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DIFFERENT CLAYS, DIFFERENT K RELEASE

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When most farmers and agronomists describe the soil in a field, the two properties most often mentioned are the soil texture and the amount of soil organic matter (SOM). For example, a farmer may say that a field has "mostly clay loam soils with 4% SOM." This information is helpful but it is missing an extremely important description …that being what type, or types, of clay are present.

The clay particles in soils might be small in size, but can have huge effects on soil properties such as moisture holding capacity, formation of soil aggregates, plant nutrient storage and release, and soil tilth. By volume, most cultivated mineral soils contain a combination of the mineral soil particles (sand, silt and clay) that makes up about 55% of the soil. The remainder is comprised of SOM (1 to 6%), depending on the climate and vegetation, plus soil pores or "voids" that make up the balance of about 40%. A moist but not saturated soil has the pores filled with about half air and half water. This level of moisture and aeration is favorable to plant growth for most arable crop species.

The volume of mineral particles in any particular soil can have different proportions of sand, silt, and clay and are described as soil texture classes. A total of 12 classes are accepted and described in **Figure 1**. Most medium-textured soils contain between 20 to 35% clay, which contributes to soil physical and chemical properties that make these soils generally suitable for cultivation and irrigation.

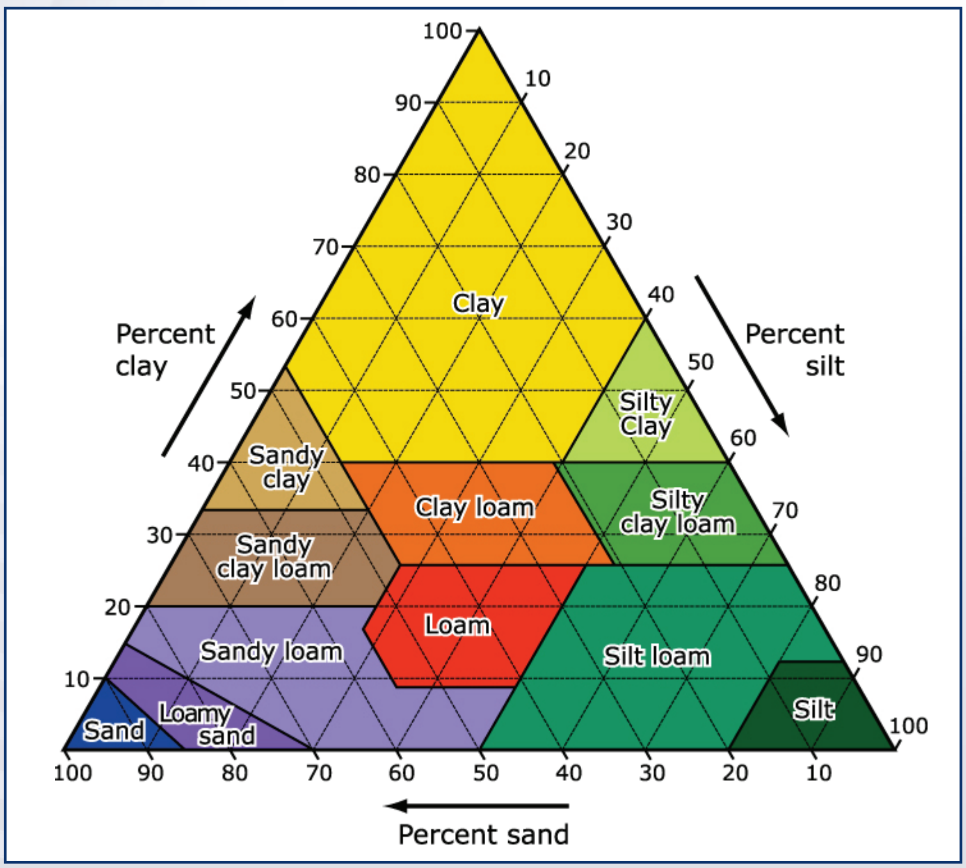

Figure 1. Soil texture classes as illustrated in the textural triangle. IPNI Soil Fertility Manual.

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> *"When a farmer or agronomist tells you the dominant soil texture and SOM content for a field soil, it is appropriate to ask if they know what clay type or types are present in the soil, as this can greatly affect how the soil can be managed."*

Clay particles are so small they cannot be seen by the human eye. Clay particles are less than 0.002 mm (2 µm or micrometers), compared to 0.002 to 0.05 mm for silt particles, and 0.05 to 2.0 mm for sand particles. Besides differences in size, the shape and structure of different clay types can be observed and differentiated using scanning electron microscopes, and x-ray diffraction techniques.

There are important differences of electrostatic, chemical, and physical properties of clay. The key properties that affect crop growth and soil management are: 1) how water molecules and many plant nutrient cations are stored and released for plant use, and 2) whether or not the specific colloid type will swell when moistened, and then shrink when dried.

For example, two common clay types present in soils of the Northern Great Plains of North America are smectite and illite. They are both "layered silicate crystalline clays" that are not highly weathered, occur as flakes, and are similar in size (i.e., 0.01 to 1.0 µm for smectites, and 0.2 to 2.0 µm for illites). However, smectite clay colloids will swell or shrink greatly if they become wet or dry, have a relatively large negative surface electrostatic charge, from -80 to -150 cmol/kg (centimoles per kilogram of soil), usually referred to as cation exchange capacity (CEC), and will "trap" a large amount of potassium (K^+) between its layers. In contrast, Illite clay will not swell and shrink, it has a lower relative CEC (-10 to -40 cmol/kg), and cannot trap as much K^+. This is because the outside layers of Illite clay colloids are strongly held together by the sharing of stored K^+ ions. In fact, these two clay colloid types usually occur together because if potassium cations (K^+) saturate a smectite clay it can become an illite clay, and conversely, if an illite clay has much of the K^+ cations removed it can become a smectite clay.

What does this mean for K storage and release? The K^+ cations stored in soils higher in illite clays are more easily released to plant roots. Knowledge gathered from recent research done in North Dakota (Franzen and Bu, 2018) has resulted in adjusted and variable K fertilizer rate recommendations for areas having greater levels of illite clay mixed with smectite clay, versus areas having low levels of illite clay and a predominance of smectite clay.

(**Editor's note:** *More detail on the clay mineral types discussed here, including images and illustrations, is available from Franzen and Bu (2018). See the reference list for the link provided.*)

When a farmer or agronomist tells you the dominant soil texture and SOM content for a field soil, it is appropriate to ask if they know what clay type or types are present in the soil, as this can greatly affect how these soils can be managed. For example, in the Cerrado region of Brazil the dominant clay type is kaolinite, as well as some occurrence of aluminum and iron oxides. These are all highly weathered tropical clay types, extremely small in size (e.g., < 0.1 µm), have hexagonal crystals for structure shape, and often have very low CEC values (e.g., -5 cmol/kg) or positive surface charges (e.g., +20 cmol/kg), which is referred to as anion exchange capacity. These soils tend to have low K reserves due to weathering and leaching of cations out of the profile, and need regular and significant K applications along with balanced applications of other plant nutrients to produce crops. If managed well, these tropical clay soils often produce high-yielding row and forage crops.

Just remember **different clays, different K release.**

References

Franzen, D. and H. Bu. 2018. https://www.ag.ndsu.edu/publications/crops/north-dakota-clay-mineralogy-impacts-crop-potassium-nutrition-and-tillage-systems/sf1881.pdf

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