Better Growing

By Tim Spann
Research Program Director

Little & Often

Key to Maximizing Fertilizer Use in Avocado

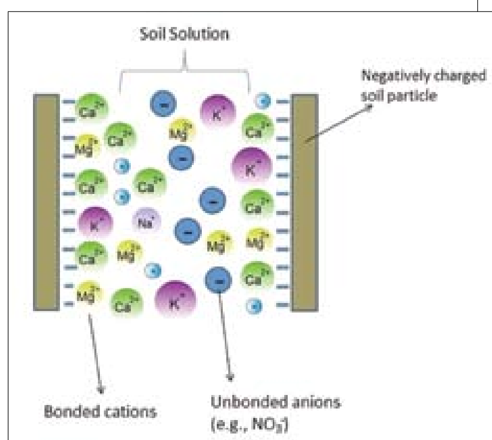
In the last issue of *From the Grove*, I wrote about the 14 essential mineral nutrients for plants and how they affect the health and overall performance of the trees in your grove. Now I am focusing my attention on application methods and how to maximize the bang for your buck. In order to optimize fertilization practices, you can learn a lot by looking at the avocado tree itself.

Avocado Ecology and Biology

The Mexican and Guatemalan races of avocado, hybrids of which make up the California industry, are native to what are commonly referred to as tropical highlands (up to about 8,000 feet elevation). Ecologically speaking, this climate is referred to as a montane forest (mountain forest). In the tropics and subtropics, this is typically a broadleaf forest that gains a large portion of its moisture from clouds and fog (cloud forest). These forests have an abundance of vegetation from low growing mosses and ferns to mid-canopy species and towering trees. Despite their elevation, these forests have a fairly warm mean annual temperature (60°F) due to their latitude.

Under these conditions (warm and moist), organic matter decomposes quickly. Leaves and limbs fall from trees, are quickly broken down by fungi and insects on the forest floor and the nutrients released are taken up by the surrounding plants. That is to say, there is a constant small supply of nutrients available to the plants growing in this environment. When these factors are combined — high moisture, warm temperatures, continuous supply of nutrients — we begin to understand a little more about why avocados grow the way they do.

Avocados are characterized as having a shallow root system with the majority of roots in the top 18-24 inches of soil. Their roots also lack root hairs — outgrowths of individual root cells that aid in nutrient uptake. Since water and nutrients are abundant in the surface layers of the soil in their native environment, the avocado has not evolved a deep root system to mine the soil for water, nor has it developed root hairs to increase the root surface area and better scavenge for nutrients. In addition, the rapidly degrading organic matter layer on the soil surface in the cloud forest is very well aerated — it feels spongy when walked on — and, as



An illustration of soil cation exchange capacity (CEC) showing positively charged cations bonded to negatively charged soil particles. Negatively charged anions are not bound and remain in the soil solution.

such, avocados are not well-adapted to heavy, poorly drained soils. Therefore, we should try to emulate these conditions as much as possible in a grove setting to maximize the tree's growth and yield.

Little and Often

Little and often is the key to avocado fertilization — the key to all good fertilization programs actually. It is important to remember that the plant itself is not a reservoir of nutrients; that role is played by soil. So when fertilizer is applied, three things can happen to the nutrients: 1) they are taken up by the plant and utilized for growth and development; 2) they are retained in the soil by various bonding forces; or 3) they are leached out of the root zone and become unavailable to the plant and may become an environmental problem. Our goal —through horticultural management of a grove — is to maximize number 1, eliminate number 3, and utilize number 2 as efficiently as possible.

Let's begin by examining the second option on the list above, nutrient retention in the soil. In general, a soil's ability to retain nutrients is referred to as the cation exchange capacity (CEC) of a soil. A cation is a positively charged atom or molecule. Thus, the CEC is a measure of the capacity of a given soil to retain positively charged molecules, such as calcium (Ca^{2+}), magnesium (Mg^{2+}), potassium (K^{+}), ammonium (NH_4^{+}) and sodium (Na^{+}). CEC can be affected, for good or bad, by factors such as soil pH, clay content and organic matter. CEC generally moves in accordance with pH – as pH increases, CEC increases and vice versa. Cations held in the soil are available for exchange with the soil water and can then be taken up by plants (or leached away).

Similar to CEC, but not often thought of, is anion exchange capacity (AEC). Anions are negatively charged atoms or molecules and include important nutrients such as phosphorus ($H_2PO_4^{-}$), sulfur (SO_4^{2-}), nitrate (NO_3^{-}) and chloride (Cl^{-}). AEC generally moves in opposition to pH: as pH increases, AEC decreases and vice versa.

It is important to know your soil's CEC in order to have an estimate of its nutrient-holding capacity. If you fertilize infrequently with large concentrations of fertilizer, you are relying on the soil's CEC to retain the nutrients and release them into the soil solution with each irrigation. However, if your soil has a lower CEC than you think (or it has changed due to pH changes since your last soil test) or if a heavy rain event happens (or an irrigation line breaks), you could leach most of those nutrients from the soil before they can be utilized by the plant.

Roots absorb only dissolved nutrients in direct contact with live cells. Depending on the nutrient, this process may be passive (no energy is expended by the plant) or active (the plant uses energy to take the nutrient in). Regardless, the nutrients must be available to the plant when it needs them. So when do plants need nutrients? Constantly. As long as a plant is growing (roots, stems, leaves, fruit) nutrients are required to support that growth. In some instances the plant can move nutrients from one organ to another — only mobile nutrients can be moved — but this is a "robbing Peter to pay Paul" scenario. For example, during bloom and early fruit set — a period of high nutrient demand — it is common to see leaf yellowing on shoots with heavy bloom. The tree has moved mobile nutrients (e.g., nitrogen) from the leaves to support a very demanding process. This tells us that not all periods of growth are equal when it comes to nutrient demand. Bloom and shoot flushes are periods of high nutrient demand, for example.

Given the potential risks surrounding heavily relying on soil CEC to meter your fertilizer supply and the uneven demand of the tree throughout the year, we start to see that more frequent applications of small amounts (little and often) of fertilizer are best. This also mimics what happens in the natural environment where avocados are constantly taking in nutrients as they are released from decomposing organic matter. Since the tree is constantly taking up water (and nutrients along with it) it is ideal for there to be a constant supply of nutrients available in the soil water.

A fertilizer program that relies on three large applications a year to supply all the nutrients the tree needs is generally inefficient. Since the tree can't take all that nutrition in at one time it must be retained in the soil, and inevitably some is lost to leaching. By increasing the number of fertilizer applications per year — as often as every irrigation for a liquid fertilizer program — the actual amount of fertilizer applied can be reduced. This is because the fertilizer use efficiency increases due to the reduction of fertilizer lost to leaching, i.e., a higher percentage of what is applied ends up in the tree. In extreme cases in some crops, moving to a little and often fertilizer program can reduce fertilizer use by up to 75 percent with no reduction in yield.

For those who use a dry granular fertilizer program, you can still supply nutrients in small, metered doses by using slow release fertilizers. Slow release fertilizers are composed of small prills coated in a membrane that slowly allows the fertilizer to be released. Good quality slow release fertilizers can mimic a little and often liquid fertilizer program. However, slow release fertilizers are not well suited to drip irrigation situations since the prills need to be moistened to release the fertilizer.