USDA Natural Resources Conservation Service

Indicator	Test	Function
P	F	W

Soil Quality Indicators

Soil Crusts

Structural soil crusts are relatively thin, dense, somewhat continuous layers of non-aggregated soil particles on the surface of tilled and exposed soils. Structural crusts develop when a sealed-over soil surface dries out after rainfall or irrigation. Water droplets striking soil aggregates and water flowing across soil breaks aggregates into individual soil particles. Fine soil particles wash, settle into and block surface pores causing the soil surface to seal over and preventing water from soaking into the soil. As the muddy soil surface dries out, it crusts over.

Structural crusts range from a few tenths to as thick as two inches. A surface crust is much more compact, hard and brittle when dry than the soil immediately beneath it, which may be loose and friable. Crusts can be described by their strength, or air-dry rupture resistance.

Soil crusting is also associated with biological and chemical factors. A biological crust is a living community of lichen, cyanobacteria, algae, and moss growing on the soil surface that bind the soil together. A precipitated, chemical crust can develop on soils with high salt content.

Factors Affecting

Inherent - Soil crusting is related to soil texture, organic matter, and sodium content. Surface crusts are more common on fine-textured soils, such as silts, loams and clays. In combination with the splashing effect of raindrops, increased runoff and erosion of fine-textured soil increases the likelihood that a crust will develop. Crusts are usually thin and weak if present on coarse-textured, sandy soils.

Low organic matter results in poor soil structure, reduced pore space, and weak, unstable aggregates that fall apart when raindrops hit them. Rainfall and runoff disperses the soil into individual particles that clog soil pores and seal its surface with a soil crust.

Soils with high sodium content are more likely to develop surface crusts since these soils are more readily dispersed with rainfall and irrigation.

Left: Note the surface crust on this soil. The field was in tall fescue sod for 11 years. It was cleared and plowed using conventional tillage methods. Photo courtesy Bobby Brock, USDA NRCS (retired). Right: Collected from a no-till field in Georgia's Southern Piedmont, good structure and aggregation are evident in the soil on the right. The same soil formed a structural crust under conventional tillage. Note the sunlight reflectance of the crusted soil. Photo courtesy James E. Dean, USDA NRCS (retired).

Dynamic - Management activities that deplete soil organic matter and leave soil bare, smooth and exposed to the direct impact of water droplets increase soil dispersion, surface sealing, runoff, erosion, and crusting. Excessive tillage tends to break up soil clods into smaller sizes more susceptible to breakdown, bury most plant residue, and accelerate decomposition of organic matter. Harvest methods that remove most or all of aboveground biomass also prevent or reduce organic matter buildup and protection of the soil surface. Until the crop and its protective canopy is established, residue removal also exposes soil to direct sunlight, which increases soil temperature and accelerates drying of the soil surface into a hard crust.

Relationship to Soil Function

A surface crust indicates poor infiltration, a problematical seedbed, and reduced air exchange between the soil and atmosphere. It can also indicate that a soil has a high sodium content that increases soil dispersion when it is wetted by rainfall or irrigation.

Problems with Poor Function

Because they are hard and relatively difficult to break, crusts restrict seedling emergence, especially in non-grass

crops such as soybeans and alfalfa. Crusts can also reduce oxygen diffusion into the soil profile by as much as 50% if the soil crust is wet. Crust development soon after a crop is planted can result in such poor emergence that the crop might have to be replanted.

Surface sealing and crusts greatly reduce infiltration, and increase runoff and erosion. Increased runoff results in less water available in soil for plant growth.

The sunlight (and energy) reflectance of a surface crust is higher than that of a non-crusted soil, so soil temperature may be lower and surface evaporation reduced where a crust exists (see photo on reverse). This could negatively effect germination and development of healthy seedlings in cooler climates.

The relatively smooth surface of a crusted soil initially increases wind erosion of sandy soils. Loose sand particles blow across and abrade the smooth surface of the crust. Roughening of the surface crust eventually reduces wind erosion. For soils with a small amount of sand, hard crusts protect the soil surface from wind erosion.

Surface crusts can have other limited benefits. Crusts decrease water loss because less of their surface area is exposed to the air compared to a tilled, fluffy soil. In addition, a crust forms a barrier to evaporation of soil moisture. Reduced evaporation of soil moisture means more water remains in the soil for plant use.

Practices that lead to soil crusting include:
- Harvesting, burning, burying, or otherwise removing plant residues and mulches so as to leave the soil surface bare for an extended period of time, and
- Soil disturbing activities that destroy organic matter, soil structure and aggregation, and result in very smooth seedbeds.

Avoiding Soil Crusting

Practices reducing the development of soil crusts or minimizing their negative impacts include those that protect or increase soil structure and organic matter and provide protective vegetative or residue cover on the soil surface. No-till or reduced tillage of cropland is the best way to reduce or eliminate crust formation. If tillage is necessary, it should only be done to the minimum level required for good seed germination and emergence. Large seeded crops do not require the same degree of clod size reduction or as smooth of a seedbed as do small seeded crops. Residue intercepts the force of falling raindrops and is a source of organic matter. Organic matter stabilizes soil aggregates making them more resistant to the physical impact of raindrops. Improved aggregation results in lower bulk density and increased pore space, and improves infiltration and water movement through soil.

Improved infiltration and water movement through soil decreases surface ponding and runoff, and helps protect soil from erosion. Good soil structure and aggregate stability are vital to supporting healthy, vigorous plants. Healthy plants provide and conservation tillage methods manage surface and subsurface plant residues needed to increase organic matter while maintaining and improving aggregate stability and soil structure.

To reduce the incidence of surface crusting of soils high in sodium, irrigation water management prevents sodium accumulation at the surface, and gypsum (calcium sulfate) can be applied to promote flocculation and inhibit dispersion of soil particles.

It may be necessary to break a soil crust with a shallow, light tillage operation such as with a rotary hoe or row cultivator, preferably when the soil is still moist. Light tillage can increase seedling emergence and help control weeds. Irrigation water can also be used to help with seedling emergence.

Conservation practices that minimize the development of a soil crust include:
- Conservation Crop Rotation
- Cover Crop
- Residue and Tillage Management
- Salinity and Sodic Soil Management

Measuring Soil Crusting

Crust air-dry rupture resistance can be measured by taking a dry piece of the crust about ½ inch on edge and applying a force on the edge until the crust breaks. Generally, more force is required for crusts that are thick and have high clay content. A penetrometer to measure the penetration resistance of the crust can be used. Crust thickness can also be measured.

Reference: Soil Survey Division Staff. 1993. Soil survey manual. Soil Conservation Service. U.S. Department of Agriculture Handbook 18. Chapter 3, Part 8. [Online] http://soils.usda.gov/technical/manual/contents/chapter3d.html

Specialized equipment, shortcuts, tips:

A penetrometer may be needed to measure penetration resistance of a soil crust.

Time needed: 30 minutes