these conditions, crops suffer from water-logging. Soil erosion is a problem if the vegetation cover is sparse and if concentrated flow occurs through unprotected channels.

Vertisolic soils can be managed for crop production by controlling water dynamics and improving soil fertility. Cotton is known to perform well on Vertisolic soils because it has a vertical rooting system which is not damaged too much by cracking (ISSS Working Group RB, 1998).

3.2.1 Textural Classes

Definitions

Sand: Soil material that contains 85% or more sand; the percentage of silt plus 1.5 times the percentage of clay does not exceed 15. (CSSC; USDA)

Loamy sand: 25% or more very coarse, coarse, and medium sand and less than 50% fine or very fine sand. (CSSC)

Loamy sand: Soil material that contains between 70 and 91% sand and the percentage of silt plus 1.5 times the percentage of clay is 15 or more; and the percentage of silt plus twice the percentage of clay is less than 30. (USDA)

Sandy loam: 30% or more very coarse, coarse, and medium sand, but less than 25% very coarse sand, and less than 30% very fine or fine sand. (CSSC)

Sandy loam: Soil material that contains 7 to 20% clay, more than 52% sand, and the percentage of silt plus twice the percentage of clay is 30 or more; or less than 7% clay, less than 50% silt, and more than 43% sand. (USDA)

Sandy clay loam: Soil material that contains 20 to 35% clay, less than 28% silt, and 45% or more sand. (CSSC; USDA)

Sandy clay: Soil material that contains 35% or more clay and 45% or more sand. (CSSC; USDA)

Loam: Soil material that contains 7 to 27% clay, 28 to 50% silt, and less than 52% sand. (CSSC; USDA)

Silt loam: Soil material that contains 50% or more silt and 12 to 27% clay, or 50 to 80% silt and less than 12% clay. (CSSC; USDA)

Clay loam: Soil material that contains 27 to 40% clay and 20 to 45% sand. (CSSC; USDA)

Silt: Soil material that contains 80% or more silt and less than 12% clay. (CSSC; USDA)

Silty clay loam: Soil material that contains 27 to 40% clay and less than 20% sand.(CSSC; USDA)

Silty clay: Soil material that contains 40% or more clay and 40% or more silt. (CSSC; USDA)

Clay: Soil material that contains 40% or more clay, less than 45% sand, and less than 40% silt. (CSSC; USDA)

Heavy clay: Soil material that contains more than 60% clay. This textural class is only found in the Canadian texture triangle. (CSSC)

Particle-size analysis: The determination of the various amounts of the different separates in a soil sample, usually by sedimentation, sieving, micrometry, or combinations of these methods.

Concepts

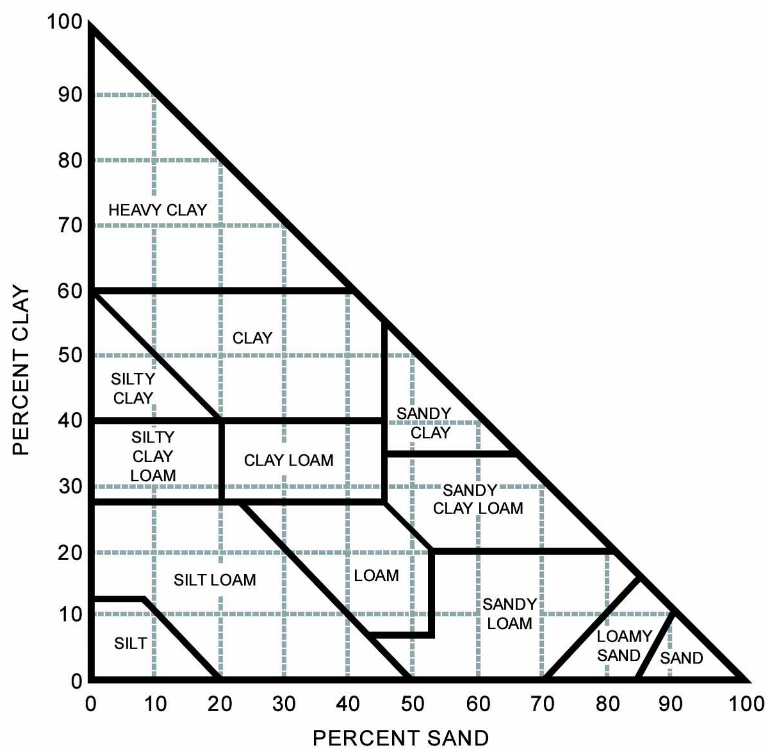

Fig. 3.3. Soil textural classes in the Canadian System of Soil Classification (Soil Classification Working Group, 1998). Reproduced with permission from NRC Research Press, Ottawa.

Soil texture refers to the content of sand, silt and clay particles in soil. Soil textural classes are determined by limits set for the amount of sand, silt and clay in a soil sample. The Canadian system uses a right angle triangle to determine soil textural class (Fig. 3.3). Percentages of clay and sand are identified for each textural class in Fig 3.3; the remainder of each class is silt. There are 13 textural classes.in the Canadian System. The amount of sand increases along the x-axis while the amount of clay increases along the y-axis. Therefore the amount of 'grit' increases as the sand content increases. In contrast, the amount of plasticity (capacity to mold the soil) increases as the clay content increases. These concepts are extremely useful when the hand texturing method is used determine the texture of soil.

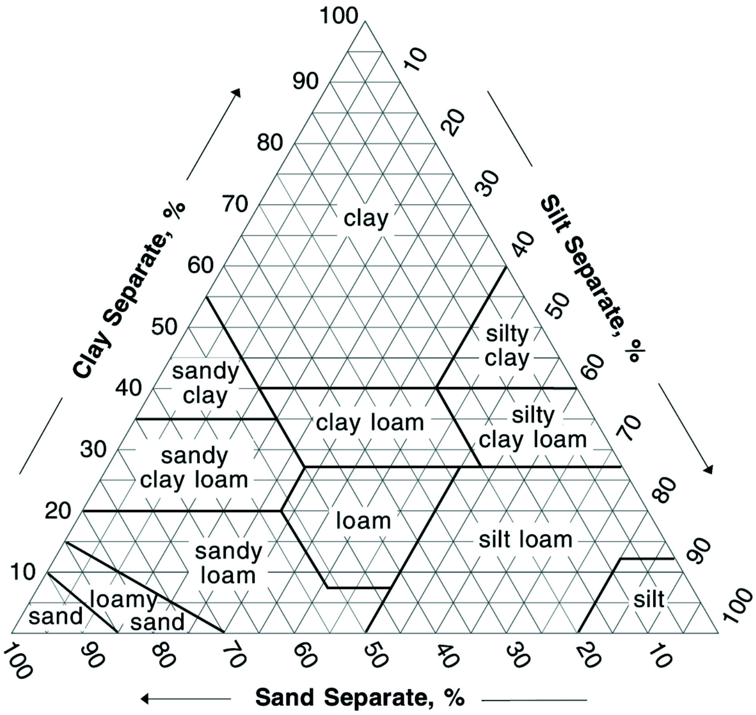

Fig. 3.4. Soil textural classes in the U. S. texture triangle (Soil Survey Staff, 1998). Reproduced with permission from Natural Resource Conservation Service, U. S. Department of Agriculture.

The U. S. texture triangle is an equilateral triangle (Fig. 3.4). Percentages of sand, clay and silt separates are identified on the sides of the triangle. For each textural class, it is possible to determine the sand, silt and clay content directly from the graph. There are 12 textural classes in the U. S. textural triangle compared to the 13 in the Canadian triangle. The heavy clay textural class is not found in the U. S. triangle. The definitions for 10 out the 12 textural classes in the U. S. textural triangle are identical to those in the Canadian triangle. Although the definitions for loamy sand and sandy loam are different, there is no difference between them for practical purposes. The U. S. textural triangle is more explict and needs information of anytwo of any three variables, sand, silt and clay, to determine the textural class. In contrast, in the Canadian triangle, only the sand and clay content are needed because silt is determined by difference.

Sandy soils are coarse. They contain at least 70% sand and <15% clay. Clayey soils are fine, and are distinctly dominated by clay particles. The clay and silty clay textural classes have at least 40% clay while the sandy clay has to have at least 35% clay sized particles. Loamy soils are moderately coarse to moderately fine, and contain many subdivisions. The texture of soil reflects the composition of mineral particles in the fine earth fraction (<2 mm diameter) and are related to a number of physical, chemical and biological properties. Soil texture is a fundamental property of soil and is an integral part of pedon description. There are a large number of engineering properties which are also affected by soil texture.

Determination of Soil Textural Classes:

The hand texturing method is used in the field to determine the textural class of a soil sample subjectively from the feel of a moist soil molded between the fingers and thumb. The way a wet soil "slicks out" - that is develops a continuous ribbon when pressed between thumb and fingers - indicates the amount of clay present. Sandy particles are gritty; silt feels like flour when dry and is only slightly plastic and sticky when wet. It takes years of practice to correctly identify soil samples belonging to all textural classes. In the laboratory, a person can practice with samples of known textures and calibrate one's sense of touch before venturing to texture unknown samples.

Quantitative laboratory methods for soil texture analysis involve the application of Stokes' Law, $\mathbf{V = kr^2}$: where k is a constant related to the density and viscosity of water, and the acceleration due to gravity, V is the velocity of settling and r is the radius of particles. The standard method involves the destruction of organic matter in the soil sample by treating it with hydrogen peroxide and dispersing the soil with sodium hexametaphosphate. The soil sample is analyzed by sedimentation and/or sieving. The larger particles in the dispersed sample fall faster than the medium and small sized particles. After about 1 minute, the sand particles settle out leaving the silt and clay in suspension, which can be determined by floating a hydrometer. After about 1 day, the silt settles out and only the clay remains in suspension. Percent sand, silt and clay can be determined by the difference between different fractions obtained at specific time intervals.

Applications

The texture of a given soil can be changed only by mixing it with another soil of a different textural class. For example, in order to change a soil sample which has a silt loam texture to a loam , one could add sand. For example, if 33 g of sand are added to 100 g of a silt loam (20% sand, 20% clay, and 60% silt), then the texture of the composite sample would be a loam (40% sand, 15% clay, and 45% silt). The addition of sand decreases the relative proportions of clay and silt in the composite soil ample. This shift in textural classes is be easily seen the two textural triangles (Fig. 3.3 and 3.4). This example shows that the texture of a small soil sample can be changed easily. In the field, massive amounts of materials would be needed to change the texture of soil. Cultural management, such as planting different crops and shallow tillage, does not change soil texture.

Pedological processes occur time scales of decades and centuries. It is possible to get eluviation of clay to occur in well-drained soils which get high amounts of precipitation. In such cases, eluviation of clay from the surface to the subsurface horizon can lead to differences in textural classes of the surface and subsurface horizon. For example, the Grosmont soil series consists of moderately well drained Dark Gray Luvisols developed on fine-loamy, weakly calcareous, glacial till materials. The soil profile has the following horizon sequence: L-H, Ah, Ae, AB, Bt, BC, and C. The Ae horizon, 8 to 13 cm depth, has a silt loam textural class (27% sand, 52% silt and 21% clay) but the Bt horizon, 25-53 cm depth, has a clay textural class (24% sand, 34% silt and 42% clay). The eluviation of clay for Ae to Bt causes a change the class of soil texture. The impact of changes in textural class are presented in Section 3.2.2.