Soil.

Physical properties

Why do we care about the physical properties of soil? Because these properties help determine how well a soil will grow good crops. Understanding our farm or garden soil will help us make good decisions about how or if we can amend the soil to make it better, and at what cost. Soil physical properties affect plant growth in many ways including; a) root penetration, b) root aeration, c) retention of nutrients, and d) water availability.

Soil physical properties include its texture, structure, consistence (weight, pore space and air), and color. The properties we'll examine most closely are soil texture and structure.

Organic Soils (the technical definition). There is a bit of confusion about what "organic" means. The name of the course you are enrolled in is "Organic soils, nutrients, and composting". To be more precise, the course should have been named "Organically managed soils". That is because there is another older, technical, definition of "organic" soil. This definition has nothing to do with whether or not synthetic chemicals or fertilizers have been used on the soil. Rather, it depends on how much decomposing material from plants is present in the soil. Mucks and peats are classic organic soils. Peat still contains some the plant tissue structure (that's why it can be burned). Muck's plant material is nearly completely decomposed. In these two true organic soils, peat and muck, plant material (organic matter) make up over 20-30% of the weight.

For purposes of this course, however, unless specifically noted, "Organic soil" should be understood to mean "organically managed"" soil, not muck or peat soils.

Soil texture is what we can feel when we rub the soil between our fingers. This depends on the size of the soil particles. In mineral soils where the parent material was rock there are 3 textures as seen in the table on the next page.

A mineral soil containing equal amounts of the three textures is considered a Loam.

Clay soils, because they have so many more tiny particles, have much, much more surface area than silt or sand. This large amount of surface area creates a huge reservoir of available area for nutrients and water films around each particle. Most soils are not ideal in texture. Areas that are very good for farming have a very good balance of sand, silt and clay. These loamy soils have good water holding, and nutrient holding capabilities.

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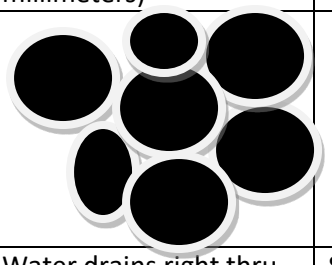
Table 1. Soil textures. The dots are depictions of relative particle size, not actual size.

Sand	silt	Clay
Large particles	medium	small
2.00-0.05 Size (in millimeters)	0.05-0.002	0.002 and lower
		……
Water drains right thru the large pores between particles	Silt feels like powder and does not stick together well.	Clay mineral particles are so small they carry a slight charge that attracts water and nutrients in a film around each particle

In northeast Wisconsin, for example, we have some soil that contains relatively large amounts of clay. These soils stay wet longer than loams, and when they do dry out they "shrink-bake" into a very hard surface. In some areas, the soils are very sandy (perhaps old lake shores). These soils do not hold water well at all. Farmers can plant sandy fields earlier in the spring because they dry out sooner than other soils, but by mid-summer, if the rainfall is scarce, then the moisture is gone and the plants will go dormant or die. When particles are larger than sand, and there are significant amounts of larger rock fragments, soils are said to be gravelly. Gravelly soils are typically not suitable for farming.

Besides water holding capacity, soil texture is important in the role of nutrient reservoir. Nutrients will be discussed elsewhere, but the reader should be aware that soil texture is an important factor in relationship to soil nutrients.

Soil texture can be determined by several methods including the use of a hydrometer which floats in a standardized chemical solution. This texture test is performed in a laboratory. An average person can, with some practice, wet a small quantity of soil and ribbon it out between their fingers. Obviously sandy soils cannot form a ribbon. However, a loam that also feels gritty, is probably a sandy loam. Clays and silts do form ribbons with clay soils sticking together better than silt soils. If a child can make a clay pot out of the soil then the texture is definitely clay.

Soil texture cannot be readily changed by farming practices. It is really just a function of the parent rock material. There are some cases where sandy soils can be mixed with organic matter and improved from a farming standpoint. Also, clay soils can be amended with a lot of work and expense, (adding sand) but this is impractical on a farm field scale. Increasing organic matter in all soil texture types can improve the soil structure, but it cannot overcome the basic original soil texture.

Soil structure is another physical property of soil. Structure really refers to the arrangement of the soil particles. Structure is a way of describing how the soil particles (sand, silt or clay) clump together. The clumps of soil are like clusters of grapes. Individual soil particles are like individual grapes. The clusters or aggregates or "peds" are described (Foth, 1958) using various terms like; columnar, blocky, platy, crumb-like, or granular. The terms are relatively descriptive. Preferred soil structure is crumb-like or

granular mainly because the peds are roundish and don't fit snuggly together. This creates more pores. Platy or plate-like soils, are considered "tight" because of the flat, overlapping nature of the peds.

Sandy soils are considered to have no structure because each particle functions as its own ped since it is unattached to any other particle. If a clay loam is tilled or trampled when it's wet the clay particles may slip down and form a layer of very fine particles. This is how plow layers form. When clay soil pores are collapsed, that soil is said to be puddled. Puddled soil or soils with plow layers are difficult to farm because they form huge peds (aggregates) called clods. I can walk my organic plowed fields in spring, but when I walk my neighbor's field that's been continuous corn or soybeans for 15 years, the puddled soil results in "cement feet" making it nearly impossible to continue walking.

The good news is that soil structure, and how it forms aggregates, can mitigate the influence of soil texture. Clay soils, if managed well, can form aggregates that are more favorable to pore space and therefore air exchange, root penetration, water retention and nutrient cycling. Let me repeat this point, agricultural practices can influence soil structure by altering the aggregation. In organic agriculture, this is mostly accomplished by increasing the soil's biological activity. The gums and sticky substances produced by living organisms help particles aggregate and give soil better structure. Conversely, many conventional agricultural practices tend to cause soil structure to become less crumbly.

To illustrate the idea that agricultural practices can affect soil structure, and thus crop yields, Foth (1958) cites studies that show that cropping systems that include a legume in rotation with corn create "marked increases in aggregation" over continuous annual cropping. Cover crops or continuous well-managed pastures can also be expected to increase aggregation because they reduce the impact of rain drops, which break soil aggregates apart.

This point is an overlooked benefit of organic and sustainable agriculture…..the point that the way we farm, the tillage and cropping practices we use, can alone alter the nature of the physical properties of soils! Changing physical structure, soil aggregation quality, will change our success as farmers and gardeners.

Forget about the effects of synthetic fertilizers and herbicides, if we just tilled and rotated crops or used cover crops we can have a huge, beneficial impact on improving, rather than degrading the quality of our soil. I'll also repeat again, the easiest way to change soil structure is to increase the biological activity of our soil fauna. Increasing soil biology is exactly opposite of the effect that conventional agriculture has. Organic and sustainable methods can have the same yields as conventional agriculture because we work to improve soil biology, thereby improving soil physical properties, and then plant growth – this is our alternative to adding synthetic fertilizers.