



## Improving Aggregate Stability

### Soil Aggregates

Aggregates are granules or clumps of soil made up of sand, silt, and clay glued together by organic matter (Figure 1). Soil structure refers to the size and shape of soil aggregates and the pore spaces between them, arranged in a layer of soil. Soil structure is an important indicator of workability and permeability; soils that are well aggregated have “good soil tilth” and drain better than poorly aggregated soils.

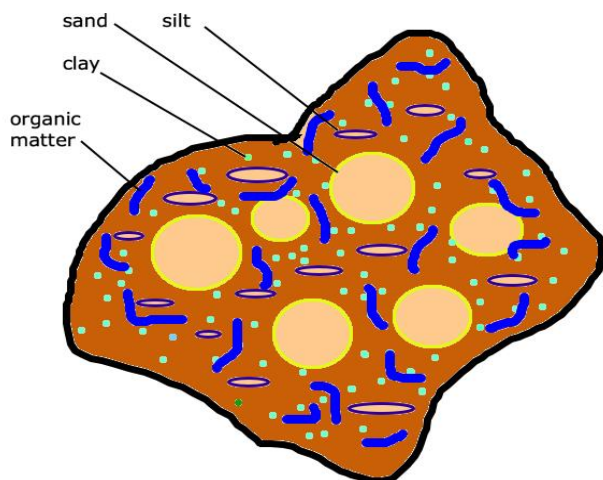


Figure 1. Aggregate structure and components.

### Why is Aggregate Stability Important?

Ideally, soil aggregates are stable and resist collapsing into smaller pieces or particles due to tillage and erosive forces such as wind and rain. Stable aggregates house and protect organic matter, improving soil structure, water holding capacity, and drought resistance. Soils that have a diversity of stable aggregate sizes are well-structured. They are expected to retain more moisture, have more organic matter, and allow more infiltration of rain. Well-structured soils can hold more water, and crops are less prone to drought as water can be drawn to the surface from the subsoil and roots may penetrate deeper. Soils with fewer stable aggregates are considered poorly structured and more prone to problems such as compaction, erosion, crusting, poor infiltration, water logging, drought, poor root health and/or root diseases. Unstable aggregates collapse, filling soil pores with

smaller aggregates and fragments potentially leading to soil crusting, sealing, and reduced permeability (Figure 2). This can result in decreased infiltration capacity and less water penetrating the soil profile, contributing to increased ponding, runoff and erosion. Additionally, a loss of soil structure and fewer pores can limit root development.

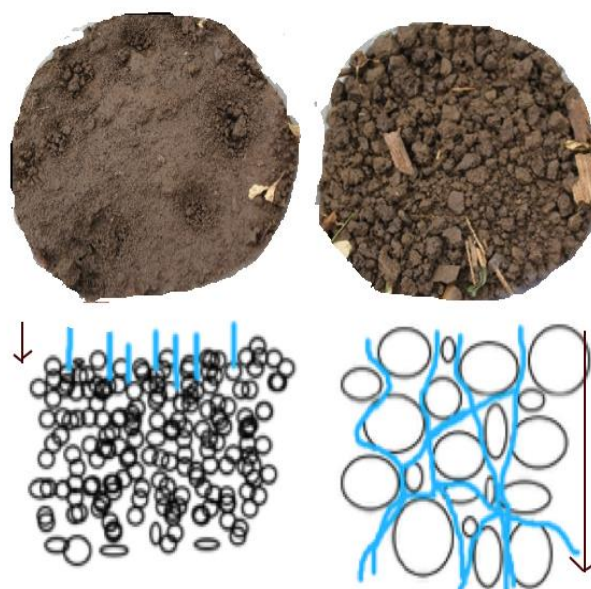


Figure 2. Unstable aggregates lead to reduced infiltration and surface sealing (left). Stable aggregates permit better infiltration (right).

### Properties that Affect Aggregate Stability

Soil texture, climate, and the health, quantity, and diversity of soil organisms affect aggregate stability.

#### Texture

Aggregate stability is impacted by texture because silt and clay can bind particles together better than sand. Texture is determined primarily by the geological material the soil is derived from (such as shale, or sandstone) as well as the forces that formed the soil (such as glacial action, wind, etc.).

#### Climate

Both temperature and the amount and intensity of rainfall, can impact aggregate stability.

Irregular rainfall events with varying intensities can lead to aggregate breakdown and result in an increased risk of water erosion. Warmer temperatures can also increase the rate of organic matter decomposition, thereby reducing the amount of organic matter in the soil, contributing to a loss of aggregate stability.

#### *Soil Life*

In healthy soils, aggregate strength is enhanced by organic “glues” produced by plants, animals, and soil microbes. Plant roots and soil microbes release sticky organic compounds that bind soil particles together. Soil organisms including bacteria, fungi, and larger species such as earthworms, contribute to aggregate strength stability over time. Diverse and active soil organisms are beneficial because they excrete a range of compounds that can work together to improve aggregate stability.

#### **Field Management and Aggregate Stability**

Field management, including tillage operations, addition of organic amendments, and planting and harvesting methods, can impact both aggregate size distribution and stability.

#### *Tillage*

Tillage destroys aggregates in two ways: (1) by physically breaking the aggregates apart and (2) by stirring air into the soil, stimulating microbes to increase the rate of organic matter decomposition. Soil organic matter is lost to the atmosphere as carbon dioxide and, over time, this can result in less organic material to bind aggregates together. Conservation practices that reduce the amount of soil disturbance such as zone or strip tillage, or no-till planting methods can reduce the loss of organic matter and aggregate destruction.

#### *Organic Matter Additions*

Adding organic materials, such as manure or mulch residues, can provide the soil with both nutrients and organic matter, while improving aggregate stability over time. The latter is a result of greater amounts of organic carbon combined with greater microbial activity, enhancing the production of aggregate glues.

#### *Crop Rotation*

Main crop selection, crop rotation, and use of cover crops can also impact aggregate stability. For main crops grown in the Northeast, those that leave surface residues (such as corn stalks)

minimize the impact of rain and wind by creating a barrier to physical destruction (runoff and direct surface impact) of surface aggregates. Cover crops and sod crops (such as grass or alfalfa hay) keep the soil covered, allowing for accumulation of soil organic matter over time. Once established, perennial crops cannot be tilled. In addition, these crops will develop deep and extensive root systems. Thus, cover and sod crops in a rotation contribute to organic matter buildup over time. This addition of organic matter promotes aggregate stability.

#### **Summary**

Aggregate stability is crucial for soil health. Soils with good aggregate stability are less susceptible to erosion and have improved infiltration. Aggregate stability increases with organic matter content in the soil and can be improved through a combination of management practices such as reduced tillage, adding organic matter amendments, and increasing the amount of crop residues and organic matter retained in the soil. Avoid extensive tillage and reduce physical disturbances to prevent the destruction of soil aggregates. By keeping soil covered with surface residues, erosive impacts can be minimized as well.

#### **Additional Resources**

- Soil Quality Indicators: Aggregate Stability. NRCS. [http://www.nrcs.usda.gov/Internet/FSE\\_DOCUMENTS/nrcs142p2\\_052820.pdf](http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_052820.pdf)
- Manure Injection in No-Till and Pasture Systems. [pubs.ext.vt.edu/CSES/CSES-22/CSES-22-PDF.pdf](http://pubs.ext.vt.edu/CSES/CSES-22/CSES-22-PDF.pdf).

#### **Disclaimer**

This fact sheet reflects the current (and past) authors' best effort to interpret a complex body of scientific research, and to translate this into practical management options. Following the guidance provided in this fact sheet does not assure compliance with any applicable law, rule, regulation or standard, or the achievement of particular discharge levels from agricultural land.

For more information



Cornell University  
Cooperative Extension

Nutrient Management Spear Program  
<http://nmsp.cals.cornell.edu>

Sarah Hetrick, Quirine Ketterings, Karl Czymmek,  
Amir Sadeghpour, Amy Langner, Kitty O'Neill, Aaron Gabriel

2016