UNIVERSITY OF FLORIDA
IFAS EXTENSION

SL29

Soil Texture [1]

R.B. Brown[2]

Soil texture is a term commonly used to designate the proportionate distribution of the different sizes of mineral particles in a soil. It does not include any organic matter. These mineral particles vary in size from those easily seen with the unaided eye to those below the range of a high-powered microscope. According to their size, these mineral particles are grouped into "separates."

A soil separate is a group of mineral particles that fit within definite size limits expressed as diameter in millimeters. Sizes of the separates used in the USDA system of nomenclature for soil texture are shown in Table 1 .

Since various sizes of particle have quite different physical characteristics, the nature of mineral soils is determined to a remarkable degree by the particular separate that is present in larger amounts. Thus, a soil possessing a large amount of clay has quite different physical properties from one made up mostly of sand and/or silt. The analytical procedure by which the percentages of the various soil separates are obtained is called a mechanical analysis.

Mineral soils (that is, those soils consisting mainly of rock and mineral fragments, rather than plant remains and other accumulated organic materials) are a mixture of soil separates, and it is on the basis of the proportion of these various separates that the textural class names of soils are determined.

There are twelve major textural classes. Their compositions are defined by the USDA textural triangle (Figure 1).

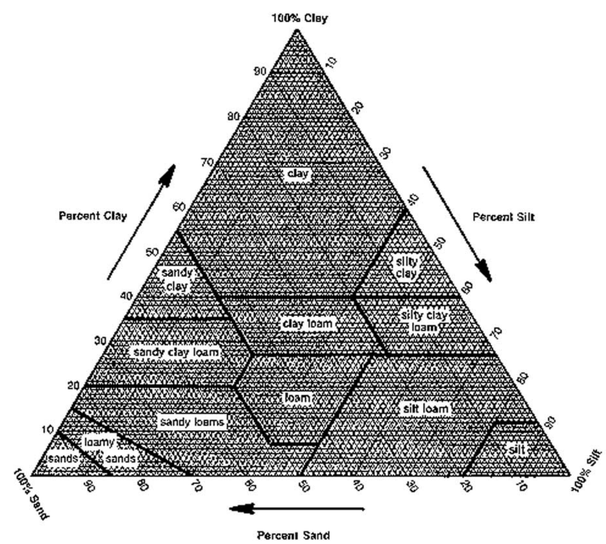

Figure 1.

1. This document is Fact Sheet SL-29, one of a series of fact sheets of the Soil and Water Science Department, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. Date first printed: April 1990. Reviewed: April 1998, September 2003. Please visit the EDIS Web site at http://edis.ifas.ufl.edu.
2. R.B. Brown, professor emeritus, Soil and Water Science Department, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida, Gainesville, FL 32611-0510.

How to Use the USDA Textural Triangle

After a mechanical analysis has been completed in the laboratory and a percentage obtained for each of the soil separates (as in the examples of soil samples from various soil horizons shown in Table 2), add up the amounts of sand from the very coarse sand through the very fine sand, to determine the total sand content. Total sand is used, along with silt and clay contents, to determine the soil textural name from the USDA textural triangle.

For example, Sample No. 3, the Bt (subsoil) horizon of soil S1 (Table 2), has an analysis of 72% sand, 3% silt, and 25% clay. Look at the USDA textural triangle (Figure 1) and notice the percent sand" arrow pointing from right to left on the bottom of the triangle. Find the 72% sand point and mentally sketch a line from that point parallel to the side opposite the 100% sand corner of the triangle. Such a line will pass through all points on the triangle that correspond to a soil having 72% sand. Now locate the 3% silt point on the upper right side of the triangle, and visualize a line from this point parallel to the side opposite the 100% silt corner of the triangle. This line intersects the sand line at a single point inside the area labeled as sandy clay loam.

Two properly sketched lines (sand and silt, sand and clay, or silt and clay) will correctly indicate the textural class name of a mineral soil. Notice that, in the case of Sample No.3, the 25% clay line sketched by drawing a line through that point and parallel to the base of the triangle (which is the side opposite the 100% clay corner) intersects the 72% sand and 3% silt lines at exactly the same point (shown with a dot on Figure 1) where the sand and silt lines intersect each other. Any three percentages of sand, silt, and clay that add up to 100 will always define a single point on the triangle.

In the cases of sands, loamy sands, and sandy loams, the proportion of individual sand separates (very coarse sand, coarse sand, etc.) must be considered in assigning a textural name to a sample. The total sand fraction of Sample No.2 (Table 2), for example, is not dominated by any one sand separate, so it is called, simply, sand. In contrast, Sample No.4 (Table 2), the A horizon (topsoil) of Soil S2, is dominated by sand particles that are in the 0.10-0.25 mm (fine sand) size range. This soil is designated fine sand to reflect that dominance.

The paragraphs that follow contain more information on the characteristics of the various sands, loamy sands, and sandy loams.

Determination of Soil Texture in the Field

In the field, the percentages of sand, silt, and clay particles in a soil are estimated by feel. The soil is rubbed between the fingers and the thumb and an estimate of the amount of the various separates present is made based on the degree to which the characteristic properties of each are expressed. This process of estimation requires skill and experience, but accuracy can be improved by frequent checks of such estimates against the findings of experienced field soil scientists in the region, and against determinations obtained by laboratory analysis of the samples.

Dry soil feels different from moist soil, due in part to the fact that soil particles tend to aggregate together upon drying. It is best to moisten dry soil when making field estimates of soil texture. The more important characteristics of the various textural classes of soils which are of value and which can be recognized by feel and/or determined by laboratory analysis are as follows.

Sands

Sands are loose and single-grained (that is, not aggregated together). They feel gritty to the touch and are not sticky. Each individual sand grain is of sufficient size that it can easily be seen and felt. Sands cannot be formed into a cast by squeezing when dry. When moist, sands will form a very weak cast, as if molded by the hand, that crumbles when touched. Soil materials classified as sands must contain 85-100% sand-sized particles, 0-15% silt-sized particles, and 0-10% clay-sized particles. These percentages are given by the boundaries of the sand portion of the USDA textural triangle (Figure 1).

The reason that sands are referred to in the plural is that there are several USDA textures within this group. All of these textures fit the "sand" portion of the textural triangle, but they differ from each other in their relative proportions of the various sizes of sand grains.

Coarse Sand: This is the sand that looks and feels most coarse and gritty. It must contain 25% or more very coarse sand and coarse sand, and less than 50% any other single grade of sand.

Sand : This is the normal sort of sand that contains a more or less even distribution of the different sizes of sand grain. It is not dominated by a particular size of sand particle. It contains 25% or more very coarse, coarse, and medium sand (but less than 25% very coarse plus coarse sand), and less than 50% either fine sand or very fine sand.

Fine Sand : This class of sand is dominated by the finer sizes of sand particle, and as such feels rather uniform in texture and somewhat less coarse than either sand or coarse sand. It must contain 50% or more fine sand; or less than 25% very coarse, coarse, and medium sand, and less than 50% very fine sand.

Very Fine Sand : This soil is dominated by the very finest of sand grains. Its grittiness seems almost to grade into the smoothness that one would expect in a silty soil. It is 50% or more very fine sand.

Remember, the term "sand" has more than one meaning in the USDA system. Sand can mean a group of soil separates (very coarse sand, coarse sand, medium sand, fine sand, and very fine sand) that collectively range in diameter from 2 to 0.05 mm (Table 1). Sands, in the plural, are a major textural grouping on the USDA textural triangle (Figure 1 ; Table 2). This major grouping (sands) includes four individual USDA textures (coarse sand, sand, fine sand, and very fine sand), depending on the proportions of the individual separates in a particular soil.

Loamy Sands

Loamy sands consist of soil materials containing 70-90% sand, 0-30% silt, and 0-15% clay. As such, they resemble sands in that they are loose and single-grained, and most individual grains can be seen and felt. Because they do contain slightly higher percentages of silt and clay than do the sands, however, the loamy sands are slightly cohesive when moist, and fragile casts can more readily be formed with them than with sands.

As with sands, the loamy sands are dealt with in the plural because there are several USDA textures within this group. The name assigned to a soil material in the loamy sands depends on the proportions of the different sand separates.

Loamy Coarse Sand : This is the coarsest and grittiest sort of loamy sand. It must contain 25% or more very coarse and coarse sand, and less than 50% any other single grade of sand.

Loamy Sand : This class includes any loamy sand whose sand fraction is not dominated by a particular size of sand particle. It consists of 25% or more very coarse, coarse, and medium sand (but less than 25% very coarse plus coarse sand), and less than 50% either fine sand or very fine sand.

Loamy Fine Sand: The sand grains in this class of loamy sand are dominantly in the finer size range. Loamy fine sand contains 50% or more fine sand; or less than 50% very fine sand and less than 25% very coarse, coarse, and medium sand.

Loamy Very Fine Sand : This soil material is so dominated by very fine sand that it almost takes on a smooth, silty quality. It consists of 50% or more very fine sand.

Sandy Loams

Sandy loams consist of soil materials containing somewhat less sand, and more silt plus clay, than loamy sands. As such, they possess characteristics which fall between the finer-textured sandy clay loam and the coarser-textured loamy sands. Many of the individual sand grains can still be seen and felt, but there is sufficient silt and/or clay to give coherence to the soil so that casts can be formed that will bear careful handling without breaking.

As with sands and loamy sands, the sandy loams comprise four different USDA textures. All four textures fit within the sandy loam section of the textural triangle, but they differ in proportions of the various sizes of sand grain.

Coarse Sandy Loam : This is the coarsest and grittiest sandy loam. It must consist of 25% or more very coarse and coarse sand, and less than 50% any other single grade of sand.

Sandy Loam : Sandy loam is not dominated by any particular size of sand particle. It contains 30% or more very coarse, coarse, and medium sand (but less than 25% very coarse and coarse sand), and less than 30% either fine sand or very fine sand.

Fine Sandy Loam : The grains in fine sandy loam are dominantly in the finer size range. It must contain 30% or more fine, and less than 30% very fine sand; or between 15 and 30% very coarse, coarse, and medium sand; or more than 40% fine and very fine sand, at least half of which is fine, and less than 15 percent very coarse, coarse, and medium sand.

Very Fine Sandy Loam: This soil material is sandy loam that is particularly influenced by the presence of large amounts of very fine sand, giving it a relatively smooth quality in comparison with the other sandy loams. Specifically, it has 30% or more very fine sand; or more than 40% fine and very fine sand, at least half of which is very fine sand, and less than 15% very coarse, coarse, and medium sand.

Loam

Loam is soil material that is medium-textured. It feels as though it contains a relatively even mixture of sand, silt, and clay because clay particles, with their small size, high surface areas, and high physical and chemical activities, exert a greater influence on soil properties than does sand or silt.

Loam tends to be rather soft and friable. It has a slightly gritty feel, yet is fairly smooth and slightly sticky and plastic when moist. Casts formed from such soils can be handled quite freely without breaking.

Sandy Clay Loam

Soil having this texture consists of materials whose behavior is dominated by sand and clay. It most nearly resembles the sandy loams in that it has considerable amounts of sand, which can be most easily detected by moistening the soil and smoothing it out between the fingers. However, as the name implies, sandy clay loam has more clay than the sandy loams and thus possesses greater cohesive properties (such as stickiness and plasticity) when moistened. Casts made from these materials are quite firm, can be handled roughly without breaking; and tend to become hard when dry. The moist soil will form a thin ribbon that will barely sustain its own weight when squeezed carefully between the thumb and fingers.

Clay Loam

Clay loam consists of soil material having the most even distribution of sand, silt, and clay of any of the soil textural grades. But it feels as though it possesses more clay than sand or silt. Sticky and plastic when wet, it forms casts that are firm when moist and hard when dry. The moist soil will form a thin ribbon that will barely sustain its own weight when squeezed carefully between the thumb and fingers.

Silt

Silt is similar to silt loam but contains even less sand and clay. Sand-sized particles, if present, are generally so small (either fine or very fine sand) that they are nondetectable to the fingers. Clay particles are present in such low percentages that little or no stickiness is imparted to the soil when moistened, but it instead feels smooth and rather silky. Silt-sized particles are somewhat plastic, and casts can be formed that will bear careful handling.

Silt Loam

Silt loam has rather small amounts of sand and clay and is composed mostly of silt-sized particles. When dry, it is often rather cloddy in the field; but the lumps are easily broken between the fingers, and the soil then feels soft and floury. Either moist or dry, casts can be formed which can be handled somewhat freely without breaking. When moistened and squeezed between the fingers it feels soft and smooth. It will not "ribbon out"; it will break into small bits.

Silty Clay Loam

This soil material resembles clay loam in cohesive properties, but possesses more silt and less sand and thus has a rather smooth feel. The small amounts of sand particles which are present are generally quite fine and are very difficult to detect. Silty clay loam is also intermediate in characteristics between the silty clay and the silt loam; it is sticky and plastic when wet, firm when moist, and forms casts that are hard when dry.

Silty Clay

Silty clay is quite smooth, nongritty, very sticky and very plastic when wet, and forms very hard aggregates when dry.

Sandy Clay

Sandy clay is somewhat similar to silty clay, but it contains much more sand and less silt.

Clay

Clay is the finest textured of all the soil classes. Clay usually forms extremely hard clods or lumps when dry and is extremely sticky and plastic when wet. When containing the proper amount of moisture, it can be "ribboned out" to a remarkable degree by squeezing between thumb and forefinger, and may be rolled into a long, very thin wire.

Organic Soils

Organic soils are made up of plant and animal remains that have accumulated, in varying stages of decomposition, in an environment that does not allow decay of the materials to take place rapidly. Such an environment may be found in some swamps, marshes, and lakes, and rarely in drier, more upland environments where the ecosystem is so productive that plant remains accumulate at extremely high rates. Muck, peaty muck, mucky peat, and peat are terms used in place of textural class names for organic soils. Muck consists of highly decomposed remains of plants and other organisms. Peat consists of relatively raw, less well-decomposed organic materials. Peaty muck and mucky peat are intermediate in decomposition. Mineral soils, as described in earlier paragraphs, are not dominated by organic materials, but consist primarily of sand-, silt-, and/or clay-sized particles of minerals or rock fragments. If you encounter a soil material that has been designated mucky sand or other such mixed name, it indicates that the soil is a mineral soil having a higher than ordinary content of organic matter (say, 10% or so by weight), but not high enough to treat the soil as an organic soil (muck, peaty muck, etc.).

Coarse Fragments and Rock Outcrops

Mineral particles in the soil that are larger than 2 mm in diameter are not soil separates, but are classified as pebbles (or, collectively, gravel), cobblestones, stones, or boulders, depending on their sizes and shapes. Collectively, they are called coarse fragments and are regarded as part of the soil mass due to their influence on water retention, infiltration, and runoff. When present in significant amounts, coarse fragments up to 25 cm (10 inches) in diameter are recognized by use of an appropriate adjective in the textural soil class name. For example, a sandy loam surface soil containing sufficient gravelly material to affect tillage could be designated as "gravelly sandy loam" or as "sandy loam, gravel phase."

Rock fragments larger than 25 cm (10 inches) in diameter (if somewhat equally dimensioned) or more than 38 cm (15 inches) in the longest dimension (if length and width differ greatly) are called stones and boulders. Stones range up to 60 cm (2 feet), and boulders are rocks that are larger than that with no upper size limit. The larger coarse fragments and rock outcrops are described in relation to their number, size, and spacing at the soil surface. Descriptive terminology is used as a phase of a textural soil class name, such as "loamy sand, bouldery phase," or "silt loam, rock outcrop phase."

Significance of Soil Texture

Of soil characteristics, texture is one of the most important. It influences many other properties of great significance to land use and management. Some terms often used to describe the various textural class names follow to discuss this relationship adequately: sandy or coarse-textured soils (for sands and loamy sands); loamy or medium-textured soils (for sandy loams, loam, silt, silt loam, sandy clay loam, clay loam, and silty clay loam); and clayey or fine textured soils (for sandy clay, silty clay, and clay).

Generally speaking, sandy soils tend to be low in organic matter content and native fertility, low in ability to retain moisture and nutrients, low in cation exchange and buffer capacities, and rapidly permeable (i.e., they permit rapid movement of water and air). Thick, upland deposits of such soil materials (common in the central ridge section of Florida, but also in other sand hill areas) are often quite droughty, need irrigation at times during dry seasons, 7 and are best adapted to deep-rooted crops (such as citrus where temperatures permit).

Sandy soils usually have high bulk densities and are therefore well-suited for road foundations and building sites. They do require good water management (generally including more frequent irrigations and/or artificial drainage to fit the needs of a specific crop) and proper fertilization (meaning more frequent but lower quantities of nutrients per application). Total amounts of fertilizer per crop are usually quite high.

As the relative percentages of silt and/or clay particles become greater, properties of soils are increasingly affected. Finer-textured soils generally are more fertile, contain more organic matter, have higher cation exchange and buffer capacities, are better able to retain moisture and nutrients, and permit less rapid movement of air and water. All of this is good up to a point. When soils are so fine-textured as to be classified as clayey, however, they are likely to exhibit properties which are somewhat difficult to manage or overcome. Such soils are often too sticky when wet and too hard when dry to cultivate. They also may have shrink-swell characteristics that affect their suitability adversely for use as building sites and for road construction.

The question is sometimes asked, "What is the best soil?" The answer can only properly be given by another question, "Best for what?" It is generally thought that (with all other factors being equal) soils having sandy loam, or loam-textured surface soils, are better suited for a wider variety of crops, and will produce higher yields more economically than most other soils in Florida. Such soils are more common in the northwest portion of the state.

Some Things Texture Does Not Tell Us

It is very important to realize that texture alone does not tell us all we need to know about soils as we try to understand and predict their behavior and their suitability for different uses.

Cementation is an example of one soil attribute that can alter the effect of soil texture. A soil may be sandy throughout its depth, but the coating of sand grains by naturally-occurring materials such as organic matter and iron/aluminum oxides may lead to the cementation of sand grains to each other and even to the plugging of the pores between sand grains. This phenomenon happens commonly in subsoils of the flatwoods. The resulting stained layer (called a spodic horizon by soil scientists and a hardpan by many others) can reduce the permeability of the subsoil, depending on the degree of cementation and plugging that has occurred, and can significantly alter the behavior of a soil relative to the behavior that it would have if there were no staining, cementation, or plugging.

Human activities can affect permeability of soils. Plowpans and other types of compaction can reduce soil permeability radically, even in sandy soils. Conversely, subsoiling or other kinds of ripping/breaking of slowly permeable soil horizons can increase soil permeability.

The water table can have an important impact on soil behavior. Sandy soils of the flatwoods, for example, are likely to be saturated with water for extended periods during most years. The sandy soils of higher, sand hill landscapes are unlikely to have high water tables even for short periods.

Comparison with Engineering Classification Systems

The system for determining USDA texture is significantly different from the Unified and the American Association of State Highway and Transportation Officials (AASHTO) systems that are traditionally used by engineers. One major difference is that the cutoffs between particle sizes are different among the three systems.

Another important difference is that USDA texture depends entirely on particle size; the Unified and AASHTO designations depend not only on particle sizes but also on other properties such as Atterberg limits (liquid limit and plasticity index).

There is, unfortunately, no way to translate directly from the USDA system to the other systems and back. Sandy clay loam in the USDA system, for example, may be either SC or CL in the Unified system, depending on the percentages of different sizes of particles; similarly, it may be A-6 or A-2-6 in the AASHTO system. Conversely, CL from the Unified system may be clay, silty clay, silty clay loam, clay loam, loam, silt loam, sandy clay, or sandy clay loam in the USDA system, depending on the results of a mechanical analysis done using USDA standards; a soil designated A-6 in the AASHTO system may be clay loam, loam, silt loam, or sandy clay loam in the USDA system.

For more information on the Unified and AASHTO systems, consult with your local office of the USDA Natural Resources Conservation Service, a modern soil survey report, or a textbook in soil mechanics.

Where to Get More Information

For additional information on the availability of soil survey reports and other soil-related information assistance in your region, contact your local County Extension Service, Soil and Water Conservation District, and USDA Natural Resources Conservation Service offices.

Acknowledgment

This fact sheet is a major revision of "Soil Texture" (Soil Science Fact Sheet SL-29), by R. E. Caldwell. It has been modified as part of a project entitled "Determining Soil-Water Seasonal Movement." Partial support for this project has been provided by the U.S. Geological Survey, Department of the Interior, through the Florida Water Resources Research Center, as authorized by the Water Resources Research Act of 1984. Additional support has come from the Soil Characterization Program of Florida's Accelerated Soil Survey, funded by the Florida Legislature through the Bureau of Soil and Water Conservation, Florida Department of Agriculture and Consumer services.

Table 1. Size limits (diameter in millimeters) of soil separates in the USDA soil textural classification system.

Name of soil separate	Diameter limits (mm)
Very coarse sand*	2.00 - 1.00
Coarse sand	1.00 - 0.50
Medium sand	0.50 - 0.25
Fine sand	0.25 - 0.10
Very fine sand	0.10 - 0.05
Silt	0.05 - 0.002
Clay	less than 0.002

* Note that the sand separate is split into five sizes (very coarse sand, coarse sand, etc.). The size range for sands, considered broadly, comprises the entire range from very coarse sand to very fine sand, i.e., 2.00-0.05 mm.

Table 2. Distribution of particle sizes and USDA textural names for soil samples from three different depths in each of two contrasting Florida soils, designated "S1" and "S2".

Sample No.	Soil	Soil Horizon*	VCS+	CS	MS	FS	VFS	Total Sand #	Silt	Clay	USDA Textural Name
1	S1	A (Topsoil)	2	13	36	37	5	93	5	2	Sand
2		E (Subsurface)	3	14	36	38	4	95	3	2	Sand
3		Bt (Subsoil)	2	8	26	32	4	72	3	25	Sandy clay loam
4	S2	A (Topsoil)	0	1	7	80	5	93	6	1	Fine sand
5		E (Subsurface)	<1	1	7	85	4	97	2	1	Fine sand
6		Bh (Subsoil)	0	1	7	77	4	89	6	5	Fine sand

* The A horizon, or topsoil, is the upper part of the soil, ordinarily somewhat enriched in, and darkened by, organic matter. The E horizon, or subsurface layer, is a leached layer, lighter in color and lower in organic matter than the overlying topsoil. The B horizon, or subsoil, is the soil beneath the A and E horizons; it may be enriched relative to overlying horizons by clay particles, in which case it is designated a Bt horizon, or by organic material that gives it a black or dark brown appearance, in which case it is designated a Bh horizon.

+ VCS = very coarse sand; CS = coarse sand; MS = medium sand; FS = fine sand; VFS = very fine sand. See Table 1 for size limits of the various soil separates.

Note that the percent total sand is obtained by adding the percentages of the five sand separates (very coarse sand, coarse sand, etc.). The percentages of sand, silt, and clay (which total 100%) are used with the USDA textural triangle (Figure 1) to determine the textural name of a sample. If the sand fraction of a sample is dominated by a particular size separate, however, a further modifier must be attached to the textural name (e.g., fine sand, or loamy coarse sand), as discussed in the text.