Interpreting Soil pH and Saturation Percentage Measurements

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This article is the first in a series of articles on understanding soil tests and making management decisions based on information provided in them. An article was written in the May 2009 issue of this newsletter and is available at http://cetehama.ucdavis.edu/newsletters.htm. The title was Soil Testing and Analysis: What to Expect in the Report and it discussed some basic principles of soil science that influence soil testing and the types of information reported. This article will focus on the role of soil testing in orchard management, describe steps to acquire informative soil testing information, and discuss two of the more familiar parameters in a soil test report: pH and saturation percentage (SP).

Soil testing helps understand the orchard soil environment and how to prevent or correct nutrient deficiencies, toxicities, or conditions that affect the availability of water to the trees in a cost effective manner. Soil testing may forewarn a problem before it actually affects growth and production. Therefore, it helps anticipate possible problems and offers the earliest opportunity to manage them. Soil testing is not a substitute for plant tissue testing, rather it is complementary. If soil and leaf tissue analyses both indicate a deficiency or toxicity, the diagnosis is obvious. If a soil analysis indicates a deficiency or toxicity but a leaf tissue test does not, it may only be a matter of time before the deficiency or toxicity develops in the trees. Conversely, if leaf tissue analysis indicates a deficiency or toxicity but soil testing does not, it may point out that either the soil testing does not represent how the trees' root system integrates the soil environment or that the soil environment has changed more rapidly than the nutritional status of the tree.

There are two basic philosophies for sampling soils. When marginal soil is known or suspected to exist**,** consider routine soil testing (at least every two or three years) to understand trends and guide long-term management. When confident that the soil is fertile, non-saline, and suitable for orchard crops such as walnut**,** almond and prune, sampling is only necessary to troubleshoot problems. Some situations do arise where a switch in sampling approach may be necessary. For example, when a change from a higher quality to lower quality irrigation water supply occurs, a change in approach from troubleshooting to routine testing may be necessary. Regardless of which approach is taken, soil sampling must represent the orchard for the test results to be of value. Within reason, sampling needs to be undertaken using methods that consider the type of irrigation system and cope with spatial and temporal variability in soils. Results from unrepresentative sampling may be misleading and costly. Sampling soils and analyzing for fertility and salinity status at multiple soil depths can give insight about irrigation and about using fertilizers and soil and water amendments.

The ***saturation percentage*** **(SP)** equals the weight of water required to saturate the pore space divided by the weight of the dry soil. Saturation percentage is useful for characterizing soil texture. Very sandy soils have SP values of less than 20 percent; sandy loam to loam soils have SP values between 20 and 35 percent; and silt loam, clay loam and clay soils have SP values from 35 to over 50 percent. Also, salinity measured in a saturated soil can be correlated to soil salinity at different soil-water contents measured in the field. As a general rule, the SP soil-water content is about two times higher than the soil-water content at field capacity. Therefore, the soil salinity in a saturation extract is about half of the actual concentration in the same soil at field capacity.

The *pH* of a soil measures hydrogen ion concentration (activity) and is sometimes referred to as soil reaction. Soil pH is closely related to bicarbonate concentration and can influence the availability of nutrients. It does not correlate with salinity in the root zone. The pH of soils in orchard production regions in the central valley of California commonly range from 5.5 to 8.4. Generally, fertility research and anecdotal experience has indicated that soil pH between 6.0 and 7.5 is ideal and attempts to change the pH within this range are unlikely to affect production. Soil pH below 5.5 and above 7.5 will begin to influence nutrient availability. Soil pH below 5.5 may result in calcium (Ca), magnesium (Mg), phosphorus (P), or molybdenum deficiency and perhaps excesses of manganese (Mn), iron (Fe), or aluminum (Al). Soil pH above 7.5 will begin to immobilize Mn, Fe, zinc (Zn), and copper (Cu) and deficiencies are more likely to occur when the soil pH is above 8.4

Orchards with soil pH below 5.5 are more likely to benefit from liming. Table 1 outlines approximate rates of limestone for different soil textures to increase soil pH from 5.0 to 6.0. The lime requirement is dependent upon soil texture, the volume of soil amended, the initial soil pH and the desired change in soil pH. Costs to increase soil pH can be expensive. One method of reducing the cost is to apply the liming material in bands and control where the soil pH is increased. The liming material should pass a 60 mesh screen to react more efficiently and must contain carbonate (CO_3) or oxide (OH) to increase soil pH. Some other alternative liming materials include dolomite, sugarbeet lime, burnt lime, and hydrated lime.

Table 1. Approximate rate of limestone (100 percent $CaCO_3$ equivalent) needed to increase soil pH from 5.0 to 6.0 in an acre-foot of soil. [1]

Soil Texture	Lime Requirement from pH 5.0 to 6.0 (tons per acre-foot soil)
Sand and loamy sand	1.0
Sandy loam	1.8
Loam	2.5
Silt loam	3.0
Clay loam	3.6

[1] Table 1 is adapted from USDA Agricultural Handbook No. 18

Orchards with soil pH above 8.4 may benefit from applying acid forming amendments such as sulfuric acid or sulfur to lower the pH. When preparing land prior for planting, effective rates of sulfuric acid have ranged from 1 to 4 tons of acid per treated acre applied in a band to optimize cost and effectiveness. In established orchards, a single application of sulfuric acid in a band should not exceed 1,500 pounds per treated acre to avoid injuring the trees. Sulfuric acid may also be applied through irrigation systems as an alternative to banded soil applications. An equivalent rate of sulfur can also be applied in a treated band of soil. If sulfur is banded it needs to be incorporated into the soil to be most effective. Gypsum is neither a rapid reacting liming nor acidifying material. It is a pH neutral amendment.

Future articles will discuss additional soil test parameters related to diagnosing and managing soil salinity, infiltration problems, specific ion toxicity, and N,P, and K nutrient management.