Buffer pH is a measure of reserve acidity and is used by the soil testing laboratory to estimate lime requirements. Low buffer pH readings indicate high amounts of reserve acidity, and therefore, high amounts of lime will be recommended. The soil pH should always be lower than the buffer pH except on some alkaline soils. Instead of using buffer pH, some laboratories calculate lime requirement form CEC and base saturation while others make this determination based on aluminum level.

Plant Nutrients—major and minor

Nitrogen

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 Nitrogen Cycle

The N cycle (Fig. 1) illustrates N inputs, losses and transformations. When inputs exceed plant needs, nitrates 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. N transformations and losses are affected by soil conditions and the vagaries of the weather.

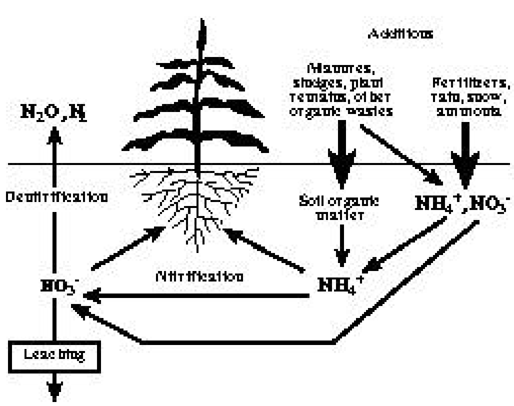

Figure 1. The nitrogen cycle.

Nitrogen Inputs

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

Soil organic matter: The total amount of N in the plow layer of agricultural soils is surprisingly large. One can estimate the total N in pounds per acre in the six to seven inches of surface 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 1% to 4% of the total N is converted annually to forms plants can use. For soil with a total of 4,000 lbs N per acre, a 1% to 4% conversion would produce 40 to 160 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. On well managed soils used for small fruit production, 20 to 30 lbs of N per acre will result from each percentage of organic matter during the growing season.

Previous cow manure applications: Up to 50% of the total N in cow manure is available to crops in the year of application. 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 to 40 tons per acre) for several years, the N furnished from previous manure increases substantially.

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 the crop’s N needs are being supplied by cow manure, the rate of cow manure needed decreases yearly.

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 carry-over of N to crops in succeeding years. This is due to the

Table 2. Nitrogen credits for previous crops.

Previous Crop	Nitrogen Credit 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
Sweet corn stalks	30
“Good” hairy vetch winter cover crop	106
Corn for grain	40

nature of the organic N compounds in poultry manure. This does not mean, however, that there is never any carry-over 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 pounds or more of N to crops that follow. Other legumes, mixed grass-legume stands and grass sods supply less N to succeeding crops (Table 2).

Manures and other waste products: 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 the animal species and the total N content of the manure, but also with the time of application and time elapsed between spreading and incorporation (Table 3).

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 3.

Compost as a nutrient source: Finished compost is a dilute fertilizer, having an analysis of about 1-1-1 (N-P_2O_5-K_2O). The nitrogen content of composts varies according to the source material and how it is composted. In general, nitrogen becomes less available as the compost matures. Nitrogen in the form of ammonium (NH_4+) or nitrate (NO_3-) is readily available, however in a finished compost there should be little ammonium, and any nitrate that is produced could have leached away, especially if the compost is cured or left out in the open. The majority of the nitrogen in finished compost (usually over 90%) has been incorporated into organic compounds that are resistant to decomposition. Rough estimates are that only 5% to 15% of the nitrogen in these organic compounds will become available in one growing season. The rest of the nitrogen will become available in subsequent years.

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.

Table 3. Nitrogen credits from manure incorporated before planting.

TIME(S) OF APPLICATION (lbs N/ton)			
Kind of Manure	April/ May	Fall Only	Other times
DAIRY (COW)			
Solid	5	2	3
Liquid	16	8	12
POULTRY, CAGE LAYER			
fresh			
(20-40% D.M.)[4]	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.*
4. *Dry matter.*

Nitrogen Losses

Nitrogen losses occur in several ways. Some, such as volatilization, denitrification or immobilization, result primarily in N being unavailable to crop plants. Leaching loss results in potential groundwater contamination in addition to reduced crop growth.

Volatilization Losses: These 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. 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 seven days after spreading.

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 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. The use of cover crops following row crops can take up this residual N and prevent it from leaching. The N will then be released for crop use after the cover crop is plowed down in the spring.

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.

Phosphorus

Phosphorus (P) is referred to as P_2O_5, for the purposes of soil testing, fertilizer grades and recommendations. We don't apply P in this form, but it has become the standard over many years. Phosphorus plays an important role in plant metabolism. This nutrient is nearly motionless in the soil, so it must be incorporated before planting. Little phosphorus enters the plant from soil water, so most uptake is by direct contact with the root surface. Plant uptake of P is very slow in cold soils. For this reason, when planting early, it is advisable to apply a liquid starter fertilizer high in P at planting.

Potassium

Plants use potassium to open and close stomates and to move nitrates from the roots to the leaves. Potassium (K) is expressed as K_2O similar to the way to P is referred to as P_2O_5. Crop need for K varies. See the table at the beginning of each crop section for the potassium needs for each crop. It is important that the soil K plus the applied K is enough to meet crop needs. However, excessive levels should be avoided because K can interfere with the uptake of Ca and Mg (see "Base Saturation"). K is subject to leaching on sandy soils low in organic matter. If high amounts of K are needed, split applications should be used. Potassium sulfate or potassium magnesium sulfate are the best sources of potassium for brambles and strawberries. Although muriate of potash is less expensive, brambles are sensitive to the chloride in this fertilizer.

Calcium

Calcium is usually supplied in sufficient quantities by liming if appropriate liming materials are chosen (see "Soil pH and Liming"). If soil pH is high and Ca is needed, small amounts can be applied as calcium nitrate fertilizer (15%N, 19%CA). Ca can also be applied without affecting pH by applying calcium sulfate (gypsum) which contains 22% Ca or superphosphate (14 to 20% Ca).

Magnesium

Magnesium is necessary for chlorophyll production and nitrogen metabolism. High soil potassium levels can lead to reduced uptake of magnesium. Magnesium deficiency is characterized by interveinal reddening on older leaves, beginning at the leaf margin. It is important to maintain a proper balance between magnesium, potassium, and calcium. These three nutrients and phosphorus can be applied in late fall after plants are dormant. Nutrients can then move into the root zone and be available when growth begins again in the spring. Magnesium (Mg) is most economically applied as dolomitic or high-mag limestone (see "Soil pH and Liming"). If liming is not needed, Sul-Po-Mag (11% Mg, 22% K) can be used. You can order blended fertilizer containing Mg.

Minor Elements

Minor elements are difficult to analyze accurately with soil tests. Plant tissue analyses are more reliable for determining whether or not plants are getting sufficient quantities of minor elements. Of the minor elements, boron (B) and Zinc (Zn) are the most likely to be needed to supplement soil levels.

Soil Organic Matter

Soil organic matter (SOM) is a small but critical component of soils. SOM is continuously being produced by plants and animals and broken down by soil microbes that use it is a source of energy. As such it provides food for a diverse population of microbes in the soil and this helps prevent any one type of organism, such as a plant pathogen, from dominating. As microbes break down SOM, nutrients are released which are available for plant growth. This process is called mineralization and can provide some or all of the nutrients needed for successful crop production. Soil microbes are most active in warm soils (over 70½ F) that are moist, but well aerated, with a pH between 6 and 7. Mineralization of nutrients will proceed rapidly under these conditions.

SOM also improves soil structure. It binds individual soil particles together into aggregates. This makes soil friable, allowing for good drainage, aeration, and root growth. SOM also improves the moisture holding capacity of soils. SOM is also the chief contributor to cation exchange capacity in New England soils.

Adding to Soil Organic Matter

Using compost is an effective way to add organic matter to the soil. Small fruit growers can make compost on the farm although most don't have enough raw materials to satisfy their needs. Some are bringing in additional materials such as municipal yard wastes to compost on site. Others are purchasing compost from the increasing number of commercial composters. Regardless of the source, compost should be finished before use. Finished compost has no recognizable bits of matter and will not heat up after turning. Compost should also be tested for nutrient content. Finished compost should have a low ammonium content, high nitrate level and a pH near neutral. Repeated use of a compost high in a particular element could cause a nutrient imbalance. For more information, obtain a copy of On-Farm Composting Handbook (see references on page 105).

Animal manure is an excellent source of nutrients and organic matter. About half of the nitrogen in fresh dairy manure and 75% of the nitrogen in poultry manure is in the form of ammonia. Ammonia is subject to loss through volatilization if not incorporated immediately after spreading. In the soil, ammonia is converted to nitrate and is available for plant use. However, nitrate is subject to leaching and large applications should generally be avoided. There are times when readily available nitrogen is needed, but fresh manure should be applied only with caution. Many people prefer to compost manure before field application. This stabilizes the nitrogen. Manure can be mixed with other materials for composting. Manure samples can be analyzed by several of the laboratories listed on page 2.

Cover crops are used by most growers to protect soil from erosion and to take up unused N. Cover crops also contribute to SOM when they are plowed down, although SOM varies considerably among crops (see cover crop section, page 8).

Carbon-To-Nitrogen Ratio

Organic matter is broken down by microbes which use carbon for energy. They also have a need