

Introduction

A soil aggregate is a group of individual soil particles (clay, silt, and sand) bonded together with organic matter. Soil aggregate sizes and shapes determine the soil's structure (Fig. 1). Poor soil structure has limited pore spaces for air and water flow which limits water infiltration, decreases water availability to roots for plant use, and results in crop yield loss. This fact sheet provides information about the importance of soil aggregates and aggregate stability; factors that influence soil aggregation, and management practices to improve soil aggregation and stability.

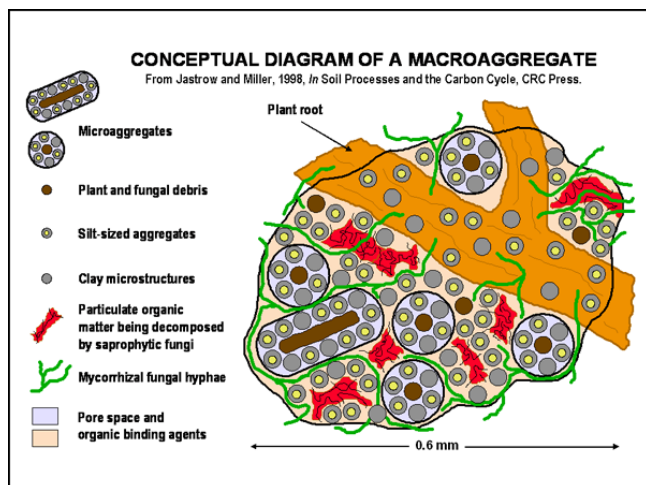


Fig. 1. Conceptual diagram of a macroaggregate (adopted from Jastrow and Miller (1996).

Importance of Soil Aggregates and Aggregate Stability

Soils that are well aggregated have more pore spaces between and within aggregates than poorly aggregated soils. The soil pores provide a space for water infiltration, permeability, water storage, aeration, nutrient leaching, and denitrification. Large aggregates (>2mm) allow water to drain freely which provides habitat for soil organisms and facilitates root growth in pore spaces. Presence of large aggregates creates a soil that is less susceptible to wind and water erosion.

Soil aggregate stability is a measure of a soil aggregates ability to resist degradation with exposure to external forces including tillage, wind and water. Higher

percentage of large aggregates and greater aggregate stability will decrease soil loss through water and wind erosion. Keeping soil in place keeps soil carbon and nutrients available for crop growth and out of waterways. This has environmental and economic benefits for growers.

Factors that Influence Soil Aggregates

Factors that influence soil aggregation and aggregate stability include climate, soil texture and clay content, soil organic matter (SOM), and soil organisms. Some factors that influences soil aggregation are discussed below.

Climate

Rainfall, temperature, and freeze/thaw and wetting/drying cycles can influence aggregate stability. Intensive rainfall events physically break up aggregates. This is particularly important when the soil surface is not covered. In warm and wet soils, SOM decomposes faster. Loss of SOM decreases aggregate formation and thus, negatively influences aggregations and aggregate stability. Soil aggregates can break up during the expansion and contraction that takes place during wetting/drying and freezing/thawing cycles.

Soil texture and clay content

Texture is determined primarily by the geological material the soil is derived from (such as shale, or sandstone) and the forces that formed the soil (such as glacial action, wind, etc.). High clay content soils are finer with small pores that have a greater ability to absorb nutrients and form aggregates. Clay particles, combined with other minerals, such as calcium (Ca^{2+}) or aluminum (Al^{3+}) form clay stacks. Soil aggregates are formed when these stacks are combined with humus. Aggregate formation is prevented when sodium (Na^+) is adsorbed to clay particles creating a structureless soil.

Soil organic matter

Organic matter glues soil particles together to create aggregates. Older, more stable forms of organic matter make up the small aggregates (<0.25 mm). Small

aggregates bond together to create unstable large aggregates that are more susceptible to break down from soil disturbance. Large stable aggregates have many pore spaces for aeration, water infiltration, and root growth, and serve as an indicator of soil quality.

Soil organisms

Soil organisms including bacteria, fungi, and larger species, such as earthworms, contribute to aggregate stability over time. Bacteria and fungi generally appear to be more important for soil aggregation than larger soil animals. Bacteria contribute to macro- and microaggregates, where fungi only affect macroaggregation. Formation of aggregates and pore space are also encouraged by earthworms that burrow throughout the soil; their casts help glue soil particles together. Water infiltration and soil aeration improves with earthworm activity in the soil. The presence of diverse and active soil organisms is important for aggregation because they contribute a range of compounds that can work together to improve aggregate stability.

Management Practices to Improve Soil Aggregation and Aggregate Stability

Management practices that could be implemented on farms to improve soil aggregation and aggregate stability include conservation tillage systems, residue management and cover crops, addition of organic materials, and crop rotation with perennial crops.

Conservation tillage practices

Tillage physically breaks up soil aggregates and promotes SOM and carbon mineralization by exposing soil to air. SOM is lost to the atmosphere as carbon dioxide and over time, can result in less organic material to bind aggregates. Tillage can also damage habitat for microorganisms involved in soil aggregation. Eliminating tillage or minimizing tillage operations using a reduce tillage/mulch tillage system or a zone/strip tillage system that reduces the amount of soil disturbance provides favorable habitat for microorganisms involved in soil aggregation, improve aggregate formation and stability.

Residue and cover crops

Residue left on the soil surface protects it from soil erosion which will maintain/improve the organic matter content and soil aggregates. Cover crops: (1) prevent soil erosion by keeping the soil surface covered and their roots hold soil in place (2) add organic matter to the soil through shoot and root decomposition.

Addition of organic materials

Adding organic materials such as compost, manure, mulch, and biochar can improve SOM and benefit soil microorganisms, resulting in enhanced aggregation.

Perennial crops

Perennial crops in rotation or as pasture stay in the field for several years and since they are not tilled annually, they cover the soil year around. Perennial crops develop deep and extensive root systems, which contribute to organic matter addition and improve aggregation.

Summary

Soil aggregation and stability are maintained and/or improved by protecting soil from erosion, improving SOM, and providing habitat for soil enriching microorganisms. Management practices such as reduced tillage, cover crops, adding organic materials, and including perennial crops will improve soil aggregation and structure.

Additional Information

- Improving Aggregate Stability. Cornell University. <http://nmsp.cals.cornell.edu/publications/factsheets/factsheet95.pdf>
- Aggregate Stability. USDA-NRCS. https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_053287.pdf

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2019

This material is based upon work that is supported by the National Institute of Food and Agriculture, U.S. Department of Agriculture, under award number 2018-38640-28416 through the North Central Region SARE program under project number GNC19-292. USDA is an equal opportunity employer and service provider. Any opinions, findings, conclusions, or recommendations expressed in this publication are those of the authors and do not necessarily reflect the view of U.S. Department of Agriculture.