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Importance of **soil texture** to vineyard management

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Natural soils are comprised of soil particles that vary in size. Soil scientists categorize particle-size groups, called "soil separates," as follows: sands (thecoarsest); silts; and clays (the smallest/finest).

What is soil texture?

Soil texture refers to the weight proportion (relative proportion by weight percentage of sand, silt, and clay) of the mineral soil separates for particles less than two millimeters (mm) as determined from a laboratory particle-size distribution. Texture is soil's most important physical property for grapegrowing, since it influences water holding capacity, root growth, and overall vine vigor.

The terminology used to describe soil texture in the popular press often does not adhere to standard definitions. Therefore, much confusion and outright misinformation is spread about this vineyard soil property.

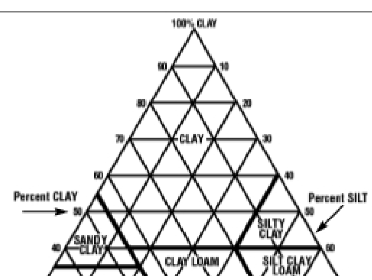
The purpose of this text is to present standardized definitions for soil texture terms and to discuss the importance of soil texture to vineyard management.

Soil separate sizes

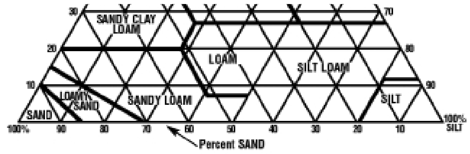
The U.S. Department of Agriculture (USDA) has established limits of variation for the soil separates and has assigned a name to each size class (Table I). This system has been approved by the Soil Science Society of America (SSSA), and is the one used in all published USDA soil survey reports. Most of the pertinent USDA publications regarding soil survey standards and soil texture terms can be accessed from the USDA web page cited in the references section below. Other standard soil science terminology can also be referenced by examining the Glossary of Soil Science Terms linked to the SSSA web page (SSSA, 2001).

USDA soil textural classes

The texture classes are shown on the USDA textural triangle (Figure I).



Subclasses of sand are subdivided into coarse sand, sand, fine sand, and very fine sand. Subclasses of loamy sands and sandy loams that are based on sand size are named similarly. Detailed definitions for the many different



subclasses of sands, loamy sands, and sandy loams are found in the USDA soil survey manual (Soil Survey Division Staff, 1993).

The textural triangle is used to resolve problems related to the detailed word definitions. The eight subclasses in the sand and loamy sand groups provide refinement greater than can be consistently determined by field techniques. Only those textural distinctions that are significant both to agricultural use and management, and which can be consistently made in the field, are commonly applied.

Groupings of soil texture classes

It is often convenient to speak of general texture groups. The general soil texture groups, in three (sandy, loamy or clayey) or five classes, are outlined in Table II. In some areas where soils are high in silt, a fourth general class, silty soils, may be used for silt and silt loam.

Table I: Soil separates and their diameter ranges

Soil Separate		Diameter (mm)	Visual Size Comparison of Maximum Size
Sand		**2.00 to 0.05**	
	Very coarse	2.00 to 1.00	House key thickness
	Coarse	1.00 to 0.50	Small pinhead
	Medium	0.50 to 0.25	Sugar or salt crystals
	Fine	0.25 to 0.10	Thickness of book page
	Very fine	0.10 to 0.05	Invisible to naked eye
Silt		**0.05 to 0.002**	Visible under light microscope
	Coarse	0.05 to 0.002	
	Medium	0.02 to 0.005	
	Fine	0.005 to 0.002	
Clay		**<0.002**	Visible with an electron microscope
	Coarse	0.002 to 0.0002	
	Fine	<0.0002	

Table II: General soil texture groups

General texture group terms	Texture classes
Sandy soil materials:	
Coarse-textured	Sands (coarse sand, sand, fine sand, very fine sand).
	Loamy sands (loamy coarse sand, loamy sand, loamy fine sand, and loamy very fine sand.)
Loamy soil materials:	
Moderately coarse-textured	Coarse sandy loam, sandy loam, fine sandy loam.
Medium-textured	Very fine sandy loam, loam, silt loam, silt.
Moderately fine-textured	Clay loam, sandy clay loam, silty clay loam.
Clayey soils:	
Fine-textured	Sandy clay, silty clay, clay

Determination of soil texture

Apparent field texture is a tactile evaluation only, with no inference as to laboratory test results. Field estimates of soil texture should be rechecked with laboratory testing when detailed data are needed, and the field criteria should be adjusted as necessary. Sand particles feel gritty and can be seen individually with the naked eye. Silt particles cannot be seen individually without magnification; whether dry or wet, they have a smooth feel on the fingers.

Clay soils range from slightly sticky to very sticky when wet. This is because soil texture and soil clay mineralogy are not directly related. Soils dominated by swelling and cracking clays are more sticky and more plastic (referring to the ability of wet soil to form a ribbon or putty ball when it is manipulated) than soils that contain similar amounts of micaceous (high in muscovite or biotite mica) or kaolinitic (non-swelling) clays.

Soil texture and soil organic matter content are also not directly related. In fact, to determine soil texture using standard USDA methods, the organic matter and all other soil aggregating agents (like calcium carbonate, silica, and iron oxides) are chemically removed from the total soil sample prior to the determination of soil texture. Therefore, standard soil texture methods call for removal of these most chemically important soil components. This fact makes it critical to look at the soil chemical properties like pH, organic matter content, and plant available nutrients — in addition to the soil texture — in order to make wise viticultural management decisions.

Many analytical labs will determine the soil saturation percentage (such as the amount of water, by weight, in a saturated soil sample) and make indirect soil texture determinations from this value (Table III). Generally, the higher the saturation percentage, the higher total soil clay and organic matter contents. The saturation percentage is directly related to the total soil porosity and total soil water-holding capacity and, therefore, is a valuable number to use for irrigation system design.

Surface cracks formed by drying of swelling clays.

Rock fragments

Rock fragments are unattached pieces of rock, 2 mm or larger in diameter, that are hard or strongly cemented. They are physically removed (by sieving) from the soil separates in the laboratory determination of soil texture. Then, volume and weight measurements are performed to determine their amounts in soil.

Rock fragments are described by size, shape, and, in some cases, the type of rock. If one size or range of sizes predominates in a soil, the textural class is modified using additional information. For example, compound terms like “fine pebbles,” “cobbles, 100 to 150 mm in diameter,” “channers, 25 to 50 mm in length” may be used.

Gravel is a collection of pebbles that have diameters ranging from 2 to 75mm. The term is applied to the collection of pebbles in a soil layer with no implication of geologic rock type. The terms “pebble” and “cobble” are usually restricted to rounded or subrounded fragments; however, they can be used to describe angular fragments if they are not flat.

Words like granite, limestone, and shale refer to a rock type, not a rock fragment. Composition of the fragments can be described as follows: “granite pebbles,” “limestone channers” and “shale gravels.”

In USDA soil survey reports, the adjective describing rock fragments in soils is used as the first part of the textural class name according to the following conventions:

- Less than 15% by volume — No mention of rock fragments is used.
- 15% to 35% by volume — The dominant kind of rock fragment is used (such as “gravelly loam,” or “cobbly clay loam”).
- 35% to 60% by volume — The word “very” precedes the name of the dominant kind of rock fragments (such as “very cobbly loam,” or “very cobbly sandy loam”).
- More than 60% by volume — Add the word “extremely” in front of the coarse fragment name (such as “extremely gravelly loam,” or “extremely cobbly clay loam”).
- If there are too few soil separates present to determine the soil textural class (less than 10% by volume), terms such as “gravel,” “cobbles,” “stones,” or “boulders” are used, as appropriate, without mention of the textural class.

Soils generally contain rock fragments smaller or larger than those identified by the adjective term. The “rock fragment” adjective applies to the most predominant rock fragment size found within any soil layer. For example, on a volume basis, a stony loam with 20% stones may also contain 10% gravel-sized pebbles, but “gravelly” is not mentioned in the name. In this case, stones are the most abundant rock fragment size and “stony” is used as the adjective.

Table III: Saturation percentage and approximate soil texture classes

Soil saturation percentage	Approximate soil texture classes
Below 20	Sand or Loamy Sand
20 – 35	Sandy Loam
35 – 50	Loam or Silt Loam
50 – 65	Clay Loam
65 – 150	Clay
Above 150	Usually organic soils (peat or muck)

Table IV: Terms to describe rock fragments in soils

Shape* and size	Noun	Adjective
Spherical, cubelike, or equiaxial:		
2–75 mm diameter	Gravel (pebbles)	Gravelly
2–5 mm diameter		Fine gravelly
5–20 mm diameter		Medium gravelly
20–75 mm diameter		Coarse gravelly
75–250 mm diameter	Cobbles	Cobbly
250–600 mm diameter	Stones	Stony
>600 mm diameter	Boulders	Bouldery
Flat:		
2–150 mm long	Channers	Channery
150–380 mm long	Flagstones	Flaggy
380–600 mm long	Stones	Stony
>600 mm long	Boulders	Bouldery

More precise estimates of the quantity of rock fragments than are provided by the defined classes are needed for some purposes as potential erosion prediction and determination of soil water holding capacity. If more precise information is needed for specific land use purposes, estimates of percentages of each size class or combination of size classes are included in the description: such as “very cobbly loam;” “30% cobbles and 15% gravel” or “silt loam; about 10% gravel.”

If rock fragments are significant in soil vineyard management, they are the basis for designing and describing new soil map units which are identified on vineyard soil maps. In contrast, bedrock exposed at the earth’s surface is not soil and is separately identified on soil maps.

The volume occupied by individual rock fragments can be seen in the field, and aggregate volume percentage can be estimated. Rock fragment volume percentage may be converted to a weight percentage, using USDA conversion tables or direct laboratory measurements.

Influence of soil texture on other soil properties

As discussed above, individual soil mineral particle diameters range over six orders of magnitude, from boulders (>600 mm) to clays (less than 10–9 mm) which can only be seen with an electron microscope. The soil textural classification established by the USDA is used for agricultural soils. The size ranges for these separates are not purely arbitrary, but reflect major changes in how the particles behave and in the physical properties they impart to soils (Table V).

Table V: Generalized influence of soil separates on other soil properties and behavior

Property/behavior	Sand	Silt	Clay
Water-holding capacity	Low	Medium to High	High
Aeration, when moist	Good	Medium	Medium to poor
Hydraulic (water) conductivity	High	Slow to Medium	Slow to very slow
Soil organic matter level	Low	Medium to High	High to Medium
Decomposition of organic matter	Rapid	Medium	Slow
Warm-up in spring	Rapid	Moderate	Slow
Compactability	Low	Medium	High
Susceptibility to wind erosion	Moderate (high if fine sand)	High	Low
Susceptibility to water erosion	Low (unless fine sand)	High	Low if aggregated, High if not
Shrink-swell potential	Very low	Low	Moderate to very high
Sealing of ponds and dams	Poor	Poor	Good
Suitability for tillage when wet	Good	Medium	Poor
Pollutant leaching potential	High	Medium	Low (unless cracked)
Cation exchange capacity (CEC)	Low	Medium	High
Resistance to pH change	Low	Medium	High

Texture is an important soil characteristic because it will, in part, determine water intake rates (infiltration); water movement through soil (hydraulic conductivity); soil water holding capacity; the ease of tilling the soil; and the amount of aeration (which is vital to root growth). Texture will also influence soil fertility.

For instance, a coarse sandy soil is easy to till, has plenty of aeration to stimulate root growth, and is easily irrigated. However, this same sandy soil will rapidly dry out after irrigation due to its low water holding capacity. Water soluble plant nutrients (like nitrates and potassium) will be rapidly leached below the vine root zone by percolating waters.

In contrast, moist clay soils (over 35% clay) are composed of very small particles that fit tightly together with fewer large interconnected pores. Clay soils should be irrigated less frequently than sands, but with higher amounts of water and over longer periods of time. Most clay soils have greater cation exchange capacities (CEC) and will adsorb higher amounts of water-soluble plant nutrients (especially potassium, calcium, and magnesium). Wet clay soils are also difficult to till due to their relative stickiness and inability to support the weight of a tractor.

Summary

For most intensive vineyard management operations, a detailed soil map should be prepared to supplement the more general USDA soil survey reports. The soil textures for each soil layer should be identified for the dominant soils using the standard USDA terms defined here.

When describing soil textures within a vineyard, it is important to not only identify the soil textural classes but also the soil parent material rock types and the amounts of rock fragments within the soil profiles. Related soil properties like saturation percentage should also be determined to aid in irrigation system design.

Soil texture information should also be supplemented with data regarding soil organic matter content and soil chemical properties, such as pH and plant essential nutrient concentrations. Soil organic matter and humus contents (highly decomposed organic matter) will modify the general effects of soil mineral texture (Table V) by enhancing soil structure formation, increasing soil water holding capacity, and increasing CEC. The complex interrelationships among all these soil properties should be considered when vineyard management decisions are made.

References

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