— Soil Fertility Note 13 —
Clay Minerals: Their Importance and Function in Soils

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People tend to have a negative opinion of clay soils. It is true that these soils can be difficult to till or spade. Also, they may not drain quickly after heavy rain and often harden when dry. In spite of these drawbacks, however, some of the most productive soils across North Carolina contain significant amounts of clay.

Most soils contain a mixture of clay, organic matter, sand and silt. If a soil contains at least 40 percent clay, then we classify it as a "clay soil." Percentages of sand, silt and clay in soil vary across North Carolina (Table 1).

What is Clay?

Clay is a naturally occuring, inorganic component of most soils. Chemically, clays are aluminosilicates [$Al_4Si_4O_{10}(OH)_8$] and carry negative charges. Sand, on the other hand, is composed of large, neutral particles of silicon dioxide (SiO_2).

Clay is made up of tiny particles less than 0.002 mm in diameter. By comparison, silt particles range from 0.002 to 0.05 mm in size and sand particles from 0.05 to 2.0 mm. For this reason, clay soils are considered to be fine textured; silts, medium textured; and sands, coarse textured.

Effect of Clay on Nutrient Availability

Because clay particles are so small, pure clay has at least 1000 times more external surface area than coarse sand. Because clays have a large surface area and negative charges, they can attract and hold positively charged ions. This characteristic is important because many positively charged ions are plant nutrients, such as calcium, magnesium and potassium.

A soil's ability to hold and store positively charged ions is known as cation exchange capacity (CEC). Soil with high CEC holds more nutrients and loses fewer of them when rainfall leaches through the soil (Figure 1). The more clay a soil has, the greater its CEC.

Of all soil types, sandy soils have the lowest CEC values. These soils hold few nutrients and lose them easily as water moves through the soil. Any nutrient-holding capacity they may have comes from a coating of clay and organic matter on the sand particles.

Effect of Clay on Soil Water

Clay acts as a binding agent between soil particles. It gives soil elasticity and provides cohesion of soil particles. The result is a network of capillary pores that hold moisture against the force of gravity.

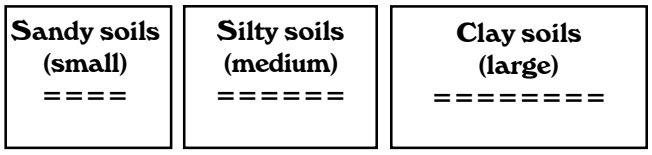

Figure 1. The soil magnet.

Table 1. Soils of three North Carolina research stations classified by texture.

Research Station	Region	Textural Classification	% Sand	% Silt	% Clay	CEC*
Central Crops / Clayton	coastal plain	sandy loam	78.5	8.8	12.7	3.29
Tidewater / Plymouth	tidewater	clay loam	38.6	22.4	39.0	8.87
Upper Piedmont / Reidsville	piedmont	clay	25.1	28.7	46.2	13.06

* CEC = cation exchange capacity

The moisture content of a soil after gravity has removed excess water is called *field capacity*. The moisture content at which plants wilt is called the *wilting point*. As illustrated in Figure 2, the moisture content of sand at field capacity and wilting point is much lower than in clay soil.

Unlike clays, sandy-textured soils have large pores that allow water to drain more easily. Although this condition may be beneficial in preventing disease development, it has a double disadvantage. First of all, it takes more water to sustain plant growth on a sandy soil. Secondly, the more water that percolates through the soil, the more nutrients are washed out—particularly nitrogen, potassium and sulfur.

Summary of the Benefits of Clay

Clay contributes many benefits to the physical, chemical and biological properties of soil. It increases the soil's cation exchange capacity, enhances water-holding capacity, provides elasticity, acts as a binding agent for the non-clay components, and reduces nutrient loss through leaching. The buffering capacity of soil (resistance to change in pH) is enhanced by clay, which means that growers do not have to apply lime as often.

Clay is an essential component of a productive soil. It plays a vital role in holding plant nutrients and water. Without it, successful crop production would be in jeopardy.

M. Ray Tucker

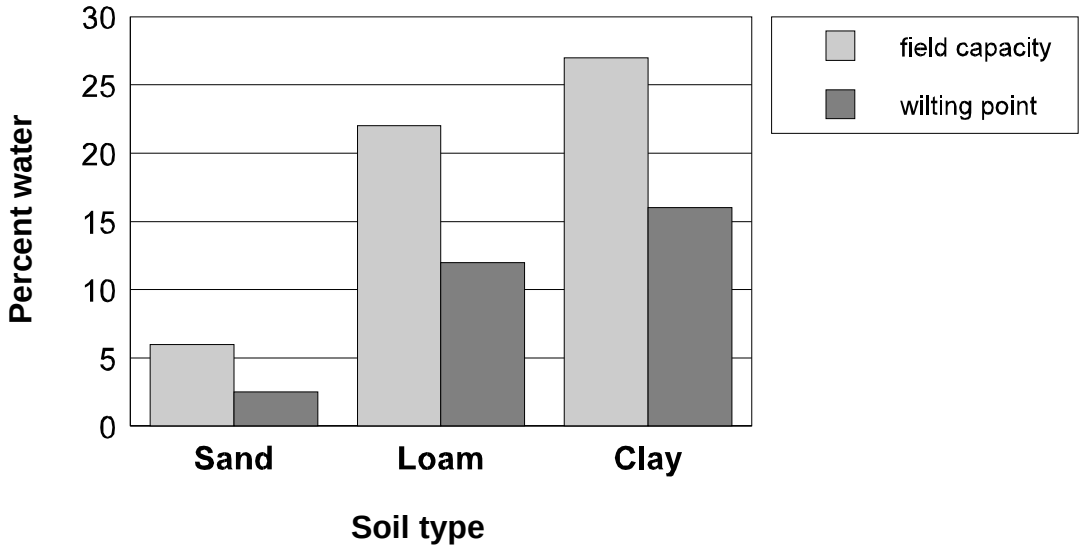

Figure 2. The percentage of water held by different soils at field capacity and at the wilting point.

Questions or comments should be directed to the Soil Testing Section of the NCDA&CS Agronomic Division. Information on soil testing, nematode assay, plant/waste/solution analyses, and field services is also available from the Division.