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Soil Crusting – Formation, Kinds, Causes & Management

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SUMMARY

Soil crusting is a thin layer of dense and tough material. Soil crusting is considerably more compacted and packed than the underlying material. A soil crust tends to look smooth and even when compared to freshly exposed soil. Rain impact on exposed soil is the main cause of soil crusting. Clay soils, especially those with high magnesium content and/or sodium content, are prone to soil crusting and sealing at the surface following rainfall events. This is because clay particles in soil are easily dispersible or splattered across the soil surface as rainwater pellets the ground. When the water eventually recedes back into the soil, the clay is filtered onto the surface and forms a hard crust. When soil crusting occurs, germinating seeds are unable to break the crust. With soil crusting, oxygen flow into and out of the soil is limited, reducing crop growth. Signs of soil crusting are poor crop emergence. Patterns of damage depend on the levelness of the field and the pattern of soil drying across the field. Soil crusting is especially a problem in dry direct seeded fields where seed is covered by soil. It is important to address soil crusting at the time of crop establishment.

INTRODUCTION

Soil crusts are classified into three morphological types. Physical soil crusts are modifications of topsoil caused by physical perturbation, such as raindrop impact or sedimentation, resulting in development of a compacted surface layer with reduced porosity; some authors prefer to use the term *seal* if no drying or hardening has taken place. Biological soil crusts (BSCs) are living communities of lichens, cyanobacteria, algae or mosses growing on and near the soil surface and binding soil particles. Chemical crusts are salt crusts, which are discussed elsewhere. These three main crust types are not mutually exclusive, as many forms of biological soil crusts will also exhibit some physical or chemical crusting. Although the word crust may also indicate hard layers of lateritic, calcareous and siliceous material, as well as horizons described as 'weathering crusts' by Russian authors, these terms have meanings that are different from those discussed in this chapter. Physical compaction by trampling or tillage also forms physical soil crusts, but this is not covered here.

Formation of Soil Crust

A number of binding agents have been identified that are related to soil aggregation and the soil structural stability. These are organic substances, silica, sesquioxides, liming materials, exchangeable cations etc. The effectiveness of binding agents depends upon whether it is soluble and if so whether the solid phase is in equilibrium with dissolved phase or whether solid phase dries irreversively or rehydrates and re-dissolves on re-wetting or whether dissolved phase ionised or remains as un-dissociated molecule or precipitates as discrete particles or surface coatings, and whether it is crystalline or non-crystalline or can acquire charge.

Kinds of Soil Crust

The three principal kinds of soil crust are structural crusts, erosion and depositional crusts and cryptogamic crusts whose brief discussions are presented below:

I. Structural Crusts:

The sub-types of structural crusts are:

(a) Slaking crusts,
(b) Infiltrating crusts,
(c) Coalescing crusts and
(d) Sieving crusts.

A more detailed description of each sub-type is described below:

(a) Slaking Crusts:

Slaking crusts are usually formed due to disintegration (or physical disruption) of a sodic or weakly aggregated soil by the impact of rain drops. It consists of a thin (1 mm to 5 mm thick) dense layer with a sharp boundary with the underlying layer. Textural separation between coarse particles (skeleton) and fine particles (plasma) cannot be noticed. Size distribution of particles released by break-down of aggregates governs the porosity of sealing crusts. If aggregate-disruption leads to aggregate fragments, porosity is relatively higher but if basic particles are released due to aggregate break-down, porosity is much lower.

(b) Infiltrating Crusts:

Infiltrating crusts are generally formed on medium textured (loam) soils due to the impact of rain drops which erodes the top of surface layer aggregates causing separation of silt particles and sealing of void space to a depth of few millimeters from the surface. They are mainly characterised by a clear textural separation. They are made by silt sized grains which form net like infillings in the top few millimeters of the soil. In few millimeters depth some clay coating are generally observed on soil aggregates. Porosity is reduced due to clogging of inter-aggregate as well as inter-grain void spaces by infiltrating material.

(c) Coalescing Crusts:

Coalescing crusts are formed in wet soils when the soil material is in viscous state by the drop energy driving force. They are generally thick (thickness up to 20 mm), more densely packed than the underlying horizon,' exhibit a gradually transition with the underlying layer for which they are sometimes called as transitional micro horizons. In the top few millimeters of the crust, porosity is low and it gradually increases with depth.

(d) Sieving Crusts:

Sieving crusts are formed by the impact of rain drops on sandy soils where aggregates are extremely fragile, leading to the sorting of soil particles causing concentration of the coarser particles at the top and finer particles in the deeper position. Thus sieving crusts are made up of two contrasting layers, the upper most of which is 1 to 5 mm thick, consists of loosely packed coarser skeleton grains and the underlying of which in 100 pm to 1 mm thick containing high amount of fine particles resulting very low porosity. The upper and lower boundaries of this plasmic layer are very sharp.

II. Erosion and Depositional Crusts:

The sub-type of erosional and depositional crusts is:

(a) Erosional crusts and

(b) Depositional crust.

A more detailed description of each sub-type is described below:

(a) Erosional Crust:

Erosional crusts are formed from the erosion of sieving crusts when the loose coarse textured upper layer is stripped away by the overland flow, leaving the under laying layer of fine particles at the surface. They are 100 pm to 1 mm thick, plasmic layer which is very dense and coherent.

(b) Depositional Crusts:

Depositional crusts are formed after sealing of the surface by a structural crust and concentration of detached particle from eroded clods or ridges in inter clods micro deposition or furrows through micro-scale run-off. Depositional crusts are thus made up of a 5 to 10 mm or thicker sedimentary layer over a previously developed structural crust. Textural separation results the development of microbials which are less distinct in the lower part of the sedimentary crust layer. Clear textural variation is noticed between the depositional crust layer and the underlying previously developed structural crust.

III. Cryptogamic Crusts:

Surface crusts made of algae, fungi, lichens, mosses, bacteria over any of the above defined crusts are known as cryptogamic crusts. They are also known as microphytic crusts as they consist of a microbiological layer over one of the above defined crusts. As cryptogams are formed due to multiplication of microbes over a structural or erosion and depositional crust, they are sometimes not considered as soil crust.

Influence of Crusting on Productivity of Soil:

- The crust causes a serious barrier for seedling emergence. The effect of soil crusting on seedling emergence depends on crust thickness and strength, as well as on the size of the seeds and vigour of the seedlings. Small sized seeds are more sensitive to soil crusting.
- Crust clogs the surface macro-pores and inhibits the infiltration of water into the soil causing more run-off, less water storage in the soil profile and less availability of water to plants. Hence, surface crusts are largely blamed initiating run-off and favouring interrill soil erosion.
- Strong crusts with high bulk densities can impede aeration under moist conditions by preventing effective diffusion of oxygen into the soil. Lack of aeration becomes a problem for germination of seeds which would also account for decrease in seedling emergence. Diffusion of oxygen is not restricted in case of dry crust because of cracks. Upon drying hard crust cracks and tears seedling roots.

Causes of soil crusting

Most producers have been advised to plant a little deeper this year to achieve good seed-to-soil contact and access to adequate soil moisture. But if a crust forms above the seed, it requires the combined pressure of several plants to crack through a crust, reducing emergence. Seedling crops trapped under a crust grow and elongate below the crust until the seed runs out of stored energy. Deep planting also presents risks because the plants leaf out underground, inhibiting growth and vigor and promoting an uneven stand. One of the first subjects I would try to explain to any beginning gardener is the evils of soil crusting. Ideal soil for growing most things has a structure or openness to it. There is space incorporated into the soil which allows the infusion of air. Since the pore spaces make the soil more friable, roots and organisms can make their way through it more easily. The structure of soil is created over time as creatures move through it, roots penetrate it and then eventually die, and worms wend their way about leaving their neatly formed earth filled droppings behind. When disturbed very much by digging and pulverizing (especially if too dry or too wet), and left exposed to the open environment without the covering of living or dead vegetation found in most natural environments, most soils form more or less of a crust. The crust is made of tightly packed small mineral particles which are no longer formed into the structures that make up good aerated soil. An extreme example would be to take some soil mix it in a blender with water, and then pour it out and form a sort of slurry that would dry to a packed smooth surface. That may be extreme, but many of our garden practices, some avoidable and some less so, can do nearly the same thing.

Slow entry but a ready exit. A soil crust resists the penetration of water. This effect will certainly vary with the soil, but it is more or less true across the board. Watering badly crusted soil by hand is frustrating. The water pools instead of sinking in and you just have to wait for it to soak down, add a little more and wait again, etc. In extreme cases the lower penetration leads to waste of water because it runs off instead of soaking in. The water that does soak in may not make it as deep as it could under better circumstances. If the water does not penetrate easily, then it does not penetrate evenly either and you may be getting less water down to the root zone, or none at all depending on how long you water for. Often only the top of the soil will be wetted, even with what seems like should be a reasonable amount of watering and water. Soil crusts increase the chances of ending up with a layer of wet soil on top and dry soil beneath it, which is a common beginner gardening mistake. Once that happens, it’s difficult to water enough to resaturate the bed without putting a sprinkler on if for a long period of time. So, the water doesn’t penetrate, but to make it worse, it leaves the soil faster as well! Water travels easily through compacted soil. If the soil is broken up, the water can’t travel from particle to particle as easily and evaporation from the soil surface is minimized. The closely packed soil particles however are like a wick that speeds water to the surface by something like capillary action and back out into the atmosphere. Long standing farming wisdom says that if left uncovered, soil should be broken up to form a pulverized mulch to prevent this effect and keep the water in the soil. I have seen the practice of cultivation as a form of water conservation called into question before, but long tradition and my own observation seem to support the idea that compacted soil, and particularly surface crusting, speed the loss of water from the soil.

There is often more talk about getting air out of the soil when planting plants than getting air into the soil, but it should probably be the other way around. Plants may not appreciate large air pockets that their roots encounter, but very few plants are well adapted to survive or thrive in completely air free soil. In fact, ideal soil for most of the stuff we grow has a good bit of pore space and a ready exchange of air and gasses. Ever stepped on a garden bed? Your foot should sink a good divet into the bed as it crushes the soil structure and closes up the air spaces in the soil. Though I have never formally tested the proposition, it seems to me that plants grow much better if the soil surface is kept very open. Soil "breathes", or at least it should, in order to keep the gajillions of living things in healthy soil thriving. Soil should be like a sponge containing a portion of air rather than like a uniform adobe brick. In fact if we are making adobe bricks or pottery, it is essential to thoroughly destroy any structure forming a homogenous mix where the clay particles are smeared over every grain of sand locking them together like glue. Digging and cultivation can ruin the structure of soil causing the air spaces to collapse. Generally the worst times to dig soil are when it is very wet, or very dry and powdery. One makes mud, the other makes powder that can turn into mud when the soil is eventually watered or rained on. Either one can lead to soil crusting. The spectrum in between when the soil is moist, but not too wet or dry is when you should do your digging and cultivating if possible.

Management of Soil Crusting:

Soil crusting can be controlled by the following ways:

(a) Surface mulches which protect the soil from the impact of rain drops minimize the formation of soil crust.

(b) Addition of organic matter which promotes stable aggregate formation and resist dispersion, prevent crust formation.

(c) Application of some artificial soil conditioners such as polyanionic soil conditioners like hydrolyzed poly acrylo-nitrile (HPAN) or vinyl acetate maleic acid copolymer (VAMA); nonionic soil conditioners like polyvinyl alcohol (PVA) etc. also reduce soil crust by producing stable aggregation.

(d) In sodic soil, lowering of exchangeable sodium percentage of the soil by application of gypsum, pyrites etc. minimizes the formation of soil crust.

(e) A light tillage while the soil is still moist will break-up the crust before it hardens.

CONCLUSION

Soil crusting is a worldwide problem occurring under a wide range of soil and climatic conditions. Soil crusts affect seedling emergence and reduce the infiltration rate causing loss of water and crop yield. Considerable research has been done in order to understand the process of crust formation and the factors affecting it. Soil crust strength and impedance to seedling emergence have been studied in detail and measures to avoid crusting and methods to ameliorate its adverse effects have been suggested.

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