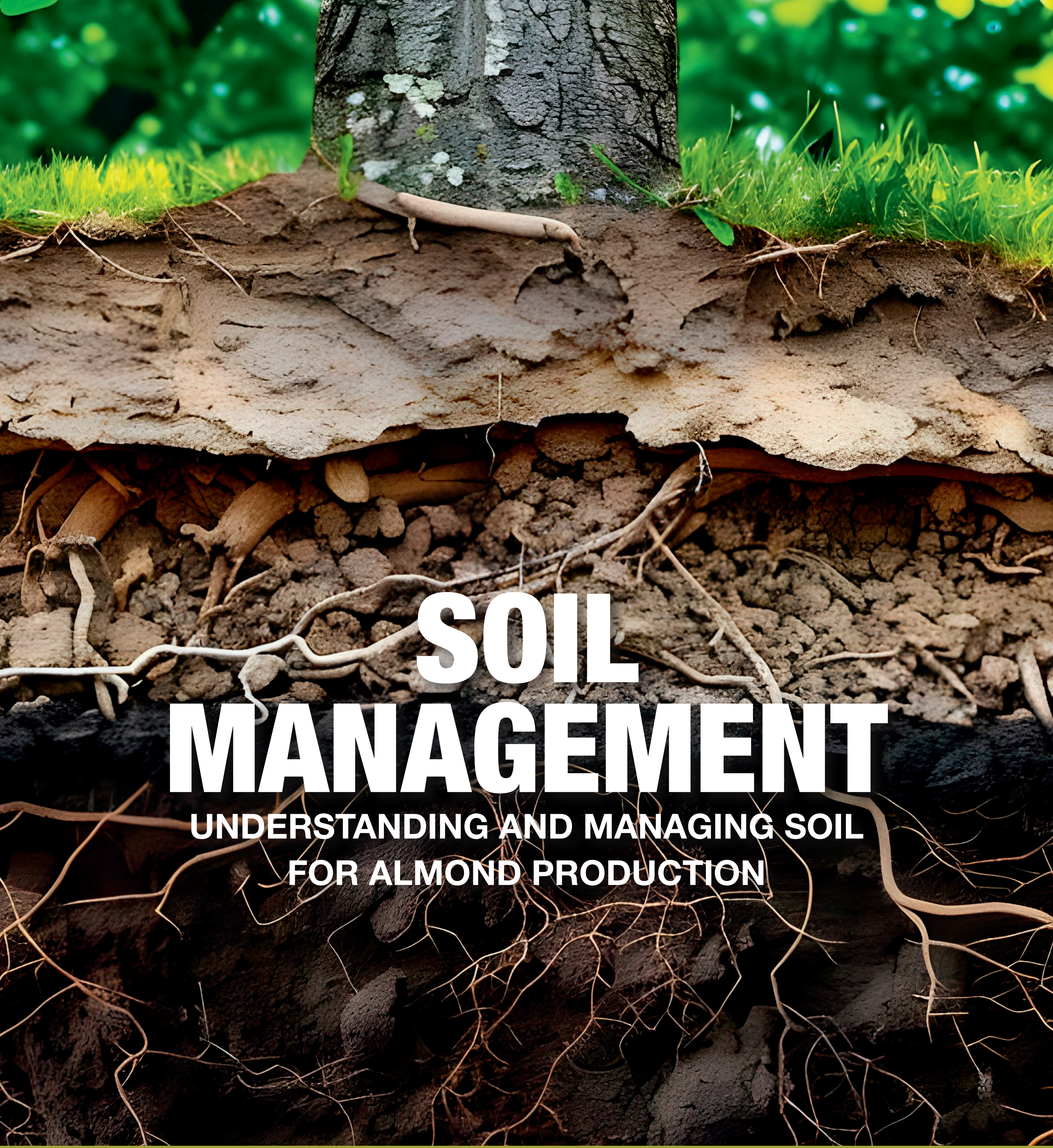

SOIL MANAGEMENT

UNDERSTANDING AND MANAGING SOIL FOR ALMOND PRODUCTION

california almonds
Almond Board of California

UNIVERSITY OF CALIFORNIA
Agriculture and Natural Resources

TABLE OF CONTENTS

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INTRODUCTION

This resource highlights the key physical, chemical, and biological properties of soils that influence almond orchard productivity. A soil profile is more than just the surface layer. Soil is a living, layered system that anchors trees, stores and moves water, recycles nutrients, and supports diverse organisms. Understanding the full profile, from topsoil to sub-soil, is essential for managing water, fertility, and long-term orchard health.

THE SOIL PROFILE

Soil consists of layers (horizons) that differ in texture, color, structure, chemistry, and biological activity. Each soil horizon contributes differently to tree growth. The topsoil is where organic matter accumulates and biological life resides, providing nutrients for growing plants, while deeper layers often control water movement and root penetration.

Soil Particles and Texture

Soil particles are the fundamental building blocks of soil, comprising over 90% of the solid material in soil. The relative amounts of sand, silt, and clay determine a soil's texture class (Figure 1). Sand particles ranging from less than 2 mm to 0.05 mm, are tiny rock fragments comprised of several minerals or solely quartz minerals. Silt is similar in shape and mineral composition to sand, but the particles are much smaller, between 0.05 mm to 0.002 mm. Clay particles are the smallest, < 0.002 mm, are flat and plate-like in shape and cannot be seen without magnification (Figure 2). Texture influences water-holding capacity, aeration, nutrient retention, and the ease with which roots explore the profile. While texture cannot be changed, it guides management choices such as irrigation scheduling and cultivation.

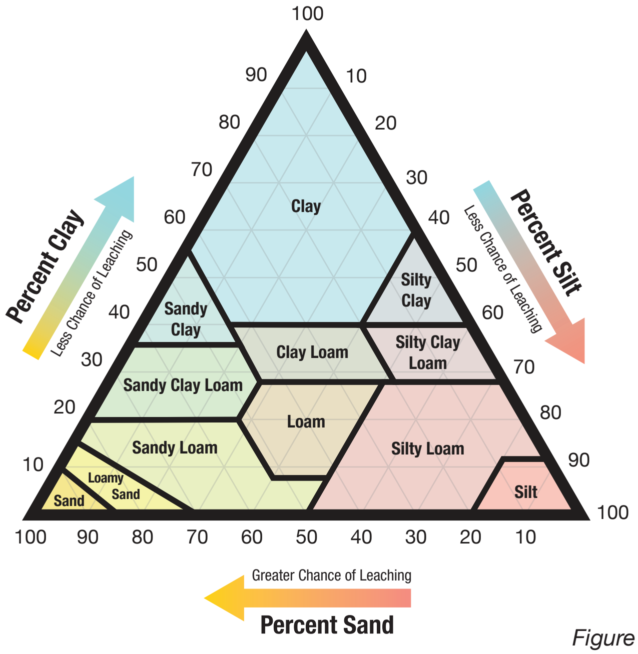


Figure 1

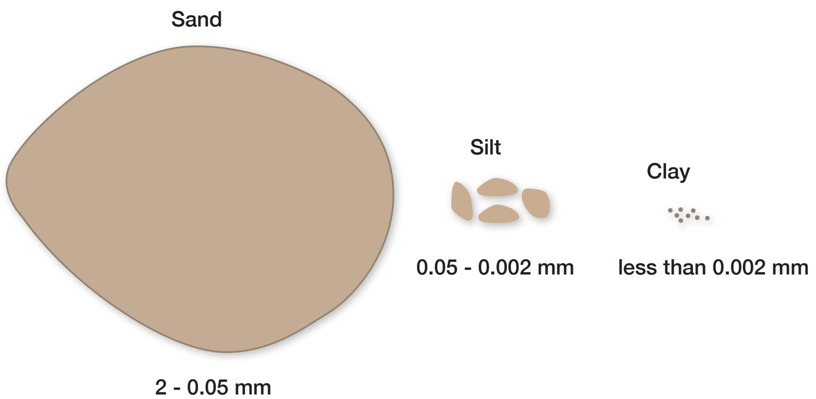


Figure 2

Soil Organic Matter (SOM)

SOM enhances fertility, water retention, and aggregate stability. Organic matter exists in soil in various forms, including living plant roots and soil organisms, fresh and partially decomposed plant residues, microbial exudates, dead microbes, and older more slowly decomposing organic compounds. Found mostly in the surface horizon, SOM supports microbial activity and nutrient cycling. SOM provides the binding agents that effectively glue soil particles together, increasing the strength of aggregates and resistance to erosion. Its presence is strongly influenced by texture, with fine clayey soils holding more SOM than coarse sandy soils.

Soil Structure and Aggregates

Soil particles and organic matter bind into aggregates that give the soil strength and create pores for air and water movement (Figure 3). Microaggregates (<0.3 mm) form through flocculation of clay, organic matter, and cations. These combine into larger macroaggregates (>3 mm) with help from roots, fungi, and organic matter. Stable aggregation improves infiltration, erosion resistance, and overall soil function.

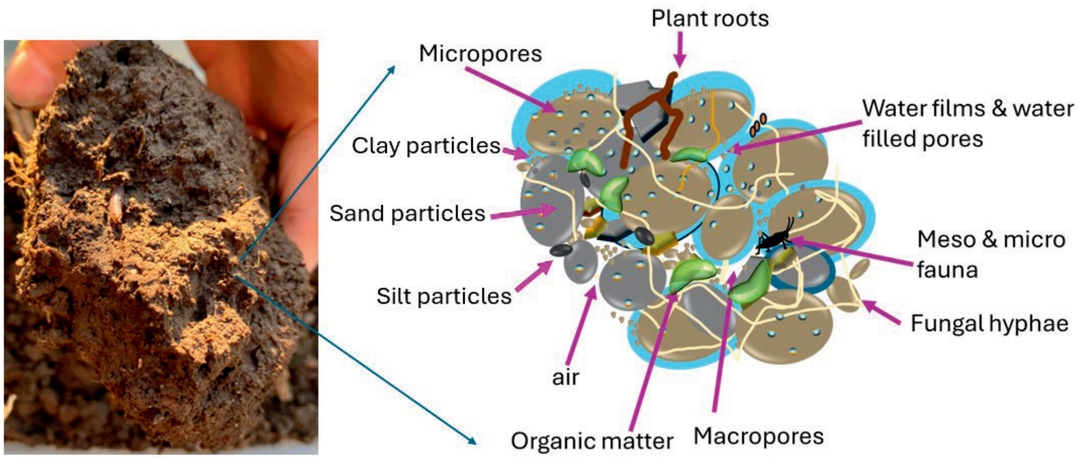


Figure 3

Soil pores

Air spaces known as pores form within and between clumps of aggregated soil. These pores are variably filled with water, air, or microorganisms depending on if the soil is wet or dry. Pores vary in shape and size depending on soil texture and the amount of aggregation in the soil. Macropores aid infiltration and drainage, while micropores store water and carbon. These characteristics directly impact orchard water and nutrient dynamics.

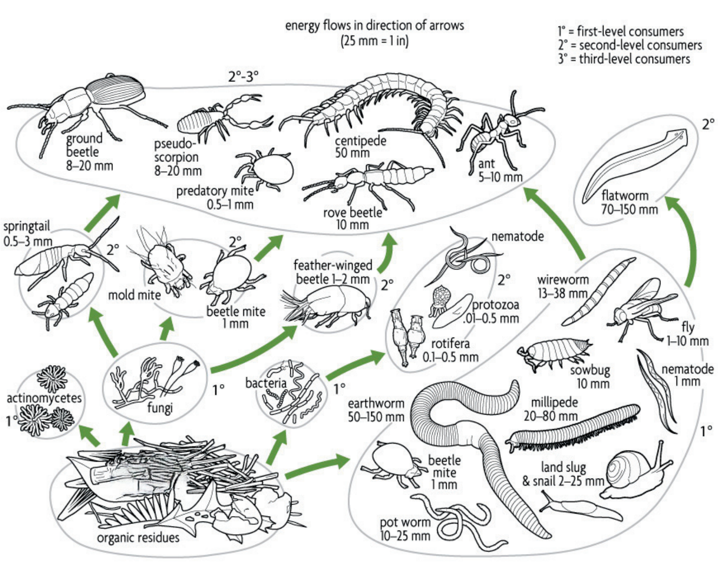


Figure 4. The soil food web. Modified from D.L. Dindal (1972). Adapted from illustration by Vic Kulihin.

Biological activity

There are is a diversity of creatures that spend their entire life in the soil. They occur in a wide range of sizes from large macrofauna (e.g. burrowing centipedes and earthworms) to microscopic microfauna (e.g. bacteria and fungi). All contribute to the soil 'food web' and the decomposition and turnover of organic residues they feed on (Figure 4). Earthworms create channels that impact the flow of water and air in the soil. Smaller living bacterial colonies and fungi excrete sticky substances that encrust soil particles and promote aggregation. Soil fungi also have filament structures, called hyphae, which extend into the soil and physically bind soil particles together (Figure 3), and can improve nutrient uptake via symbiotic association with tree roots.

FACTORS AFFECTING THE SOIL PROFILE

Soil can be significantly altered by both natural forces and orchard management operations. Seasonal wet and dry cycles, as well as fluctuations in soil moisture between irrigation sets can also impact the physical, chemical, and biological properties of the soil.

When heavy precipitation or irrigation exceeds the soil's ability to absorb it, water may either run off or pond depending on if the surface is sloped or level. On sloped surfaces runoff can erode soil structure, displace soil particles and move nutrients away from tree roots. On level ground, ponding is more likely, especially in areas with compacted or dispersed soils where the surface pores have been filled. Repeated cultivation and wheel traffic, particularly when the soil is wet, can exacerbate these conditions by creating soil crusts, surface compaction, and plow pans that limit root growth and slow water movement through the profile. Additionally, soils with high sodium levels or sodic conditions tend to develop poor soil structure and reduced infiltration capacity.

Surface ponding occurs when water cannot infiltrate or percolate through the soil profile, leading to saturated conditions that reduce the air movement through the rootzone. Low oxygen availability inhibits roots and microbial function, impairing plant uptake and nutrient cycling. Prolonged saturation can push soil particles apart, disrupting aggregate stability (Figure 5). As the soil dries to field moist or field capacity conditions (usually 1 to 3 days after an irrigation or precipitation event), excess water drains from pores, while residual soil moisture maintains cohesive forces between aggregates enhancing structural stability.

However, in extremely dry conditions, soils with weak aggregation and low SOM can result in structural breakdown (Figure 5). As the moisture that binds aggregates is depleted, soil may become very loose and highly vulnerable to loss to wind erosion. Strongly aggregated soils are more resilient to erosive forces such as intense precipitation, high winds, and extreme heat, making them better suited to withstand environmental stressors.

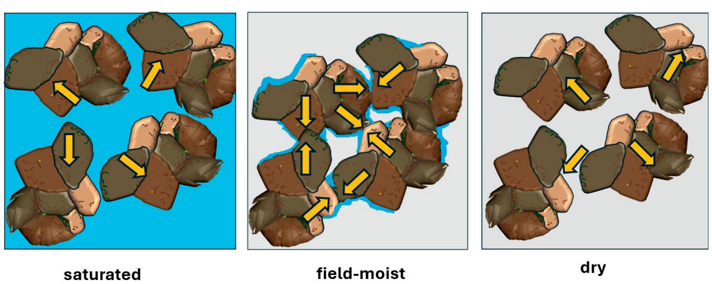


Figure 5

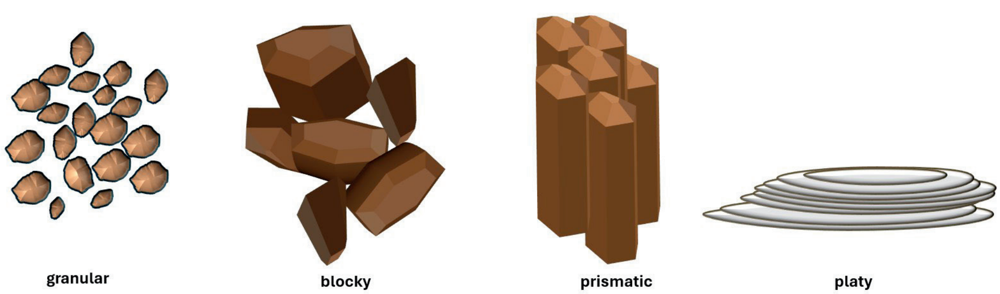


Figure 6

Structure changes with soil depth

Soil aggregates also known as 'peds' can take many different shapes and often differ significantly between soil horizons, from the surface layer to the deeper subsoil. In the topsoil, aggregates typically have a granular or single grain structure (Figure 6), which is loosely arranged and promotes rapid water infiltration. In contrast, subsoil aggregates tend to be larger and denser, which can restrict water movement, reduce aeration, and limit root penetration. Common subsoil structures include blocky and prismatic peds (Figure 6) that slow water drainage along the narrow cracks between aggregates. Platy thin, flat, horizontal structures are another type of ped that can be found either close to the surface or in the subsurface of compacted soil. Platy layers can greatly slow the movement of water and may need to be managed with cover crops or by mechanical ripping.

SOIL EVALUATION TOOLS

Understanding orchard soil conditions is important at the orchard planning stage for irrigation system design, and any time during the life of an orchard to make appropriate management decisions to support tree growth and productivity.

Web Based Resources

When assessing the soil profile, it is important to choose locations that are representative of the field conditions.

Web based soil maps (Figure 7) can provide insight into changes in soil type across the field and are useful to identify the most suitable locations for soil pit excavation to observe the entire soil profile. The UC Davis California Soil Resource lab offers a variety of tools to access detailed soil survey data (SSURGO) https://casoilresource.lawr.ucdavis.edu/soilweb-apps. These maps were prepared with field and laboratory verified soils information and extrapolated based on climate and repeatable landscape patterns using Geographic Information Systems (GIS). Digital soil mapping (DSM) is a relatively new approach to classifying soils that integrates information from soil sensors, SSURGO maps, satellite imagery, and machine learning to improve the accuracy of soil maps. Commercial DSM services are increasingly available to interpret on-farm soil conditions to assist growers with nutrient and irrigation precision management.

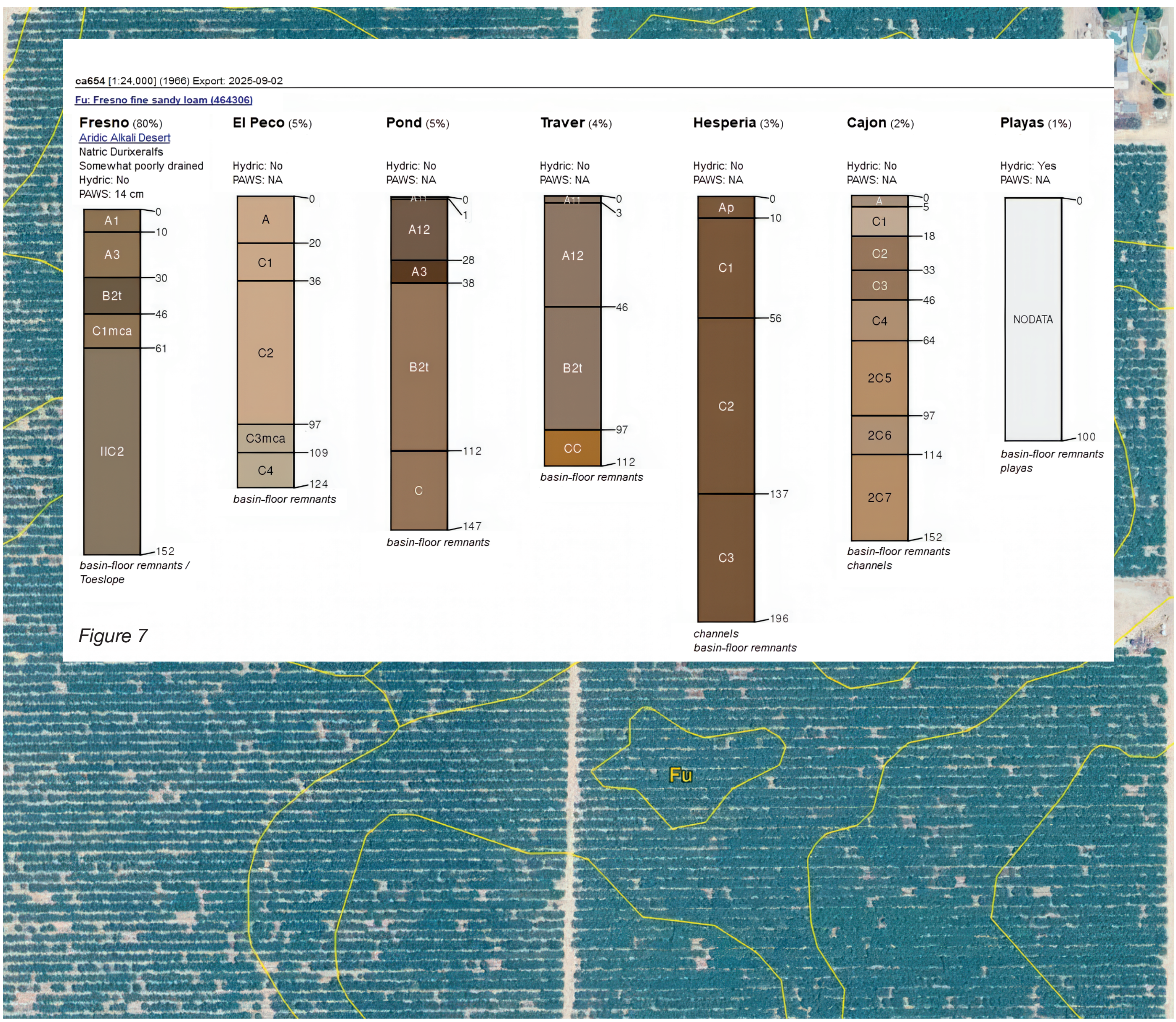


Figure 7

Field Methods

Whole profile evaluation can be conducted by excavating soil pits with a backhoe down to 5 to 6 feet. Soil pits provide important information about changing soil layers in an orchard (Figure 8). Visual inspection can reveal transitions in soil texture and structure that can impact tree rooting and the flow of water. Soil samples are commonly collected using augers or cores to a defined depth (often by one-foot increments).

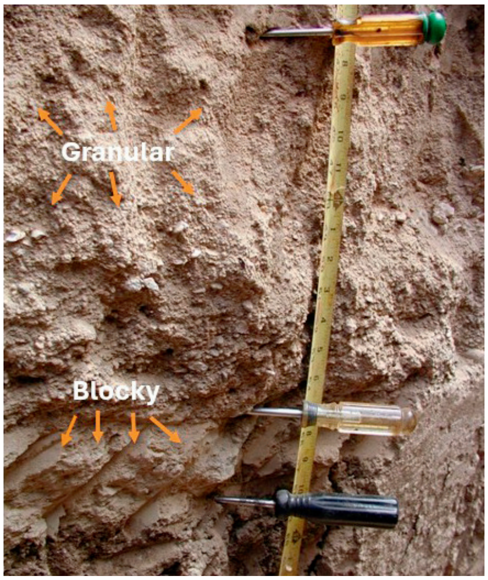


Figure 8

In-field soil infiltration measurement with a double ring infiltrometer.

Texture by Feel

Texture by feel is a simple hands-on method that can be used to estimate soil texture and soil moisture conditions with a handful of soil from each identified layer. Soil is formed into a ball, then squeezed between the thumb and index finger to form a ribbon (Figure 9). The length of the ribbon and the determined level of grittiness can be assessed to determine different soil types (Table 1). A detailed flow diagram for the procedure for the texture by feel method can be found on the NRCS.gov webpage https://www.nrcs.usda.gov/sites/default/files/2022-11/texture-by-feel.pdf.

Figure 9. Photo credit: Blake Sanden.

		Texture		
		Gritty	**Smooth**	**Neither**
Ribbon Length	**0-1”**	Sandy Loam	Still Loam	Loam
	1-2”	Sandy Clay Loam	Silty Clay Loam	Clay Loam
	2-3”	Sandy Clay Loam	Silty Clay Loam	Clay Loam

Table 1. Texture by feel soil ribbon length and texture associated with different soil types.

Soil infiltration rate

Soil infiltration rate refers to the maximum rate at which water moves into the soil surface and through its layers. This rate varies depending on moisture conditions, dry soil generally absorbs water more quickly than moist or saturated soil. Understanding a soil's infiltration capacity can help with selecting drip emitters or micro sprinkler nozzles and fine-tuning irrigation sets duration and frequency. Scheduling irrigation to match the soil's infiltration rate helps minimize surface runoff, reduce erosion, and prevent nutrient loss.

Infiltration is typically measured in inches per hour (in/hr). While general infiltration rates can be estimated based on soil texture (Table 2), field-based infiltration tests provide more accurate, site-specific information. On-site measurements are especially valuable for evaluating how soil health practices affect infiltration in orchards. These tests can be conducted using standard procedures outlined in the NRCS Soil Quality Test Kit Guide: https://efotg.sc.egov.usda.gov/references/public/WI/Soil_Quality_Test_Kit_Guide.pdf.

Soil texture	Permeability Class	Inches / hour
clay	Very slow	0.1
sandy clay, silty clay	Slow	0.1 - 0.2
clay loam, sandy clay loam, silty clay loam	Moderately slow	0.2 - 0.8
very fine sandy loam, loam, silt loam, silty clay loam, silt	Moderate	0.8 - 2.5
sandy loam, fine sandy loam	Moderately rapid	2.5 - 5
sand, loamy sand	Rapid	5 - 10
coarse sand	Very rapid	>10

Table 2. Typical infiltration rates for different soil types

The Slake Test

The **Slake Test** field method is a simple approach to evaluate structure and aggregation based on how well clumps of soil hold together when placed in water. If soil clods fall apart soon after placed in water, this suggests water moves into the pores and easily destroys the bonds of soil material (Figure 10). A list of materials and procedure instructions to conduct the slake test can be found on the Food and Agriculture Organization webpage: https://www.fao.org/fileadmin/user_upload/GSP/GSDP/Field_exercises/Aggregate_stability_EN.pdf

Figure 10

Aggregate stability

Aggregate stability is the percentage of aggregates remaining after a known volume of soil is subjected to a controlled exposure to water or mechanical agitation. A soil with > 80% aggregates remaining is considered to have excellent physical quality, 50 to 75% medium to good, 30 to 50% medium to low, and less than 30% poor physical quality. There are both field and laboratory methods evaluating the effect of management practices on aggregate stability at the surface and subsurface of the soil. A soil stability kit can be purchased or constructed with a few materials including:

- mesh-bottom sieves
- clear plastic cups
- spoon for collecting soil
- stopwatch or timer

Detailed methods for the soil stability test and interpretation are described by Herrick et al. 2017 pages 47-54. (https://www.blm.gov/sites/default/files/docs/2022-04/TR_1734_8_vol1_508.pdf).

Laboratory Methods

Laboratory techniques can provide more controlled and precise measurements than field observations to assess soil health conditions. In orchard research, these methods are used to make quantitative comparisons of how different orchard management practices impact soil function over time.

Soil organic matter

Soil organic matter analysis is an important indicator of the soil condition. SOM can be measured on an annual basis or every few years to determine if organic matter levels are either increasing or decreasing in response to soil management. SOM is determined by oxidation or combustion methods. Soil values typically range from 1 to 2.5% in California almond orchards depending on the location, soil texture, and historical management practices.

Carbon-to-Nitrogen ratio of organic materials

Adding organic materials to soil influences the balance of carbon (C) and nitrogen (N), two key elements that sustain soil biological activity. Inputs such as cover crops, composts, and mulches can supply N to trees, but the amount available within the same growing season depends largely on the material's C:N ratio. Microbes primarily use C as an energy source but also require N in smaller amounts for growth and metabolism. When organic matter has a high C to N ratio, microbes consume more N than the material provides, leading them to immobilize soil N into their cells. This reduces the N available to plants and can limit growth. Laboratory analysis using oxidation and combustion methods can determine C:N ratio and help guide organic amendment rates and application timing.

Soil available nitrogen

Although N exists in many forms in the soil, only inorganic ammonium and nitrate are immediately available to plants. To determine the appropriate fertilizer rate, it is important to account for these soil reserves along with other N sources. Commercial laboratories can analyze soil samples to measure inorganic N content and help guide nutrient management decisions.

For guidance on interpreting C:N ratios and soil inorganic N values to achieve efficient and environmentally responsible N management see the **Almond Board of California Nitrogen Best Management Practice** guide and the **California Almond Sustainability Program (CASP) Nitrogen Calculator** also available at the Fruit & Nut Research & Information Center website. This budgeting tool calculates fertilizer needs based on predicted yield demand, tree leaf tissue sampling and other factors from sources like groundwater, soil N, and cover crops.

Microbial biomass and activity

Soil microbes play a vital role in decomposing plant residues, releasing essential nutrients and stabilization of soil organic matter. Microbes metabolize the carbon in organic matter to extract energy, releasing carbon dioxide (CO_2) as a byproduct. Measuring soil CO_2 flux provides a useful indicator of overall microbial activity, soil health and the effects of orchard soil management. Several commercial kits are available to track changes in soil CO_2 flux while other products can directly estimate microbial biomass and the relative abundance of fungi and bacteria in the soil.

Bulk density

Bulk density is an indicator of soil compaction. Soil cores are extracted from the field to determine the grams (g) of solid soil particles in a known volume of soil typically expressed as cubic centimeters (cm^3). In addition to compaction, bulk density indicates the proportion of pores among soil particles. A low bulk density value, generally less than 1.4 g cm^3 in a sandy loam or clay loam soil, indicates higher porosity and higher water holding capacity. While a higher bulk density >1.6 g cm^3 indicates lower porosity and lower water holding capacity.

Slide hammer used to excavate bulk density cores. Photo credit: Cameron Zuber.

Available Water Holding Capacity (AWHC)

Available Water Holding Capacity (AWHC) is the amount of water in the soil that can be stored and made available for plant use. It is an important factor for guiding irrigation scheduling. Soil texture strongly influences AWHC (Table 3). Clay soils generally store more water than sandy soils, which hold less and require more frequent irrigation (Table 3).

Soil Texture	Plant-Available Water-Holding Capacity (in. of water per ft. of soil)
Very coarse sand	0.40 – 0.75
Coarse sand, fine sand, loamy sand	0.75 – 1.25
Sandy loam, fine sandy loam	1.25 – 1.75
Very fine sandy loam, loam, silt loam	1.50 – 2.30
Clay loam, silty clay loam, sandy clay loam	1.75 – 2.50
Sandy clay, silty clay, clay	1.60 – 2.50

Table 3. Approximate available water holding capacity for different soil types (Adapted from Schwankl and Prichard, 2009)

Organic matter can further enhance soil water holding capacity, with the greatest benefit in sandy soils. AWHC can be estimated based on the difference between the soil water content at field capacity (FC) and permanent wilting point (PWP):

- Field capacity (FC) is the amount of water soil retains after gravitational drainage. Most orchard soils will reach field capacity one to three days after irrigation.
- Permanent wilting point (PWP) is the point at which soil is too dry for plants to extract water (Figure 11).

Some commercial labs may offer site specific measurements of AWHC, which might be particularly useful in orchards where SOM levels have substantially increased.

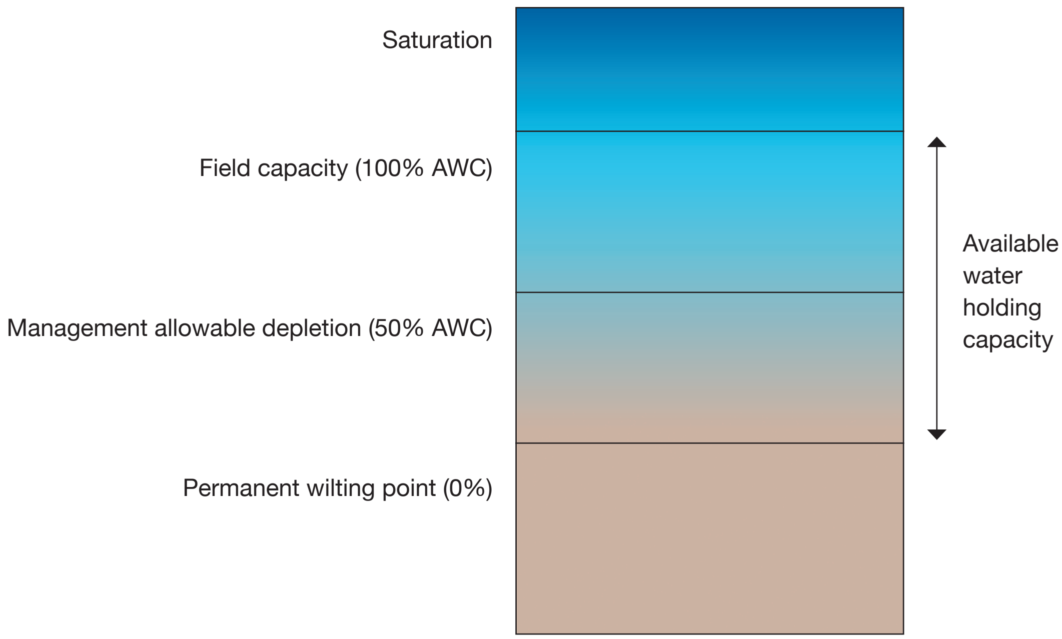


Figure 11

IMPROVING AND MAINTAINING SOIL CHARACTERISTICS

There are several cultural practices that add organic matter, reduce disturbance, conserve water, improve nutrition, and enhance overall soil function to support tree growth. These practices improve infiltration and protect the soil from the damaging energy of heavy rain and runoff during the winter and spring months. Some practices enhance soil nutrients and may partially substitute for chemical fertilizer without compromising yields and revenue.

Field operation timing

Moist soil is more vulnerable to structural damage and compaction than dry soil. Drier soil can support heavier loads with less risk of compaction (Figure 12). When soil becomes compacted, pore spaces collapse and soil bulk density increases, negatively affecting root growth, oxygen availability, water infiltration and water holding capacity and the availability of nutrients. To minimize compaction, avoid tillage and other equipment traffic when the soil moisture is at or above field capacity. The soil texture-by- feel method is a practical way to assess soil moisture conditions in the field before conducting orchard operations. Additionally, ensure equipment tires are properly inflated. Lower tire pressure increases the contact area with the soil surface, helping distribute weight more evenly and reduce compaction risk.

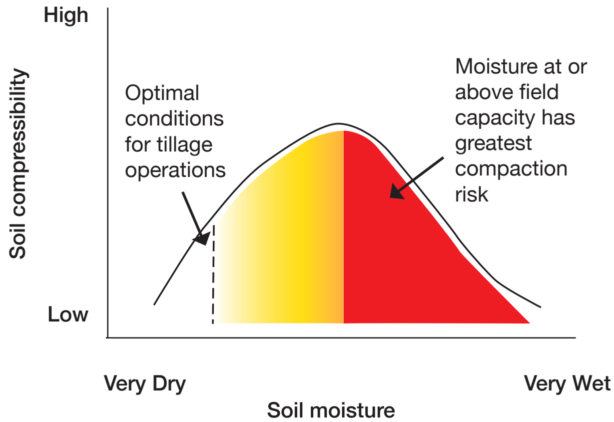


Figure 12

Cover crops

There are many documented benefits to maintaining a cover crop from fall to spring in mature bearing orchards. Cover crops protect the soil surface from rain droplets, reducing soil erosion and the formation of soil crusts that restrict water infiltration. Different plant species offer distinct advantages: grasses provide increased root biomass and suppress weeds, while legumes supply nitrogen and flowers for pollinators, with some species also suppress nematodes. In addition, cover crops can reduce Navel Orangeworm pressure by increasing overwintering mortality and interfering with egg deposition. They also serve as a natural forage source for pollinators that may improve honeybee colony strength and nutrition. Guidance on the key stages of cover crop management including planning, planting, growth, termination, and post-termination until harvest can be found in the **ABC Cover Crop Best Management Practices** Resource.

Whole Orchard Recycling (WOR)

Whole orchard recycling (WOR) involves shredding entire orchards or vineyards into chips, spreading them onto the soil surface, and incorporating them before replanting. WOR has been shown to improve SOM, total N, water infiltration rates, and water holding capacity. Incorporating large amounts of wood biomass increases SOM levels but also raises the C to N ratio (≥ 30:1), which can temporarily immobilize N and reduce fertilizer availability. Research shows only a modest N increase (about 22% increase above the standard recommended ~4 oz N per tree) is needed, and needed and applying N directly to the root zone after planting meets young tree growth needs without over application. Soil moisture monitoring also shows greater retention in WOR soils, especially at depth, with more sustained moisture between irrigation events, indicating potential long-term water savings.

For more details, see the **ABC Whole Orchard Recycling** resources.

Organic amendments

Organic amendments like compost, manure, residue mulches, and biological products provide carbon that fuels soil microbial activity and diversity, while also improving soil water holding capacity and fertility. Residue mulches add further benefits by creating a physical barrier on the soil surface, reducing evaporation, erosion, and dust, and helping conserve soil moisture to lower tree water stress.

Some amendments can supply nutrients that partially offset synthetic fertilizer needs. Research has shown dairy manures, composts, and almond hulls and shells can provide a significant portion of potassium (K) needs for almond. Compost supplies nitrogen (N), but at relatively low concentrations (0.8 to 2.5%). Because most compost N is in an organic form, it must mineralize before becoming available for trees, with less than 25% typically available in the first year. The remainer is slowly released over several years. The rate at which nitrogen becomes available is largely dependent on the carbon to nitrogen ratio of the organic amendment.

To estimate nutrient contributions from amendments, producers should submit samples for laboratory analysis of total N (%) and potassium oxide (K_2O, %). Total nutrient contribution can be calculated by multiplying the analysis (%) by the dry-weight application rate. Calculated compost N should be reduced to 25% to account for the slow mineralization release of N.

Example: For a 2,500 lb almond crop, a grower estimates N and K needs are about 200 lbs of N and 225 lb K_2O. Using urea ammonium nitrate 32% (UAN32) at $380/ton and sulfate of potash (SOP) at $750/ton, the fertilizer budget is $282 per acre (Table 4.1).

Product	Rate/acre	N%	Available N lb/acre	K_2O%	K_2O lb/acre	Cost/ton	Annual cost/acre
UAN32	56 gal	32	200	0	0	$380	$112
Sulfate of potash	450 lb	0	0	50	225	$750	$170
Total			200		225	$1130	**$282**

Table 4.1

If the grower applies 3 tons/acre of manure compost (2.3% N, 2% K_2O, $35/ton), and 2 tons of almond hulls and shells (0.3% N, 2.8% K_2O, $45/ton) the amendments will supply about ~47 lb available N and 235 lb K_2O. By crediting nutrients from manure compost and almond hulls and shells, synthetic fertilizer needs drop to 43 gal UAN32 and 0 lb SOP per acre, matching the total budget without compromising nutrient supply (Table 4.3).

Product	Rate/acre	N%	Available N lb/acre	K_2O%	K_2O lb/acre	Cost/ton	Annual cost/acre
Manure compost	3 tons	2.3	35*	2	120	$35	$105
Almond hulls and shells	2 tons	0.3	12	2.8	115	$45	$90
UAN32	43 gal	32	153	0	0	$380	$87
Total			200		235	$460	**$282**

*Table 4.3 (*Assumes 25% first-year N availability.)*

Biological products

Biological products encompass a wide range of inputs containing microorganisms (fungi, bacteria, or algae) or their byproducts. These products are intended to colonize the rhizosphere or internal tissues of crops, improving nutrient uptake, growth, vigor, and productivity. Humic substances, another type of organic input, can chelate nutrients and potentially improve nutrient and moisture uptake. Some studies suggest biological products may improve soil biological, chemical, and physical properties, especially when soil organic matter is less than 0.5%. However, not all biological products have undergone rigorous testing to evaluate their effectiveness.

IRRIGATION WATER MANAGEMENT TECHNIQUES

To effectively manage irrigation, it is important to understand several key soil properties: infiltration rate, changes in soil texture with depth, and water-holding capacity. This information is essential for determining the appropriate frequency and duration of irrigation sets and ensuring moisture is maintained in the effective rootzone, the top 3 ft depth where most almond tree roots are concentrated (Figure 13).

Calculating Available Water in the Rootzone

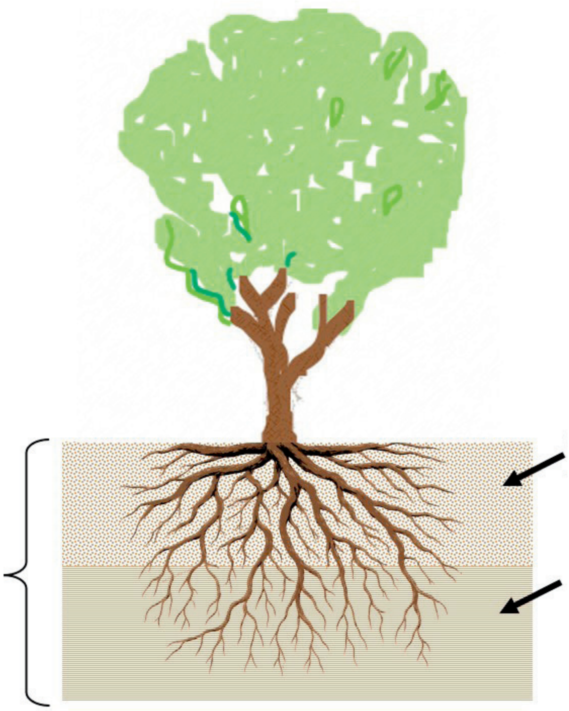
The total volume of water that can be held in the effective rootzone is calculated as:

Total Available Water (inches) =
Available Water-Holding Capacity (W_a) × Effective Rooting Depth (Z_E)
(Values are typically expressed in inches per foot of soil.)

Example:
If a sandy clay loam soil holds 1.37 inches of available water per foot and the effective rooting depth is 3 feet:

Total Available Water = 1.37 in/ft × 3 ft = 4.11 inches

3 ft



Sandy loam:
AWC 1.0 in/ft
Depth = 1 ft
1.0 in/ft x 1.5 ft = 1.5 in total

Sandy clay loam:
AWC 1.75 in/ft
Depth = 1.5 ft
1.75 in/ft x 1.5 ft = 2.63 in total

Total rootzone AWC: 1.5 + 2.63 = 4.13 in
4.13 in ÷ 3 ft = 1.37 in/ft

Figure 13

Understanding management allowable depletion (MAD)

Plants can typically access about 50% of the total available water between field capacity and the permanent wilting point before experiencing water stress. This 50% threshold is known as the **Management Allowable Depletion (MAD)** (Figure 11).

Maintaining soil moisture above the MAD threshold supports optimal tree health and productivity.

Estimating Maximum Water Application Per Irrigation Set

Use Formula 1 to estimate the maximum water to apply per irrigation set.

Where:

- MAD = Management allowable depletion (MAD), typically 50% for almonds
- W_a = Available water holding capacity (inches/ft) based on soil texture (Table 2) or a site-specific determined value (see laboratory methods section)
- Z_E = effective rooting depth (feet)
- Eff_A = Irrigation system efficiency (e.g. 85-95% for surface drip systems)

Formula:

$$Water\ applied\ (Inches) = \left(\frac{MAD}{100}\right)\ X\ Wa\ x\ ZE\ \div EffA$$

Example:

$$Water\ applied\ (Inches) = \left(\frac{50}{100}\right)\ X\ 1.37\ in\ x\ 3\ ft\ \div 0.095 = 2.17\ inches$$

Formula 1

Calculating Maximum Irrigation Set Time

Standard applied water calculations typically assume uniform coverage across the entire orchard floor. However, micro irrigation systems including drip and microsprinklers do not wet the entire planted area. If the wetting pattern is not accounted for, there is increased risk of over irrigation and water loss to deep percolation below the rootzone. Wetting patterns vary depending on the emitter flow rate and soil texture, both of which influence the vertical and lateral movement of water in the soil. Incorporating the wetted area into irrigation calculations improves water efficiency and helps maintain soil moisture within the effective rootzone.

To account for the wetted area, use Formula 2.

Formula:

$$Maximum\ Irrigation\ Time = \left(\frac{water\ applied}{application\ rate\ \frac{in}{hr} \div \%\ wetted\ area}\right) = hours$$

Example:

If the system application rate is 0.05 in/hr and the wetted area of the drip irrigation covers 50% of the orchard floor:

$$Maximum\ Irrigation\ Time = \left(\frac{2.17\ in}{0.05\ \frac{in}{hr} \div 0.50}\right) = 21.7\ hours$$

Additional sets may be needed to meet the weekly water requirements.

For additional guidance on irrigation scheduling and best practices, refer to the Almond Irrigation Improvement Continuum from the Almond Board of California: https://www.almonds.com/sites/default/files/2020-02/Almond-Irrigation-Improvement-Continuum.pdf

Formula 2

Salinity Management

Many orchards are located in salt-affected areas and require targeted soil and water management strategies to prevent or mitigate salinity-related issues and ensure long-term almond tree health and productivity. While saline soil occurs naturally in several almond-growing regions, salinization is becoming more widespread due to declining water quality, reduced water availability, poor drainage, and prolonged drought conditions.

Salinity problems arise when elevated levels of sodium (Na), chloride (Cl), boron (B), and bicarbonate (HCO_3^-) are present in soil or irrigation water, either individually or in combination. High Na concentrations disrupt soil structure by weakening the bonds holding soil colloids together. This leads to dispersion, reduced aggregation, and poor drainage, which creates low oxygen conditions that will compound tree root stress. Soils with excessive Na levels can be reclaimed with Ca based amendments to replace sodium on soil exchange sites. This improves soil structure and increases the ability to leach salts from the rootzone, restoring conditions for healthy tree root growth and function.

More information about salinity management in orchards is available in the Salinity Management Guide for Almond Growers from the Almond Board of California: https://www.almonds.com/sites/default/files/2023-06/Salinity%20Management%20Guide%20for%20Almond%20Growers.pdf

CONCLUSION

- Healthy productive soils support tree growth by storing water, cycling nutrients, and allowing roots to access air and moisture
- A structured soil is composed of aggregated soil particles and pore spaces that allow for air and water movement.
- Soil characteristics often change with depth, which can impact the flow of water, air and nutrients through the soil profile.
- Compaction from frequent cultivation and wheel traffic reduces soil porosity and root growth, working soil when dry helps prevent damage
- Adopting practices that add organic matter, protect the soil surface, minimize disturbance, and conserve moisture can improve long-term soil function and orchard resilience.
- Field and laboratory assessments help track how management practices influence soil function over time.
- Soil infiltration and water holding capacity should be considered for irrigation system design and scheduling irrigation to minimize surface runoff and deep percolation, preventing nutrient loss from soil.
- Salinity challenges worsen with poor water quality, limited supply, drainage issues, and drought. Calcium amendments and organic matter (e.g., cover crops) improve soil structure, displace sodium, and increase salt leaching for healthier roots.

INCENTIVES AND RESOURCES

California Almond Stewardship Platform
https://almondstewardship.org/

CDFA - Healthy Soils Program
https://www.cdfa.ca.gov/oars/healthysoils/incentivesprogram.html

Blue Diamond Growers Advancing Markets for Producers (AMP) Grant
https://www.farmraise.com/blue-diamond-amp-program

NRCS - Environmental Quality Incentives Program (EQIP)
https://www.cdfa.ca.gov/oars/sweep/ (SWEEP)

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