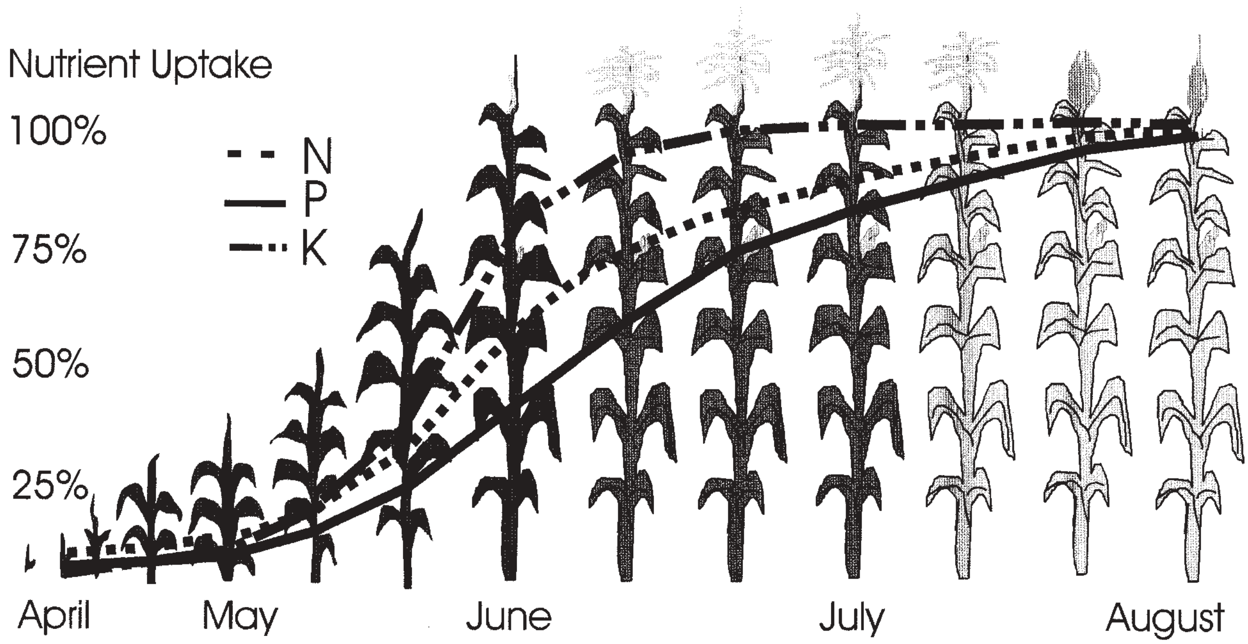
Common N-fertilizer sources include ammonium, nitrate and urea (Table 4-5). These are sold in dry or in liquid formulations (with urea ammonium nitrate

Table 4-5. Nitrogen Sources for Corn

Situation	Preferred Sources[1]
Preplant	Urea, DAP, AS
Sidedress	Urea[2], DAP, AS, 32% UAN

[1]DAP = diammonium phosphate, AN = ammonium nitrate, AS = ammonium sulfate, UAN = urea-ammonium nitrate solution.
[2]Urea post applied to dry soil.

Figure 4-1. Typical nutrient uptake pattern of a corn plant.



having a N content of 28 to 32 percent, for example). Ammonium has a positive charge that is attracted to the negatively charged surface of clay and humus and, as a result, is not as mobile as the nitrate ion. However, under alkaline conditions N, in the ammonia form, may be lost through volatilization.

Nitrate is the form used in the largest proportion by most plants. Nitrates are repelled by the negative charges of soil since nitrates possess a negative charge as well. Nitrate thus tends to remain in solution, subject to leaching and denitrification.

Urea is in reality an organic form of fertilizer, which is commercially manufactured for fertilizer purposes. Plant roots cannot use it directly, so the nitrogen first needs to be converted to an inorganic form (ammonium or nitrate). This conversion is mediated by enzymes present in the soil. In cold, wet soils, urea behaves as a slow-release fertilizer since soil enzymes are not very active under such conditions. Under dry soil conditions, urea is stable for up to seven days after surface application. Rainfall or irrigation and incorporation with cultivation are needed to reduce potential nitrogen losses. Urea itself is highly mobile in soils, and thus urea-N also can be lost from the crop root zone.

Animal Manures

Animal manures and particularly poultry litter may be used as supplements to commercial fertilizers. Rates should be based on soil test results and the nutrient content of the manure, keeping in mind that only 50 to 60 percent of the nitrogen in manure becomes plant-available the first year, and that applying manure based solely on crop N requirements may supply P in excess of plant needs. Where higher rates of animal manures are used, plant analysis should be used to monitor N needs in order to make possible adjustments during the growing season.

Phosphate and Potash

Phosphates have been called the “key of life” because they play an important role in the storage and transfer of energy within plant cells. Phosphates react rapidly with soil constituents that reduce the availability of this nutrient to plant roots. Phosphates interact positively with nitrogen and potassium, while high soil phosphate levels may also reduce plant uptake of zinc and copper. In soils of pH 7.0 or higher, phosphorus also binds with calcium, forming insoluble compounds that are largely unavailable to plant roots. Starter fertilizers may be beneficial for high pH soils and/or with rice in the rotation, with a typical starter rate being 5 gallons per acre of 10-37-0 material.

Apply all recommended P and K at or before planting, along with at least 30 pounds of N per acre. Early planted corn, and corn under no-till, may exhibit phosphorus deficiency symptoms even on soils that have high levels of soil-test P. Where this occurs, as little as 15 pounds per acre of P_2O_5 sidedressed near the row has proved effective in overcoming these temporary P deficiency symptoms. However, a warming period will usually allow the corn to recover, and seldom are yields permanently reduced by the temporary phosphorus deficiency. Phosphorus is recommended unless soil-test P is higher than 100 pounds per acre. Recommended rates range from 50 to 100 pounds of P_2O_5 per acre, depending on the soil test level, the soil type and the yield goal (Tables 4-3 and 4-4).

Potash also plays a critical role in the nutritional balance of a plant. Potash deficiency in corn results in reduced growth, delayed maturity, lodging caused by weak straw and low bushel weight, with visual symptoms including leaf burning. Potash is recommended at soil test levels below 275 pounds per acre. Recommended rates range from 50 to 200 pounds of K_2O per acre, based on needs. Potash applications greater than 90 pounds per acre should be split to avoid salt injury.

Calcium, Magnesium and Sulfur

The secondary elements calcium, magnesium and sulfur are generally considered adequate in most soils. Calcium is generally adequate for corn as long as crop lime needs (pH) are being met, but magnesium and/or sulfur deficiencies are possible on sandy soils low in organic matter. The University of Arkansas Soil Testing Laboratory routinely determines both magnesium and sulfate-sulfur. A low level of available magnesium or sulfur in the topsoil is difficult to interpret unless a subsoil test is also obtained. Both elements tend to leach downward and accumulate with the subsoil clays.

However, medium to high soil-test levels of these elements in the topsoil should indicate adequate levels for the corn crop. A good rule of thumb is that soil-test sulfur levels below 20 pounds per acre and magnesium levels below 75 pounds per acre may be an indication of a deficiency. It is not uncommon for well waters to contain 1 to 2 pounds of magnesium and 2 to 6 pounds of sulfate-S per acre-inch.

Secondary element needs are best assessed by foliar analysis of corn leaves during the growing season. When a soil test indicates very low levels of magnesium (generally on very sandy soils of low CEC), 20 to 40 pounds per acre of additional magnesium are needed.

Dolomitic lime is the most economical source of magnesium where lime is needed. Potassium magnesium sulfate, commercially known as K-Mag or Sul-Po-Mag, typically contains 23 percent potash, 23 percent sulfur and 11 percent magnesium. It has relatively high water solubility compared to dolomitic lime. There is also a granular 36 percent magnesium product that contains both magnesium sulfate and magnesium oxide.

Micronutrients

Micronutrients are needed in small amounts by corn, but deficiencies still may occur which could limit yields. The University of Arkansas Soil Testing Laboratory routinely tests soils for iron, manganese, zinc and copper. Molybdenum should not be deficient in corn under most circumstances in Arkansas. Iron, manganese, zinc, copper and boron are adequate in most soils. However, low levels and possible deficiencies of some of these could occur on leached, sandy soils of low CEC and on medium-textured soils that have an alkaline pH or that have been over-limed.

Zinc is the micronutrient most likely to be found deficient for corn. The deficiency typically occurs at the V2 through V8 growth stages. Analysis of plant tissue during the growing season and comparison of these results over time against published standards is the best way to assess micronutrient status. The University of Arkansas Diagnostic Laboratory at Fayetteville will also analyze plant tissue for a fee. Zinc sulfate (10 pounds Zn per acre)

Table 4-6. Reference Tissue Sufficiency Ranges for Corn According to Growth Stage

Growth Stage	N	P	K	Ca	Mg	S	Mn	Zn	Cu	B
	%						ppm			
Seedling	4.0-5.0	0.4-0.6	3.0-4.0	0.3-0.8	0.2-0.6	0.18-0.5	25-160	20-60	6-20	5-25
Early Growth	3.0-4.0	0.3-0.5	2.0-3.0	0.25-0.8	0.15-0.6	0.15-0.4	20-150	20-70	5-25	5-25
Tasseling	2.8-4.0	0.25-0.5	1.8-3.0	0.25-0.8	0.15-0.6	0.15-0.6	15-150	20-70	5-25	5-25

Source: Southern Series Cooperative Bull. #394.

is the preferred inorganic source for soil applications since it dissolves fairly easily and should be at least 50 percent water soluble. Foliar Zn applications should be made with chelated Zn at a rate of 1 pound Zn per acre. A 9 percent Zn solution typically requires 1 gallon per acre of product. Foliar Zn can be mixed with post-applied herbicides, unless the herbicide label recommends otherwise.

Plant Analysis

Plant analysis is a more direct indicator of plant nutrition than are soil tests. However, care must be taken in interpreting plant analysis values because of environmental and cultural factors that may interfere. If a deficiency is suspected, collect whole plant samples if the corn is less than 12 inches high, or the uppermost mature leaf if the plant is more than 12 inches high but before the tassel stage. If the tassel has emerged, collect the ear leaf.

Table 4-6 shows reference sufficiency ranges for corn grown in the southern United States. This table may be used as a guide for all plant food elements in leaf or whole corn plants, while keeping in mind that collecting the appropriate plant part at the proper stage of growth is critical for the identification of nutritional disorders. Certain elemental ratios are also important. Ratios larger or smaller than those in Table 4-7 suggest possible plant nutrient imbalances or errors in testing or reporting.

Table 4-7. Desired Elemental Ratios in Plant Tissue

N/K = 0.8 to 1.6
N/P = 8 to 12
N/S = 10 to 20
K/Mg = 8 to 16
Fe/Mn = 2 to 6