Developing Fertilizer Programs for Fruit Crops Utilizing Soil and Tissue Analysis
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Fertilizer decisions for fruit crops should be made based on scientific evidence of need. This is accomplished using tissue analysis every 1-2 years and soil analysis every 3-4 years. A tissue analysis indicates the levels of macro and micro nutrients present in the plant. Optimal levels of each nutrient have been established for specific fruit crops, and in some cases cultivars, based on research. A soil analysis indicates the levels of macro (not nitrogen) and some micro nutrients available in the soil, as well as pH. However, many fruit growers do not use these tools, and instead base their fertilizer decisions on previous experience, advice from sales representatives, recommendations listed on the fertilizer container, plant age, or plant appearance. When decisions are made based on previous experience, a grower could be missing interactions of elements that are hindering production and/or quality. This can also lead to the over-application of nutrients the plant does not need. Although recommendations on fertilizer containers have a scientific basis, they are considered a maintenance amount and are not reflective of the nutrient needs of a specific farm site. Plant age does not take into account specific plant needs, or soil nutrient levels. When fertilizer decisions are based on visual appearance, reductions in crop yield or quality may have already occurred. Diagnosing based on appearance alone does not take into account nutrient interactions.

Excessive rates of certain nutrients can cause interactions leading to deficiencies of other nutrients. For example, high rates of nitrogen can lead to an induced potassium deficiency which has a negative impact on winter hardiness and fruit size. An over application of potassium can lead to an induced deficiency of calcium. The lack of scientific evidence when making fertilizer decisions can result in over- as well as under-applications of many nutrients. The resulting imbalance can affect yield, quality, and may contribute to ground or surface water contamination. An excess amount of phosphorus doesn’t impede plant growth but creates environmental problems that are well documented. Nutrient imbalances can also affect the longevity of a planting which can have an economic impact on a farming operation. Nutrient deficiencies can result in stunted growth, reduced fruit yield and quality, and overall reduced plant health. Excessive rates of nutrients can cause a delay in fruit maturity, an over-abundance of vegetative growth, reduced bud set, and an increase in insect and disease problems. Improper soil pH for a crop can lead to nutrient deficiencies and toxicities affecting fruit quality and plant health.

Combine factors to develop a fine-tuned fertilizer program. Simply put, combining factors that impact nutrient usage, availability and uptake, with tests that provide the status of the nutrients in the soil and plant, will allow for the development of a fine-tuned fertilizer program, and avoiding over- and under-application of nutrients. These include soil and tissue analysis, crop load, tree and plant growth, ground management, environmental conditions, fungicides and previous materials used for fertilizer programs.

Soil analysis indicates the pH level and the amount of nutrients in the soil that are available for uptake by the plants. The macro-nutrients potassium, phosphorus, magnesium and calcium are standard. Some labs will also indicate the level of several micro-nutrients – boron, copper, iron,
zinc, manganese, sulfur and aluminum. Nitrogen is a ‘moving target’ and soil tests are not reliable indicators of the amount available to the plants. Relying on this test alone for fertilizer decisions does not take into account what is in the plant or other factors impacting nutrient uptake. It is important to note that if the pH is outside of the recommended range for the fruit crop, even if there is an ample supply of nutrients in the soil, one or more of them may not be as readily available to the plant as they would if the pH was within the optimum range.

Soil samples may be taken any time the soil is not frozen. A single sample may encompass up to 10 acres if the entire area has been treated the same, the soil type is the same, the age of the fruit crop is the same (young plantings are often fertilized differently than older plantings), and the topography is the same. Otherwise, smaller sampling units are recommended. Sample pre-plant and every 3-4 years throughout the lifetime of the planting.

Samples should be taken going to a depth of six to twelve inches, removing the top one inch of soil to avoid skewing the results from recently applied ground fertilizers, as well as foliar nutrient sprays and pesticides containing nutrients that settled on the soil surface.

There are several extraction methods used by labs each with established standards for nutrients. It is difficult to compare results year to year or look for trends when the standards are different. Once you have chosen a lab, stick with that lab or a lab using the same method.

At least once during the lifetime of the crop, ask the lab for the percent organic matter (OM) in the soil. This is important for nitrogen decisions. Roughly 10-20 pounds of nitrogen per acre is released for each 1% OM, dependent on soil temperature and moisture level. Of that, approximately 60% is available to the plant. For example, soil with an OM content of 4% may have 40 to 80 pounds of nitrogen released, and of that approximately 24 to 48 pounds of nitrogen per acre would be available to the plant. Some sites may not need additional nitrogen applied in a particular year.

Compost should be tested for nutrient levels prior to application. In addition to adding organic matter to the soil, compost contains many nutrients at various amounts and should be taken into account when determining fertilizer rates.

Pre-plant soil analysis is critical. This is the time to incorporate needed amendments, and to adjust the pH if needed. Incorporation is difficult after planting.

**Tissue analysis** indicates the level of macro- and micro-nutrients that are in the plant with standards that have been developed for most deciduous fruit crops. Samples may be taken anytime but standards have been established for specific times during the growing season when most nutrients are fairly stable.

Foliar sampling of tree fruit is 60 to 70 days after petal fall; grape petiole sampling may be done at bloom or veraison; June bearing strawberry foliar sampling uses the first fully developed trifoliolate leaf after renovation; day-neutral strawberry sampling consists of the most recently mature tri-foliate leaf; brambles, blueberries, currants and gooseberry foliar sampling is late July through early August.
Results will vary with plant stresses including a lack of water, too much water that creates waterlogged soils, crop load, pest injury (foliar pests, borers and vole damage); pesticides containing nutrients (copper, sulfur, mancozeb, etc.); and with cultural practices (pruning, ground management, previous fertilizer practices, etc.).

For troubleshooting, sample plants that exhibit visual or suspected symptoms separately from those that appear healthy.

Nutrient availability depends on several factors including:

1. **Soil texture** is indicative of the percentage of sand, silt and clay in the soil. Soil with a high percentage of sand does not hold onto or bind to nutrients as well as soils with a high percentage of clay. Often split applications of nutrients are recommended on sandy soils to allow for maximum uptake by the plants and reduced movement away from the root zone.

2. **Soil pH** measures the acidity and alkalinity levels using a logarithmic scale ranging from 1 to 14 with 7 being neutral, below 7 is acidic and above is alkaline. pH impacts the availability of nutrients. Ideal pH differs with specific fruit grown and is based on plant needs. For example, blueberries prefer a pH of 4.5 to 5 (#1 on the chart below), a range where iron is readily available in the form the plants utilize; brambles, currants, gooseberries, strawberries and deciduous tree fruit prefer a pH of 6 to 6.5 (#3). The type of grape determines the optimum soil pH. Native varieties (Concord, Fredonia, Niagara) prefer a pH of 5.5 to 6 (#2); hydrid

(Soil pH graphic source unknown)
(Cayuga, Traminette, St. Croix) prefer a pH of 6 to 6.5 (#3); and European varieties (Chardonnay, Pinot Gris, Cabernet Franc) grow best with a soil pH of 6.5 to 7.0 (#4). Will these fruits grow well outside of these pH ranges? Yes, if the pH is not too far off, but they will grow best within the optimum range. For instance, blueberry will do OK (not great) at a pH of 5.5 with high organic matter but not above that pH range. Native grape varieties are used to our naturally acidic soils while European grape varieties are used to the more alkaline soil pH of Europe.

3. The concentration and balance of existing mineral nutrients in the soil impacts the availability of other nutrients. For example, a high soil level of potassium will have a negative impact on the availability of magnesium, calcium and nitrogen. This makes a visual diagnosis of nutrient deficiencies difficult.

4. **Available water**: water is required to move nutrients through the soil and throughout the plants. During a drought, deficiency symptoms may become visually evident even though there is ample in the soil. For example, potassium deficiency was common during the drought of 2016 while soil levels were adequate. Severe deficiency results in premature drop in apples as well as necrosis on leaf margins.

5. **Ground management**: vegetation under trees and plants will compete for available water and nutrients. A permanent ground cover will often necessitate an increase in nitrogen. There are situations when this vegetation may be advantageous. A mature planting that has no crop will tend to produce excess vegetative growth. Allowing vegetation to compete for nitrogen may lead to reduced, manageable growth. However, in most situations, reducing or eliminating competition is preferred.

6. **Climatic conditions** such as heat and moisture positively impact soil microbial activity. Many nutrients are converted to forms readily available for plant uptake by soil microbes. Organic phosphorus is converted by soil microbes to the inorganic form plants can take up. In addition, roots don’t absorb as much in cold soils as they do in warm soils which is one reason phosphorus deficiency symptoms may be observed during a cool spring. Once the soil warms, the deficiency symptoms disappear.

7. **Condition of the root system**: impaired or damaged roots (from water-logged soils, rodent damage, soil compaction or other causes) are unable to move water and nutrients into the plants creating the potential for deficiencies of one or more nutrients to occur.

Let’s look at an example. Soil and tissue samples were analyzed for 15-year-old apple trees showing typical potassium deficiency symptoms – necrosis on the leaf margins. The tissue results indicated a very low amount in the trees which aligned with the visual symptoms. However, the soil test results indicated more than enough potassium in the soil and the pH was within the
optimum range. The results also indicated magnesium and calcium were within the optimum range and therefore were not impeding the uptake of potassium. The potassium was readily available to the crop. Why then was the potassium in the soil not being taken up by the trees? Time to look at other factors. The root systems of the trees were not impaired. Herbicide strips were under the trees eliminating competition for available water and nutrients. The crop load was moderate with average sized fruit. However, that summer, there was a severe drought. No irrigation system was in place and no supplemental water was applied. Recommendation: no additional potassium is needed, but irrigation is.

Problems with guessing

1. **Multiple deficiencies may exist.** The visible symptom may be indicative of a true deficiency or it may be the result of a toxic level of another element. For example, a high level of potassium may impede the uptake of calcium and magnesium resulting in deficiency symptoms, even though there are ample amounts of those two nutrients in the soil. Multiple deficiencies may also mask the underlying problem such as a lack of or too much water, poor root system or a compromised root system.

2. **Guessing may result in**

   - Inadequate or excessive tree or plant vigor
   - Over or under nutrient applications
   - Poor fruit set
   - Reduced fruit quality
   - Misdiagnosis – for example, the problem pictured to the right is boron deficiency and has been mistaken for stink bug injury, and vice versa.

3. **Costs you money** from over or under-application of nutrients which impacts your bottom line.

4. **Once visual symptoms are evident, damage has already occurred.**

**Long term management decisions:**

1. Supplemental water is needed during dry periods
2. Tissue analysis annually, or at least every couple of years
3. Soil analysis every 3-4 years using the same lab each time or one that uses the same testing method
4. Combine both the soil and tissue analysis with crop load, tree and plant growth, ground management, environmental conditions during that growing season, fungicides used, and cultural practices for fine-tuned fertilizer programs
5. Comparing results from year to year will show a reliable trend.

Contact your local Extension Educator for questions and guidance developing a sound nutritional program.
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