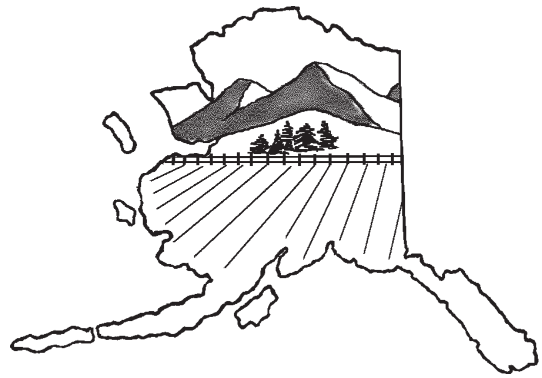
Crop Production and Soil Management Series



FGV-00242A

SOIL FERTILITY BASICS

by
J.L. Walworth *

CONTENTS

This publication provides general information on soil fertility, plant nutrition, and the behavior of nutrients in soils. Its purpose is to furnish the reader with a general understanding of these topics and to act as a supplement to the other sections of the *Field Crop Production Handbook – Alaska.*

All higher plants require at least 17 nutrient elements for proper development. Of these, three (carbon, hydrogen and oxygen) are provided by air and water, and the remaining 14 are usually provided by the soil. Six of the 14 elements normally provided by soil are required by growing plants in relatively large amounts and include nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg) and sulfur (S). The first three (N, P, and K) are called primary plant nutrients because they are most commonly limiting in agricultural situations. A complete fertilizer contains the three primary nutrients. The others, Ca, Mg, and S, are just as important for normal plant growth, but are called secondary nutrients because they are less frequently limiting to crop production than the primary nutrients.

The remaining plant nutrients, boron (B), chlorine (Cl), copper (Cu), iron (Fe), manganese (Mn), molybdenum (Mo) nickel (Ni), and zinc (Zn) are required in relatively small amounts and are called micronutrients. Plants may contain levels of some micronutrients as high as the primary and secondary nutrients, but the minimum required micronutrient level is generally much lower. Again, these nutrients are just as critical to normal plant growth as the primary and secondary nutrients.

The field of soil fertility is largely devoted to studying the behavior of these elements in soils and factors that affect their availability to plants. These may include soil texture, organic matter content, and pH.

---

*James L. Walworth, formerly a Soil Scientist with the Agricultural and Forestry Experiment Station, Palmer Research Center, University of Alaska Fairbanks, currently with the University of Arizona.

SOIL TEXTURE

Soil texture is determined by the relative amounts of various sized particles that make up a soil. Soil particles are divided into three size categories. The smallest or finest is clay, followed by silt, and the coarsest or largest particle category is sand. The proportions of sand, silt, and clay in the mineral or inorganic portion of a soil determines its texture. There are 12 soil textural classes ranging from sand, which is the coarsest class, to clay which is the finest. Loamy sand, sandy loam, silt loam, and clay loam are common soil textural classes with progressively finer particles. The texture of a soil affects its physical properties (how much water it holds, how difficult it is to till, etc.) as well as its chemical properties. In general, a fine textured soil has more particle surface area than a course textured soil per given volume of soil. The surfaces of soil particles are chemically active. Fine textured soils are more chemically active than coarse textured soils and are able to hold more nutrients and also have a greater capacity to bind or "fix" nutrients, rendering them unavailable to the plant. (See also Cooperative Extension Service (CES) Publication FGV-00242, *Soil Fundamentals* - Soil Texture).

SOIL ORGANIC MATTER

Organic material makes up less than 10% of most soils, yet is extremely important in terms of plant nutrition. Organic matter has a tremendous amount of surface area that can react with various soil constituents, and it may impart a large influence on soil chemical properties. In addition, because organic matter is composed largely of decayed plant material, it contains plant nutrients which may become available for use by growing plants as the organic matter is decomposed. Thus, the bulk of several nutrients including N, P, S, Mo, Cu, Zn and B may be contained in the organic fraction of a soil. As a result, the available levels of these nutrients are affected by the processes of organic matter decomposition. Organic matter decomposition is dependent upon adequate aeration and moisture, and increases with increasing soil temperature. This process is also accelerated when organic matter is incorporated into soil by tillage operations. (See CES Publications FGV-00242, *Soil Fundamentals* and FGV-00349, *Organic Fertilizers*).

SOIL pH

Reaction or pH describes acidity or alkalinity of an aqueous system. Water (H_2O) is comprised of charged hydrogen (H^+) and hydroxide (OH^-) molecules or ions. In water there are always some of these free ions which are not combined in the water molecules. If water is pure, the amounts of H^+ and OH are equal and the system has a pH of 7.0. This system is considered neutral. If a system has an excess of H^+ ions it is acidic, and if there is an excess of OH^- ions, it is basic or alkaline. pH is simply a measure of the amount of H^+ ions in a system, but it is presented as the negative log of the H^+ concentration. Concentration is expressed in moles per liter (one mole equals 6.02 x 10^{23} molecules). Therefore, the relationship is:

pH	4	5	6	7	8
H^+ concentration (moles/liter)	.0001	.00001	.000001	.0000001	.00000001

The H^+ concentration is greater at lower pH values, and diminishes as pH rises. The concentration of H^+ ions changes by a factor of ten for each change of one pH unit (Figure 1). The pH scale runs from 0 to 14, although the range found in natural soil systems is about 3.5 to 9.0.

Soil acidity is important because it determines solubility of soil minerals, and it affects many microbial processes such as organic matter decomposition and nitrogen fixation. Some soil minerals contain nutrients, and these nutrients may become available for plant growth only when the soil pH is in a favorable range. Additionally, some soil minerals contain elements which are toxic to plants. Primary among these elements is aluminum, which is a major constituent of all mineral soils. Aluminum may be released when soil pH is allowed to drop below pH 5.2 and many plants will not grow well when soil pH drops below this level. The general relationship between soil pH and nutrient availability is shown in Figure 2. The widths of the bands represent the relative availability of each nutrient. Note that availability of most of the nutrients is maximized in the pH range of 5.5-6.5. This is the optimum pH range for many cultivated plants, although the optimum pH level for various plants may differ widely. Optimum soil pH for several crop species is given in Table 1.

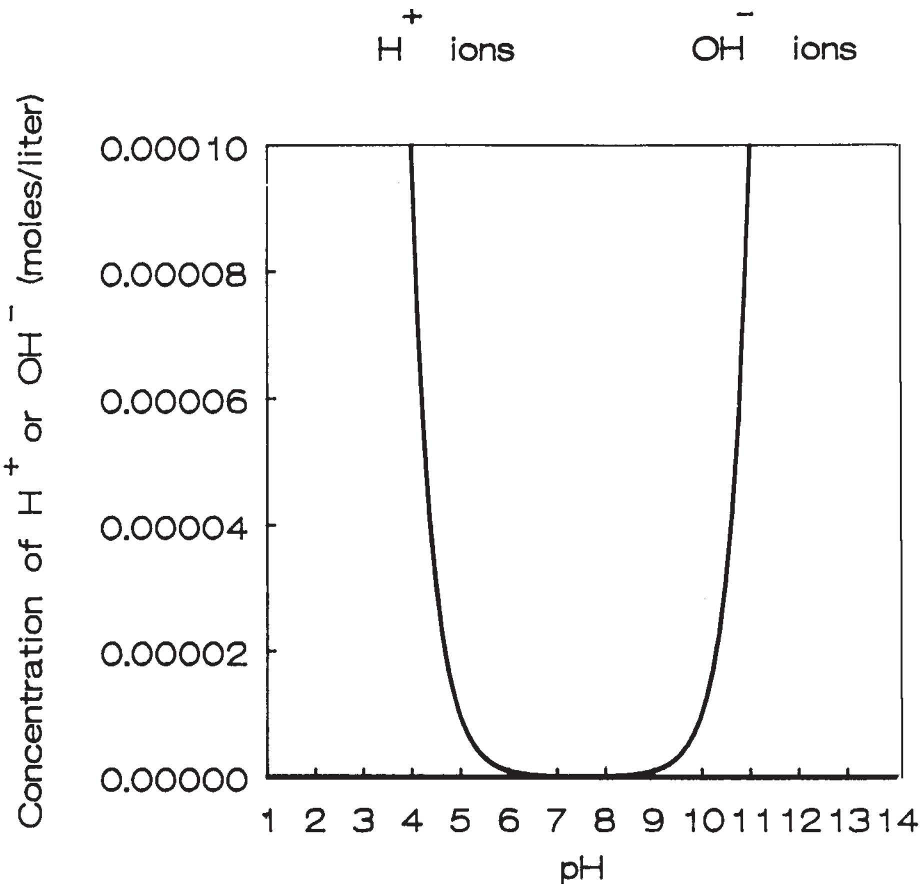


Figure 1. Concentration of H^+ or OH^- related to pH

Most soils in Southcentral Alaska, in their unlimed condition, have a pH lower than 7.0 (pHs as low as 4 are not uncommon). Some soils in the Interior are neutral to slightly alkaline. Soil pH may be adjusted by addition of liming materials (to raise pH) or acidifying materials (to lower pH). Plants generally increase soil acidity as they grow. Additionally, many N fertilizer materials add considerable acidity to soils. Therefore, most corrective action is undertaken to raise pH rather than to lower it. Liming materials are generally calcium oxides, hydroxides, or carbonates, that combine with H^+ ions to decrease acidity. All are adequate for liming agricultural soils.

Oxides	(quick or burned lime)	$2H^+ + \underline{CaO} \rightarrow Ca^{2+} + H_2O$
Hydroxides	(hydrated lime)	$2H^+ \underline{Ca(OH)_2} \rightarrow Ca_2^+ + 2H_2O$
Carbonates	(limestone)	$2H^+ + \underline{CaCO_3} \rightarrow Ca^{2+} + CO_2 + H_2O$

Most commercial lime is simply crushed limestone and may be either dolomitic or calcitic. Dolomitic lime is a mix of Ca and Mg carbonates, while calcitic lime refers to Ca carbonates. Application of dolomitic lime may be desirable where Mg supply is insufficient for crop production.

Since lime is fairly slow to react in soil, recommended amounts should be applied as early as convenient; lime may be applied 1 to 2 years before needed for a crop to ensure optimum reaction time. However, some benefit is realized the year of application. Hydrated lime or quick lime will react more rapidly than crushed limestone. One of the best methods of application is to broadcast the lime and thoroughly mix it with the soil during tilling. The better the soil contact with the lime and the finer the lime particles, the quicker soil acidity will be neutralized. (See CES Publication FGV-00348, *Field Crop Fertilizer Recommendations for Alaska: Fertilizer Nutrient Sources and Lime*).

Soils may be acidified by adding elemental S, or by direct application of acidic materials such as sulfuric acid (H_2SO_4), aluminum sulfate ($Al_2(SO_4)_3$), or ferrous sulfate ($FeSO_4$). Elemental S produces acidity as it is converted to sulfuric acid by soil microbes. The microbial transformation to sulfuric acid is slow, and elemental S should be applied well in advance of the growing crop. Extreme care should be taken when acidifying soils, since it is easy to reduce soil pH to undesirable levels.

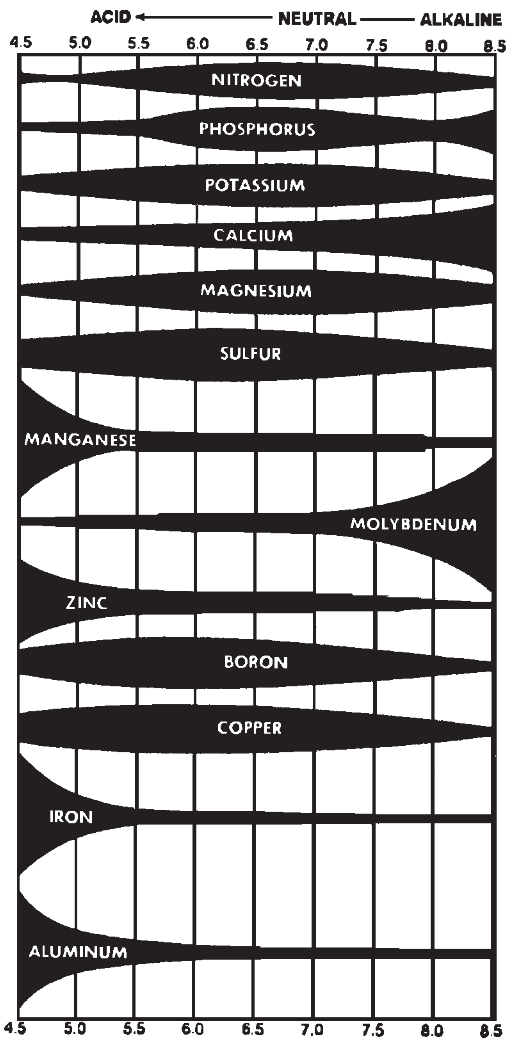


Figure 2. Relationship of soil pH and nutrient availability.

Source: Schulte, E.E. and K.A. Kelling. 1984. Aglime, key to increased yields and profits. University of Wisconsin, Cooperative Extension Service Publication A2240.

Nutrient Elements

This publication provides basic information about each mineral nutrient. The various forms of nutrients contained in fertilizer materials, and the advantages and disadvantages of using each are discussed in more detail in CES Publication FGV-00348, *Field Crop Fertilizer Recommendations for Alaska: Fertilizer Nutrient Sources and Lime*.

PRIMARY NUTRIENTS

Nitrogen (N)

Nitrogen is generally required in larger amounts than any other plant nutrient. It may be taken up in two forms, nitrate and ammonium. Nitrate (NO_3^-) is an anion, or negatively charged molecule, while ammonium (NH_4^+) is a cation, or positively charged molecule. Because of their charges, these two forms of N behave very differently. Soil particles and soil organic matter generally have a negative charge; therefore they attract positively charged cations and repel negatively charged anions, much like the positive and negative responses observed when two magnets are put together. Nitrate (negative charge), which is not held by soils, is easily lost through leaching, while positively charged ammonium is not. When ammonium fertilizers are applied, soil bacteria can convert the N to nitrate in a process called nitrification. The rate that nitrification takes place is largely dependent on soil temperature and occurs mainly in the summer months. In waterlogged soils, nitrate may be converted to several gaseous forms of N and lost to the atmosphere. To avoid N loss due to gaseous loss or leaching, N containing fertilizers should not be applied in the fall. Most plants are not particular about the form of N they take up and since the various N forms are easily converted in the soil, the choice of N fertilizer material is usually based on cost.

Roughly 95% of soil N is found in the organic material in unfertilized soils. In these situations, organic matter decomposition is critical to N nutrition of plants. Nitrogen applied in inorganic fertilizers is generally very soluble and may be subject to loss by leaching if excessive rain or irrigation is present. However, N moves to plant roots largely through the flow of water. Therefore, providing adequate water for crop plants is critical to maintaining a satisfactory N supply.

Table 1. Optimum crop soil pH ranges.

Crop	Optimum pH range[1]	Crop	Optimum pH range[1]
alfalfa	6.5-8.0	oats	5.5-7.0
apples	4.8-6.5	parsnips	5.3-6.8
apricots	4.8-6.5	peas	5.8-6.8
barley	6.5-8.0	peppers	5.3-6.8
beets	5.8-8.0	potatoes	4.9-6.5[2]
blackberries	5.7-6.5	pumpkins	5.3-7.5
blueberries	4.0-4.8	quackgrass	5.5-6.5
cabbage	5.8-8.0	radishes	5.8-7.0
carrots	5.3-6.8	rape	6.0-7.5
cauliflower	5.8-6.8	raspberries	5.7-6.5
celery	5.8-6.8	red fescue	5.5-6.5
cherries	4.8-6.5	reed canary grass	6.0-7.0
chives	5.8-7.0	rhubarb	5.8-7.0
clover,		rutabagas	5.3-6.8
Alsike	5.5-7.5	rye	5.0-7.0
red	6.0-7.5	snap beans	5.3-6.8
white	6.0-7.5	spinach	5.8-7.5
cucumbers	5.3-6.8	strawberries	4.8-6.5
currants	5.8-8.0	summer squash	5.8-7.5
gooseberries	5.8-8.0	timothy	5.5-7.5
horseradish	5.8-7.0	tomatoes	5.3-7.5
Kentucky bluegrass	5.5-8.0	turnip	6.0-7.0
lettuce	5.8-7.0	wheat	6.0-8.0
lupine	5.5-7.0	vetch	5.5-7.0

[1] These ranges are estimates only; they are for mineral soils (not mucks or peats).

[2] Potatoes grown at the upper end of this range may be more susceptible to potato scab than those grown at lower pHs.

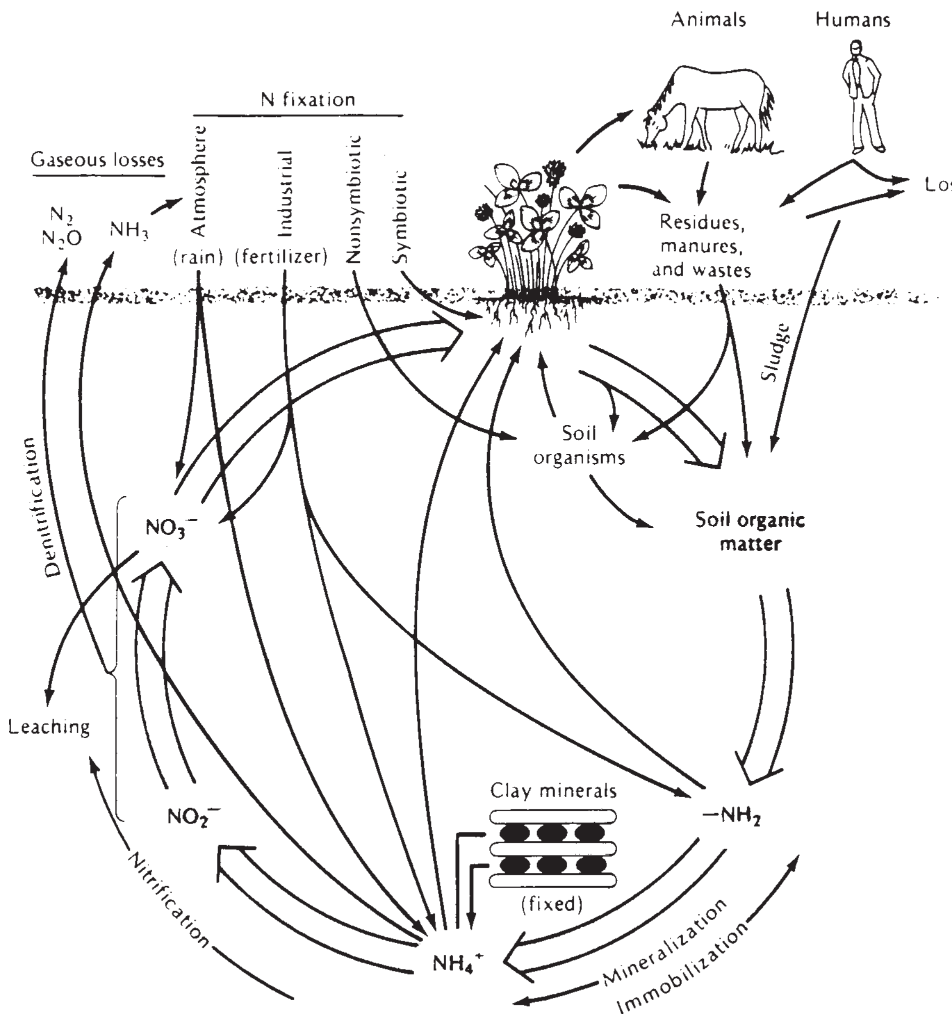


Figure 3. Nitrogen cycle.

Source: Brady, N.C. 1990. The Nature and Properties of Soils. MacMillan Publishing Co., NY.

Some plants, including legumes and alders can "fix" N from the atmosphere. Although our atmosphere is 78% N, higher (vascular) plants can not directly use this gaseous form of N. It must be captured by microorganisms and converted into usable forms first. This process is carried out to a small extent by free living soil microorganisms, but occurs primarily in bacteria growing in conjunction with legumes, alders and a few other higher plants. The bacteria live in lumps of root tissue in the host plant called nodules, receive carbohydrates from the host plant, and provide "fixed" N in exchange. In legumes properly inoculated with N fixing bacteria, this process can supply all the N the host plant requires. It may provide enough to supply part or all of the N for a subsequent crop as well.

Phosphorus (P)

In contrast to N, P is very insoluble in soil systems. Maintaining proper soil pH is critical to providing adequate P for optimum plant growth. When soil pH drops below 5.0 to 5.5, aluminum becomes soluble and will bind P, making it less available for plant use. Alternatively, if soil pH is above 7.5, Ca may bind P, rendering it less available to crops. Within the range of pH 5.0 to 7.5, P solubility is maximized, but is still low compared to the other primary and secondary nutrients.

Some types of soil minerals have a very strong affinity for P molecules. Primary among these are volcanic ash particles which predominate in many Alaskan soils, particularly in the Kenai and Susitna Valley areas. In these soils large amounts of fertilizer may be necessary to provide adequate P. Organic matter decreases the ability of soil mineral particles to fix or bind P, so adding organic materials may reduce the P requirement of volcanic ash soils. Another method of reducing the P requirement in P-fixing soils is to apply P fertilizer in a concentrated band to minimize its contact with soil mineral particles and thus decrease fixation.

Potassium (K)

Although the total amount of K in most soils is quite large, a relatively small portion generally is available for plant growth. Most K is held as part of the soil minerals structure, or inside layered clay particles, and may become available very slowly. The release of K from K-bearing minerals is usually not sufficient for crop plants.

Potassium is held tightly enough to soil particles that K fertilizer may be applied in the fall or spring in all but the sandiest soils. In very sandy soils, K fertilizers should be applied only in the spring.

Potassium availability is not strongly affected by soil pH. However, K uptake by plants can be limited if soil moisture is insufficient. Potassium management consists largely of maintaining soil K levels and providing adequate water to the growing crop. A large amount of K can be taken up by crop plants, and this must be replaced by inorganic or organic fertilizers.

SECONDARY NUTRIENTS

Calcium (Ca)

Calcium is the dominant positively charged molecule in nearly all soil systems except those with a very low pH. In soils with a pH above about 4.8, Ca is usually present in amounts adequate for crop growth. In acid soils, however, Ca is subject to leaching, and native Ca levels may be low. This situation can be corrected by using a liming material.

Even when soil Ca levels are satisfactory, supply to growing plants may be interrupted if adequate water is not provided. Calcium moves with water in a plant, and if water flow is interrupted during the formation of certain plant tissues, localized Ca deficiencies may occur. This can result in disorders such as tomato blossom end rot, tip burn in lettuce, cabbage, and strawberries, and bitter pit of apples. These and related disorders are more often the result of drought and other plant stresses than of inadequate soil Ca availability.

Magnesium (Mg)

Magnesium is positively charged and, like Ca, is most likely to be deficient in low pH soils. Under acidic conditions, Mg is very soluble and may be lost due to leaching. If an acidic soil is limed with a material that contains little or no Mg, a deficiency of this nutrient may result. When liming a very acid soil (below pH 5.2) it is a good practice to use a liming material that contains Mg, or to monitor soil Mg levels closely.

Magnesium and K compete for uptake by plant roots. Plants growing in soils with very high levels of K may exhibit Mg deficiencies when soil Mg is low. This situation can occur in sandy soils which are over-fertilized with K, particularly if the soils have been limed with a calcitic material.

Magnesium can be added in fertilizers as well as in liming materials. Using a Mg fertilizer may be desirable where inexpensive sources of calcitic limes are available or where the soil pH level is adequate. Magnesium is held tightly by negatively charged soil particles and can be applied at any time of the year.

Sulfur (S)

Sulfur is taken up by plants as the negatively charged sulfate (SO_4^{2-}) molecule. Because it is a negatively charged molecule or anion, sulfate may be easily leached from the soil. Most S, however, is not present in soil in the anionic form, but is tied up in soil organic matter. Sulfur availability, therefore, is controlled largely by the amount and rate of organic matter decomposition. In most soils, adequate S for crop plants is supplied through this process and through rainfall.

In soils with a marginal S supply, insufficient S may be taken up by crops to induce S deficiencies. Crops with pungent sap (onions, cabbage, broccoli) generally have high S requirements. Sulfur may be supplied in many complete fertilizers or may be applied in materials like gypsum ($CaSO_4$) or elemental S. If elemental S is used, it must be converted to the sulfate anion before being used by the plant. This conversion process produces considerable quantities of acidity. Elemental S is used as a soil acidifying agent more often than as a S fertilizer source (see discussion under "Soil pH", above).

MICRONUTRIENTS

Several micronutrients, including Mn, Zn, Fe, and Cu, behave similarly. As soil pH increases, the solubilities of these micronutrients decrease. Therefore deficiencies of these nutrients are most common in high pH soils.

Even when plants exhibit deficiencies of these four nutrients, they are usually present in the soil in substantial quantities. However, they are unavailable for plant growth because of unfavorable soil conditions, usually high soil pH. Adding fertilizer may not correct the deficiency, because added nutrients will quickly become unavailable due to the soils condition. There are two ways to address this problem. One is to correct the underlying problem – acidify the soil if it is too alkaline. The other is to add the nutrient in a "chelated" form which is more readily available to plants than that normally present in the soil. Chelated micronutrients are complexed with a material that increases the solubility of the nutrients, which reduces the degree of fixation by soil minerals and organic matter. In addition, all micronutrients can be applied as foliar sprays. This is a very effective way of applying micronutrients to growing crops, but does not address the soil problem. Deficiencies will likely occur in subsequent crops.

Manganese (Mn)

In addition to the effects of soil pH described above, Mn solubility is affected by soil water content. Under waterlogged conditions Mn becomes very soluble and can reach toxic levels. This is most likely to occur in acidic soils with pH levels less than 5.5, although it can happen even when soils are not very acidic. Manganese toxicity can also occur when soils are steam sterilized, and is a frequent problem in greenhouse production. Well-drained, high pH soils are most prone to Mn deficiency. Manganese deficiency can be induced when acidic, low-lying sandy soils are limed to pH levels above 6.5, or when wet, sandy soils are drained.

Zinc (Zn)

Soil acidity is the primary factor affecting Zn availability. Zinc deficiency occurs on moderate to high pH soils, and may be more pronounced if soil P levels are high. Zinc deficiency may occur in soils with a pH of 6.0 to 7.0 if they are over-fertilized with P. Zinc deficiency is most likely to be found on sandy or high organic matter soils.

Iron (Fe)

Iron deficiencies occur only in high pH soils. In soils with high pH, most of the Fe is insoluble and therefore unavailable to plants. Reducing the pH with elemental S or some other acidifying agent will correct the problem by solubilizing the Fe in the soil.

Copper (Cu)

Copper solubility also decreases as pH levels increase. Therefore, Cu deficiency can occur in soils with pH levels above 7.5. In contrast to Mn, Zn, and Fe, Cu is tightly bound by soil organic matter. As soil organic matter content increases, Cu availability decreases. In some soils with large amounts of organic matter, Cu can be deficient when soil pH is 5.5 or below.

Molybdenum (Mo)

Higher plants require molybdenum in extremely small amounts. It behaves very differently from most other micronutrients. The most common form of soil Mo is anionic, which can be easily leached from sandy soils. Molybdenum is most soluble at high pH levels, and is most likely to be deficient in acidic sandy soils. However, Mo deficiencies are sometimes found in moderate pH, fine textured soils. This generally occurs where the parent material is low in Mo. Molybdenum is essential to N fixation by legumes, and these plants are very sensitive to Mo deficiencies. The crucifers (broccoli, Brussels sprouts, cauliflower, canola and the forage rapes) all have a high Mo requirement. These plants are sensitive to low Mo levels and also remove substantial quantities of Mo from the soil when harvested.

Boron (B)

Boron is present in soils as an uncharged molecule that is held weakly by various mineral and organic soil constituents, and can be easily leached, particularly from sandy soils. Boron availability is affected by soil pH. It may become unavailable to plants when soil pH is above 6.5.

The crucifers and most of the legumes have high B requirements. The difference between deficient and toxic levels of B is small. Many crops are susceptible to B toxicity including cowpeas, lupines, onions, and strawberries.

Chlorine (Cl)

Chlorine is rarely deficient in agricultural soils. In fact there are more problems with excess Cl in saline soils than with deficiencies. The functions of Cl are poorly understood, but it appears that Cl is involved in both cold and drought plant tolerance. Chlorine deficiencies may also be involved in disease susceptibility (for example in take-all root rot of wheat in the Pacific Northwest). Adequate Cl is provided by rainfall, air pollution, and in various fertilizer materials in most situations.

FERTILIZERS

Note: The following discussion is excerpted from CES Publication FGV-00142, *Field Crop Fertilizer Recommendations for Alaska*.

Most commercial fertilizers are "complete" fertilizers and contain N, P and K. The N, P, and K levels constitute the grade of the fertilizer and must appear on the container. A fertilizer may contain other nutrients as well, although listing these is not required. A fertilizer grade consists of three numbers: the first number indicates the percentage of total N; the second the percentage of citrate-soluble P (expressed as P_2O_5); and the third the percentage of water-soluble K (expressed as K_2O). For example, "10-20-20" has a guaranteed analysis of at least 10% N, 20% P_2O_5, and 20% K_2O.

The above analysis is stated on the "oxide" basis for P and K. This form of reporting nutrient composition is a carryover from the time when chemists reported all elements on an oxide basis. You can easily convert an oxide to an elemental basis by multiplying the oxide value by the appropriate factor:

Oxide x Factor = Elemental

K_2O x 0.83 = K

P_2O_5 x 0.44 = P

Thus, a fertilizer with a 10-20-20 analysis on the oxide basis contains 10% N, 8.8% P, and 16.6% K. Some fertilizer companies give both the oxide and elemental forms of analyses on the label.

If a fertilizer contains nutrients other than N, P, and K, it may be listed following the N-P_2O_5-K_2O analysis. For example, a bag with the label 10-20-20-5S contains, in addition to the N, P and K, 5% S. Many fertilizers contain substantial quantities of Ca, but this is not reported on the label.

The grade and amount of a complete fertilizer that equals the recommendation can be determined from fertilizer recommendations based on soil analysis, or from the general recommendations provided in other publications in the *Field Crop Production Handbook*. For example, if a recommendation calls for 50 pounds of N, 100 pounds of P_2O_5, and 50 pounds of K_2O, a fertilizer having approximately a 1-2-1 ratio should be used. Pounds of fertilizer multiplied by the percentage of the nutrient in the fertilizer equals the pounds of the nutrient, so 500 pounds of 10-20-10 or 1000 pounds of 5-10-5 fertilizer would provide the required nutrients.

Fertilizer materials are discussed in further detail in CES Publication FGV-00348, *Field Crop Fertilizer Recommendations for Alaska: Fertilizer Nutrient Sources and Lime*, however, a discussion of some basic aspects of fertilizers follows.

Decisions on fertilizer purchase should include the following points:

(1) cost
(2) ease of handling and application
(3) storability of the fertilizer if held over to next season

Comparisons of fertilizer costs and fertility values are based on cost per unit of available plant nutrient (for example, cents per pound of N, P_2O_5 or K_2O). When liquids are priced by volume, the buyer must know the weight per unit volume as well as the percentage of available nutrients to calculate the cost per unit of nutrient.

The cost of fertilizers often differ from year to year as prices change; moreover, they frequently differ from seller to seller in any given year. To determine the cost per pound for a straight material (containing only one nutrient), divide the cost per bag by pounds of the nutrient in the bag. For example, a 50-lb bag of 0-0-50 contains 25 lb K_2O; if it costs $7.00, then the cost per pound of K_2O is equal to:

$7/25 = $ .28

For mixed materials having a similar $N\text{-}P_2O_5\text{-}K_2O$ ratio, the buyer needs to calculate an average value for all nutrients before comparing prices. For example, an 80-lb bag of 10-20-10 (1:2:1 ratio) costs $14.00. The nutrient content is 8+16+8 or 32 lb nutrient per bag. The cost per pound of nutrient is equal to:

$14/32 = $ .44

Comparing mixed materials having a dissimilar ratio is more difficult. For example, comparing the price of 8-32-16 (1:4:2 ratio) with 10-20-10 (1:2:1 ratio). This can be accomplished by comparing the price-adjusted nutrient content. First calculate the price per pound of nutrient for straight materials (in the previous example, K_2O cost 28 cents per pound). Suppose your calculations reveal the N, P_2O_5 and K_2O cost 55 cents, 46 cents, and 28 cents per pound, respectively. Compared to the cost per pound of K_2O, N costs 1.96 times as much, while the cost of P_2O_5 is 1.64 times that of K_2O. Suppose a 100 lb bag of 10-20-20 costs $15.50. The price-adjusted cost per pound is equal to:

(N)	0.10 x 1.96 =	0.196
(P_2O_5)	0.20 x 1.64 =	0.328
(K_2O)	0.20 x 1.00 =	0.200
		0.724

($15.50/100)/0.724 = $ .21

Similarly, the price-adjusted cost per pound of a 100 lb bag of 8-32-16 costing $16.20 would be:

(N)	0.08 x 1.96 =	0.157
(P_2O)	0.32 x 1.64 =	0.525
(K_2O)	0.16 x 1.00 =	0.160
		0.842

($16.20/100)/0.842 = $ .19

Therefore, in terms of pounds of nutrients per dollar, the 8-32-16 is a better buy. (This is just an example, and is not meant to imply that 8-32-16 and 10-20-20 are interchangeable).

In addition to cost, the physical attributes of a fertilizer material must be considered. Blended, granular fertilizers are mixtures of several prilled dry fertilizer materials, blended for the purpose of achieving a desired fertilizer grade. Depending on the formulation, the individual materials may have a tendency to separate during shipping and handling, and can result in non-uniform application. In a dry blended fertilizer, it is important that the size and weight of the individual prills is similar to prevent this. Some complete fertilizers are formulated such that each prill contains all three nutrients: N, P and K. These cannot settle out or separate and offer some advantage over dry blended fertilizers.

Particle size is important in non-prilled materials, such as lime. Fine particles are desirable for rapid reaction in the soil, but a dusty material can be particularly difficult to spread in windy conditions.

Storage properties are important if fertilizers are to be kept for more than one season. Some materials can cake or solidify into a solid block making application impossible. In general, N containing fertilizers are hygroscopic (they absorb water from the atmosphere) and will cake quite easily if stored for a long time.

Ammonium nitrate is an explosive material, and should not be stored from one year to the next.

The information given herein is supplied with the understanding that no discrimination is intended and no endorsement by the Cooperative Extension Service is implied.

Visit the Cooperative Extension Service Web site at
www.uaf.edu/coop-ext

111/3-92/RG/1000 Reprinted April 2003