Mineral Nutrition of Fruit Crops

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In addition to water, sunlight, and carbon dioxide from the air, plants require 13 mineral nutrients that are typically derived from the soil. The macronutrients nitrogen (N), phosphorus (P), potassium (K) are needed by plants in relatively large amounts and often have to be added to the soil. Intermediate amounts of secondary nutrients magnesium (Mg), calcium (Ca), and sulfur (S) are needed by plants. Trace or micronutrients [boron (B), chlorine (Cl), copper (Cu), iron (Fe), manganese (Mn), molybdenum (Mo) and zinc (Zn)] are needed in small amounts and are seldom deficient in Wisconsin soils.

In a healthy plant the essential mineral elements are present in adequate levels and in correct proportion to other elements. Plant productivity or fruit quality is reduced if:

- one or more of the required elements is not present in sufficient quantity (deficiency);
- one or more elements is present in too great a quantity (toxicity);
- or the levels of one or more elements is out of balance with other nutrients.

These nutrients perform a variety of functions in plants ranging from being structural components of cell walls and membranes to activating enzyme systems. About 95% of the dry weight of a typical plant is made up of carbon, oxygen and hydrogen. The soil supplied minerals make up only 5% of a plants total dry weight.

The nutrition of plants and animals is very different. While animals need proteins, carbohydrates, vitamins and minerals to be healthy, plants need only water, sunlight and the 13 essential nutrients. No scientific evidence supports the use of vitamins or other similar supplements for plant growth. Plants don't need to be "fed". They simply need adequate supplies of water, sunlight and minerals.

While fertilizers can be added to soils to improve their fertility, the best plan is to establish your fruit planting on a fertile soil. The soil pH should be between 6 and 7 for optimum production. Ag limestone must be incorporated to be effective because lime only moves about ½ inch per year if topdressed. Plants can make best use of soil applied nutrients if these nutrients are distributed within the soil rooting volume.

Factors affecting soil fertility

Soil fertility is a complex concept referring to the potential of a soil to supply nutrients in amounts, forms and proportions required for optimum plant growth. Describing soil fertility in detail is beyond the scope of this bulletin. Soil properties that affect the nutrient supply to plants include cation exchange capacity, soil pH and soil texture.

Cation Exchange Capicity

One of the most important "reservoirs" of plant nutrients in the soil is the exchangeable nutrients held on cation exchange sites. Most of the potassium, ammonium, calcium and magnesium used by plants comes from the exchange sites. Each soil has a finite capacity to hold positively charged nutrients, the cation exchange capacity (CEC). Silty and clayey soils can hold several times more positively charged nutrients than sandy soils. However, even sands have adequate exchange capacity to hold all of the nutrients needed by plants in an available form.

Soil pH

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Establishing and maintaining proper soil pH by use of ag limestone plays an important role in productivity because of the influence soil pH has on nutrient availability and other chemical/biological processes affecting plant growth.

Soil pH affects the availability of plant nutrients. Optimum availability of plant essential nutrients is ensured if mineral soil pH is maintained between 6.0 and 6.5 (except for blueberries and other *Vaccinium*). In some instances nutrient deficiencies or toxicities can be avoided by adjusting soil pH to the proper level.

Organic Matter

Soil organic matter affects both the chemical and physical properties of a soil even though it makes up only 1 to 5 percent of the soil mass. In addition to holding available plant nutrients in an exchangeable form, organic matter releases nutrients when it decomposes. Crop residues, manure, and other organic materials contain significant amounts of nitrogen, phosphorus, sulfur and boron and serves as a "reservoir" for these nutrients, which become available as soil microorganisms convert the organic nutrients into inorganic, plant available forms.

Soil organic matter influences soil physical characteristics such as soil erosion, soil temperature, water holding capacity and drainage. Additions of organic materials will increase the amount of water held available for crops in sandy soils and improve drainage in heavier textured soils by its influence on pore space. Adding organic matter to soils as manure or green manure crops before planting is more beneficial than surface applications with no incorporation after plant establishment

Texture

Soil texture describes the feel of the soil, its coarseness or fineness. More specifically it is the relative proportion of sand, silt and clay that make up the mineral portion of a soil.

All textures of soil are found in various parts of Wisconsin. Fruit will grow in most soil types as long as they have enough, but not too much, water and nutrients. Additions of organic matter will help minimize soil limitations due to texture but will not entirely alleviate severe problems.

Plant response and soil fertility

Soil fertility can be thought of as the ability of the soil to supply nutrients needed for optimum yield. A soil test is the most practical way of measuring the nutrient supplying power of the soil and telling if fertilizer and/or lime are needed.

Fertilizers are applied to supply essential nutrients that may be in short supply or unavailable to plants from the soil. Plants absorb nutrients from the soil and use them to produce new growth or fruit. The application of agricultural fertilizers has greatly increased crop yields over the past 50 years by eliminating nutrient availability as a major limitation to yield.

When a particular nutrient is in short supply, application of additional nutrient will increase growth and yields (Fig. 1). Initially this may be a linear response where yield increases one unit per unit of fertilizer added. At some point the response levels out and yield increases become less pronounced as additional fertilizer is applied. This is followed by a plateau where yield is not increased with additional applications of nutrients. However, plants may continue to absorb nutrients without having a corresponding increase in yields. This is known as luxury consumption. At the far end of the plateau there is a point where excessive nutrient levels, especially micronutrients, may become toxic to plants and will reduce yields. The goal in applying fertilizer is to supply enough nutrients to provide optimal plant growth without supplying too much fertilizer.

Figure 1. Plant and profit response

Diagnosing the mineral nutrition status of fruit crops

Fruit growers have three main tools to use in evaluating the mineral nutrition status of their plantings. These are:

- examine visual symptoms exhibited by leaves, stems, and fruit;
- analyzing leaf tissue and;
- .testing the soil.

Used together properly these are powerful tools that can be used to prevent nutrient deficiencies or toxicities as well as to assess current fertility management practices.

Visual Symptoms

Visual symptoms have been used for many years to diagnose deficiencies of certain elements. Color photographs of various deficiency symptoms have been published as diagnostic tools. However, there are at least two disadvantages associated with this approach as the primary method for estimating nutrient need. First, once the visual symptoms have appeared the crop quality and yield has likely already been reduced. Second, some visual deficiency symptoms look similar while others may be confused with disease, insect or environmental stress symptoms. Further confusion arises when the symptoms from more than one deficient element is confounded by a deficiency or toxicity of another.

Tissue Analysis

Tissue analysis is a powerful tool in assessing mineral nutrition of crops. Chemically analyzing the concentration of nutrients in the leaves of growing crops can more precisely define the nutrient status than an examination of deficiency symptoms. This is particularly true for perennial fruit crops. This method is based on collecting samples of tissue in the field and measuring the amounts of mineral elements in the tissue. Tissue analysis provides a "snapshot" picture of the nutrient status of a crop at a particular point in time resulting from all factors that affect plant growth. In addition to confirming suspected deficiencies, plant analysis can also detect toxicities or hidden deficiencies before visual symptoms appear. Experimentation has shown the amounts of the various minerals that should be present in plants to provide optimal growth. These amounts are different for each crop species.

Collecting a sample

The most important part of tissue analysis is taking a proper sample. Nutrient levels within plants differ depending on the plant part sampled, the stage of maturity, the location on the plant and environmental factors. It is important to follow standard sampling procedures for each fruit crop.

Plants must be sampled at the proper stage of maturity in order to correctly interpret the results. Nitrogen, for example, is relatively high in leaves in the spring, levels off in midseason and then declines in the late summer and fall before the leaves drop. Interpretations are based on knowing the relationship between nutrient levels in a particular part of a "standard" tissue in a specific time in the growing season. A leaf sample taken in the spring could show excess nitrogen compared to mid season standards and a sample taken in the fall could show a deficiency even if it were adequate at mid season. Samples taken at a time during the season different than the "standards" used for nutrient interpretation will likely show erroneous results.

Sampling a different plant part than the "standards" will also lead to incorrect interpretations of the analysis. For example, nitrogen is mobile in plants and old leaves are the first to show deficiency symptoms. If old leaves are sampled a deficiency may be indicated, while if young leaves are sampled an adequate amount or an excess may be shown. The correct plant part to sample is shown in Table 1.

The sample should be representative of the planting because the results of the test can be no better than the sample sent in for analysis. The amount of tissue the lab actually tests is less than a teaspoon, so it is very important that the sample be characteristic of the field or block. If the planting consists of different cultivars that are intermixed, take leaves from each cultivar. Make sure an adequate number of plants are sampled. The numbers listed in Table 1 should be considered minimums. Don't sample diseased, damaged, insect infested or abnormal tissue. If you suspect a nutrient related disorder, sample early in the growing season. Submit a sample of abnormal appearing tissue along with a sample not showing the symptoms that is collected on the same day. By doing so a comparison of the two samples can be made and a better evaluation can be made between the nutritional status of healthy and abnormal plants.

Include a soil sample with your plant analysis sample. Soil test results for pH, organic matter, and available P and K can be useful when interpreting the plant tissue results. In Wisconsin, a routine soil analysis is included as part of the plant analysis program at no additional cost.

Submitting a sample

Once the tissue sample has been collected it should be prepared for shipment or delivery to the lab. Any soil or foreign material should be dusted off the sample. DO NOT WASH the leaves as this will remove soluble nutrients. If the sample is to be mailed, allow the sample to air dry for one day to prevent mold from forming during shipment. Place the dry sample in a paper envelope for shipping. Do not use plastic or cellophane bags since these retain moisture and promote molding. Try to ship samples early in the week (Wednesday at the latest) to avoid samples deteriorating in warm post offices over the weekend. Plant samples that are delivered to the lab do not need to be air dried if they are delivered within a day after sampling. Please submit an information sheet describing the crop type, date sampled, and other information necessary to make the best interpretations of lab results. Plant analysis information sheets are available from the laboratory or your County Extension office.

Table 1. Proper fruit plant sampling for diagnostic plant analysis.

Crop	Stage of Growth	Plant Part	#Plants to sample
Apples, cherries, pears, plums, apricots	current season's shoots taken July 1 to 15	fully expanded leaves from midpoint of new shoots	4 leaves from each of 10 trees
Raspberries (fall or summer)	August 10 to Labor Day	leaf blade and petiole, #5-12 from shoot tip	2-3 leaves from each of 10 canes
Strawberries	At renovation before mowing	young, fully expanded petioles and leaves	2 parts from each of 20-25 plants
Grapes	Bearing, primary shoots	petioles from newest leaves	5 petioles from each of 10 vines

Soil analysis

Soil testing is a means of measuring soil pH and estimating the supply of nutrients available for plant growth. There is a poor relationship between soil and plant nutrient levels in perennial fruit crops, particularly tree fruits. When plant tissue levels (from tissue analysis) are compared to corresponding soil nutrient contents (from soil analysis), no correlation is found. Therefore, soil testing alone may not provide enough information to make accurate fertilizer decisions for perennial fruit crops.

Reliable commercial soil tests have not been developed for nitrogen, copper or iron. The need for these elements can best be evaluated by plant analysis. Deficiencies of most minor elements can better be identified by plant analysis too. Some fertility problems such as those associated with very acid or very alkaline soils are difficult to identify by plant analysis alone and are better evaluated by a soil test when used in concert with tissue analysis.

Soil testing

Soil samples should be taken from the same areas as the tissue samples. For strawberries, raspberries and grapes take the sample to the side of the plant row, but not in the middle between the rows. For tree fruits take the sample within the drip line of a tree and within the vegetation free area. Don't sample from the sod area.

Take individual samples with a trowel or small shovel. A good sample consists of about 8-10 subsamples, taken to 6 inches, per area. Mix the subsamples and place about 1 cup of soil in a soil bag or pint plastic bag. Identify the bag with the same sample number as the corresponding tissue sample. Submit the soil sample along with the tissue sample for analysis to the lab of your choice. Be sure the bags are sealed tightly so the tissue samples cannot be contaminated with soil. No fee is assessed for routine soil analysis corresponding with a tissue sample at the UWEX lab.

A soil analysis should always be a part of preparing the site before planting. Because fruit plants are relatively long lived it makes sense to amend the soil **prior to planting**. Take soil samples from the site a year before planting and apply and deeply incorporate any fertilizer or lime recommended. This is an especially good practice for strawberries since they are replanted every 3 to 5 years. A soil test is the only practical means to determine which and how much fertilizer and/or lime are needed for best growth. Evaluating soil fertility is a good practice to establish in order to make most efficient use of applied fertilizer.

Interpreting the report

About two weeks after samples have been submitted you will receive a computerized report showing the concentrations of various nutrients in the tissue and soil. Beside each number is a letter designation indicating that the concentration is deficient, low, sufficient, high or in excess for that nutrient. This interpretation is provided only if the plant was sampled at the proper stage of maturity. Soil pH, organic matter and an estimate of plant available phosphorus and potassium will also be reported if a soil sample was submitted. If soil was not sampled, interpretations of plant tissue results will be based on an assumption of optimum soil test results.

The indication that the tissue nutrient concentration is deficient, low, adequate, high or excessive will tell you whether applications of fertilizer program is warranted.

Long experience and experimentation has shown what concentrations of each required element should be found in plant tissues. These concentrations are listed for each major Wisconsin fruit crop in Tables 3-6. Interpretation of the results with these standards is possible only if the correct plant part was sampled at the proper stage of maturity. ***No valid interpretation is possible if the wrong part was sampled or the plants are sampled at other times in the season.***

Table 2. Fertility status of **apples** in relation to nutrient content in leaves.

Concentration of (%)	**Plant Nutrient Status**				
	Deficient	Low	Sufficient	High	Excess
Nitrogen (N)	<1.7	1.7-1.9	1.9-2.2	2.2-2.5	>2.5
Phosphorus (P)	<0.15	0.15-0.2	0.2-0.25	0.25-0.35	>0.35
Potassium (K)	<0.6	0.6-1.0	1.0-1.6	1.6-2.0	>2.0
Calcium (Ca)	<0.4	0.4-0.6	0.6-1.0	1.0-1.2	>1.2
Magnesium (Mg)	<0.2	0.2-0.3	0.3-0.5	0.5-0.7	>0.7
Sulfur (S)	<0.1	0.1-0.14	0.14-0.18	0.18-0.22	>0.22
Concentration of (ppm)					
Zinc (Zn)	<15	15-25	25-35	35-50	>50
Boron (B)	<18	18-30	30-40	40-55	>55
Manganese (Mn)	<20	20-30	30-50	50-70	>70
Copper (Cu)	<4	4-7	7-10	10-15	>15
Iron (Fe)	<60	60-90	90-120	120-150	>150

Table 3. Fertility status of **strawberry** in relation to nutrient content in leaves.

Concentration of (%)	Plant Nutrient Status				
	Deficient	Low	Sufficient	High	Excess
Nitrogen (N)	<1.7	1.7-2.0	2.1-2.8	2.9-3.0	>3.2
Phosphorus (P)	<0.20	0.2-0.24	0.25-0.3	0.3-0.35	>0.35
Potassium (K)	<0.8	0.9-1.19	1.2-1.7	1.7-2.5	>2.5
Calcium (Ca)	<0.3	0.3-0.6	0.6-1.0	1.0-1.5	>1.5
Magnesium (Mg)	<0.2	0.2-0.3	0.3-0.5	0.5-0.7	>0.7
Sulfur (S)	<0.1	0.1-0.14	0.14-0.18	0.18-0.22	>0.22
Concentration of (ppm)					
Zinc (Zn)	<15	15-25	25-35	35-50	>50
Boron (B)	<18	18-30	30-40	40-55	>55
Manganese (Mn)	<20	20-30	30-50	50-70	>70
Copper (Cu)	<4	4-7	7-10	10-15	>15
Iron (Fe)	<50	60-90	90-120	120-150	>150

Table 4. Fertility status of **raspberries** in relation to nutrient content in leaves.

Concentration of (%)	Plant Nutrient Status				
	Deficient	Low	Sufficient	High	Excess
Nitrogen (N)	<2.1	2.11-2.4	2.41-2.60	2.61-2.99	>3.0
Phosphorus (P)	<0.15	0.15-0.18	0.19-0.22	0.23-0.39	>0.4
Potassium (K)	<0.60	0.6-1.19	1.2-1.3	1.31-1.59	>1.6
Calcium (Ca)	<0.60	0.6-0.79	0.8-1.0	1.1-1.14	>1.15
Magnesium (Mg)	<0.3	0.30-0.39	0.4-0.48	0.49-0.69	>0.70
Sulfur (S)	<0.10	0.10-0.14	0.15-0.2	0.21-0.29	>0.3
Concentration of (ppm)					
Zinc (Zn)	<15	15-25	25-35	35-50	>50
Boron (B)	<18	18-30	30-40	40-55	>55
Manganese (Mn)	<20	20-30	30-50	50-70	>70
Copper (Cu)	<4	4-7	7-10	10-15	>15
Iron (Fe)	<60	60-90	90-120	120-150	>150

Fertilizer application

Fertilizers are materials that contain nutrients required by plants. In some cases, organic materials such as manures and plant residues can supply some or all the nutrients required by plants. However, plants cannot differentiate between nutrients from organic, inorganic, liquid or granular sources. All nutrients are absorbed by plant roots as ions and all ions of a given element are identical regardless of the source. The benefits from using organic materials on soils are many, but relate mostly to 1) the contribution of mobile nutrients (nitrogen) in a slowly available form and 2) improvement of the physical condition of the soil. Since plant nutrient requirements can be met with easily blended and precisely measured commercial fertilizers, the use of organic materials is encouraged mostly for their beneficial effect on soil physical properties.

Fertilizers can be applied to the soil and taken up by the roots or applied to the plant as a liquid for uptake by the leaves, stems or fruit (foliar application). Each method has advantages. Soil application is usually less expensive and is better suited for large application rates of the major nutrients and for pre-plant application. For the most part, soil applications by broadcasting, banding or top dressing are the most economical and efficient.

Foliar application is best for correcting micronutrient deficiencies or for increasing the concentration of immobile elements to specific tissues, such as calcium and boron to fruits and flower buds, respectively. Liquid fertilizers that are foliar applied are more expensive per unit of nutrient. In many cases the liquid fertilizer runs off, or is washed off leaves onto the soil where it is later taken up by the roots. In this case it would have been much less expensive to apply a granular fertilizer to the soil. The expense of foliar applications of nutrients may be decreased if they can be mixed with pesticides in a cover spray. Fertilizers commonly used on fruit crops are described below.

Fertilizers

A soil and/or plant tissue analysis are the most reliable methods to determine nutrient need and amount. Nutrients of most common concern to Wisconsin growers include nitrogen, phosphorus, potassium, calcium, boron and zinc.

Nitrogen

Nitrogen is the nutrient most commonly applied to fruit crops. It is usually applied in one of two inorganic forms: ammonium or nitrate. Research comparing these two forms of nitrogen have shown each to be equally effective in supplying nitrogen to most fruit crops, however, cranberries and blueberries use only ammonium nitrogen. Nitrogen may also be applied in organic forms as manures, fish hydrolysate, mulches, etc. The timing of nitrogen fertilizer applications can affect their efficiency and potential for losses. Sources that are least expensive per unit of nitrogen are preferred.

Phosphate

Wisconsin soils typically contain enough phosphate to supply plant needs. An average fruit crop would remove only 6 to 12 pounds of phosphate per acre per year. This amount does not need to be applied annually. As phosphate is removed from the soil solution by plants, additional previously insoluble phosphorus moves into the soil solution to maintain an equilibrium. This phosphorus is available because it binds tightly to the soil matrix in a plant available but relatively immobile form.

The best time to add phosphate fertilizer is before the crop is planted. Based on a pre-plant soil test, the soil should contain 25 ppm soil test phosphorus. Once plants are in the ground it is difficult to incorporate phosphate fertilizer into the rooting zone. Maintaining soil pH between 6 and 6.5 will ensure maximum availability of soil phosphorus.

All commonly used phosphate fertilizers presently sold in Wisconsin (except rock phosphate) contain at least 85% water soluble phosphorus. Rock phosphate is not an effective phosphorus source for most Wisconsin soils.

Potassium

Fruit crops are relatively heavy potassium users. Some Wisconsin soils will require additions of applied potassium because of removal by crops and because Wisconsin soils have little native exchangeable potassium. A typical acre of soil may contain 20,000 ppm of total potassium in the top 6 inches, but nearly all of this is a structural component of soil minerals and is unavailable to plants. Plants can only use the exchangeable potassium on the surface of soil particles and the potassium dissolved in soil solution. A soil test measures the readily available form of potassium in soil. Tissue testing is critical to monitoring potassium levels. A fruit crop may remove 20 to 40 pounds per acre of potash per year. Potassium deficiency can be exacerbated by high tissue nitrogen or low soil moisture.

Potassium fertilizer is best added to soils and incorporated before the crop is planted. Soil test levels of about 100 ppm (200 lbs/A), depending on soil type, are recommended. If tissue or soil samples show low potassium levels, it should be corrected as soon as possible. In areas where potassium deficiency is a problem annual applications of potash may be warranted, depending on the crop and soil type. If soil potassium levels are high, less potash fertilizer is needed allowing for some decrease in soil test level.

Calcium

Calcium is critical for the growth of quality fruit. It binds cell walls together and helps maintain fruit firmness. Bitter pit and cork spot are physiological disorders of apple that are calcium related. Wisconsin soils typically contain adequate amounts of calcium. However, adequate amounts of calcium may not reach developing fruit. Calcium is relatively immobile in plants and developing fruit are not able to draw calcium from adjacent tissues. Calcium deficiency can be exacerbated by high nitrogen and low soil moisture.

Calcium is the predominant positively charged ion held on soil and organic matter surfaces. Leaching of calcium does not occur to any appreciable extent because of its relatively strong attraction to the soil.

The relationship between tissue test calcium and flower bud or fruit calcium is not very strong. Even if tissue levels of calcium are sufficient, fruit may be deficient. Calcium moves into tissues through the xylem in the transpiration stream. Since fruit don't lose a lot of water through evaporation, not enough calcium may flow to the fruit. Some apple cultivars are more susceptible to calcium related disorders than others. A history of calcium related fruit disorders is good evidence that additional calcium is needed.

Applying calcium to the soil has not been an effective fertilizer practice to increase leaf or fruit calcium concentrations. Soil limed to pH 6-6.5 has more than adequate levels of available calcium for fruit crops. The problem is in moving calcium to the developing fruit. To improve fruit calcium content, calcium can be applied directly to the fruit and absorbed through the skin. Calcium chloride is the least expensive form of calcium that can be applied to fruit plants to increase tissue calcium. Calcium chloride is very corrosive to metal so spray equipment should be cleaned thoroughly after application. Calcium chloride can build up on leaves and cause leaf burning. Repeat applications should not be made unless rain has been received since the last application.

The recommended application regime for apples is to add calcium chloride to cover sprays beginning with the first cover spray (early June) at the rate of 2 lbs per 100 gallons dilute or 4 lbs per acre concentrate. This can be increased to 3 lbs per 100 gallons and 6 lbs per acre concentrate for later sprays. Calcium chloride is compatible with most pesticides and should not alter their action nor affect fruit finish. Three or four applications per year should be sufficient to increase fruit calcium content. Calcium sprays will not eliminate calcium related disorders, but should reduce their incidence.

Boron

Boron is the micronutrient that is most likely to be deficient in fruit plantings in the Midwest. Soils may contain 0.5 to 2.0 ppm of available boron, but more that 5.0 ppm available boron can be toxic to many crops. Most of the boron in soils is in the organic matter. As a result, most of the available boron is in the plow layer where organic matter is highest. Soils low in organic matter are deficient in boron more often than soils with high organic matter content. Soils with a pH of 7.0 or above are more likely to be deficient in boron than are more acidic soils.

Boron is essential to proper flower development and pollen germination. Although required in small amounts its role is very critical and deficiencies may reduce yields severely. Minor deficiencies can be corrected by soil application of boron containing fertilizers. Severe deficiencies can be mitigated by foliar application. The most common boron fertilizers are borax and sodium tetraborate. Solubor, sodium pentaborate and boric acid are used occasionally for soil application or in a foliar spray. Foliar boron is usually applied as a soluble 20.5% wettable powder applied at 2.5 lbs per acre or 10 ounces per 100 gallons dilute. Do not apply over 5 lbs of boron per acre per year as toxicity may occur. Soil application can be made at any convenient time during the year. Foliar application should be made in the fall after harvest but while the leaves are still green and active or in the spring at the pink stage of flower development.

Organic fertilizers

Nutrients can also be applied in organic forms such as manures, compost, mulches, etc. These materials have the added advantage of adding organic material to the soil which will help maintain soil structure, improve water holding capacity and drainage characteristics. Composts and mulches have relatively little nutrient value (Table 8). These are usually considered soil conditioners, and credit is usually not given to their minimal nutrient content. However, sometimes organic materials such as manure cannot supply all of the nutrients needed by plants in sufficient quantities to optimize yields. Supplementing organic fertilizers with synthetic fertilizers may be necessary for best management of applied nutrients and optimum yields.

Organic fertilizers are, by their very nature, highly variable in their nutrient content. Approximate nutrient values of various organic fertilizers are listed in Table 5.

Table 5. Estimates of available nutrients from various organic fertilizers for a single year of application, surface applied.

Organic material	Dry matter	Total Available Nutrients		
		N	P_2O_5	K_2O
	(%)	---------lbs/ton (fw basis)---------		
Dairy manure	13	3	3	8
Beef manure	12	4	5	8
Swine Manure	9	4	3	7
Poultry manure	25	13	14	9
Horse manure	20	10	8	10
		------------% dry weight-----------		
Bone meal		0.2-1.0	12-14	--
Dried blood		13	1.5-2.0	1
Fish meal		9-11	5-8	0-3
Fresh leaves		0.5-1.0	0.05-0.08	0.3-0.6
Grass clippings		1	0.3	2
Sewage sludge		2-6	2-3	0-1
Wood ashes		0.5	0.8-10	2.0-3.5
Compost (yard debris)		0.3	0.2	0.4

Some of these data were extracted from Organic Soil Conditioners (A2305) by E.E. Schulte and K.A. Kelling.

Summary

Fertility of fruit crops is an important management practice where much misinformation exists. Plants require light, water and 13 mineral elements to grow and produce fruit. Growers need to be sure that these needs are met. Once you provide an adequate nutrient supply, additional nutrient applications will not enhance yields, only reduce profits. You can monitor the nutrient status of your fruit crop by routine soil and tissue analysis. By doing so, you can prevent deficiencies before they occur and minimize inefficient use of applied nutrients.