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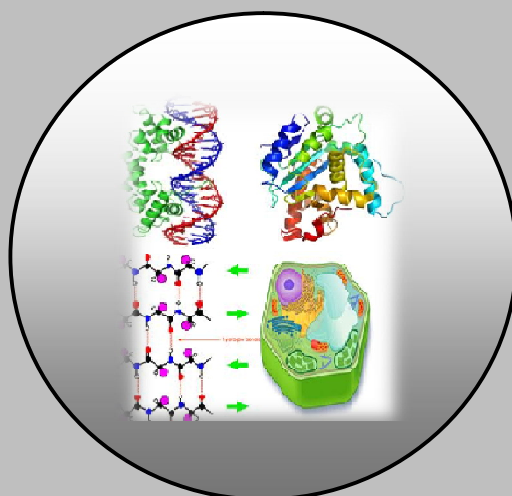
ISSN 0970-4973 (Print)
ISSN 2319-3077 (Online/Electronic)

J. Biol. Chem. Research
Volume 30 (2) 2013 Pages No. 674-681



Journal of Biological and Chemical Research
(An International Journal of Life Sciences and Chemistry)

Published by Society for Advancement of Sciences®

J. Biol. Chem. Research. Vol. 30, No. 2: 674-681 (2013)
(An International Journal of Life Sciences and Chemistry)
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ISSN 0970-4973 (Print)
ISSN 2319-3077 (Online/Electronic)
Published by Society for Advancement of Science®

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RESEARCH PAPER

Received: 10/06/2013 Revised: 19/08/2013 Accepted: 27/08/2013

Studies of Different Soil Quality Indicators

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ABSTRACT

There are some different Soil Quality Indicators such as soil microbiological, Soil physical and chemical indicators). The physical properties of soils, in order of decreasing importance, are texture, structure, density, porosity, consistency, temperature, color, and resistivity. These determine the aeration of the soil and the ability of water to infiltrate and to be held in the soil. Soil texture is determined by the relative proportion of the three kinds of soil particles, called soil "separates": sand, silt, and clay. Soil enzyme activities are the direct expression of the soil community to metabolic requirements and available nutrients. While the diversity of soil organisms is important, the capacity of soil microbial communities to maintain functional diversity of those critical soil processes through disturbance, stress or succession could ultimately be more important to ecosystem productivity and stability than taxonomic diversity. Farming systems that return plant residues (e.g. no-tillage) tend to increase the microbial biomass. Soil properties such as pH, clay, and the availability of organic carbon all influence the size of the microbial biomass.

Keywords: Soil, Enzyme, Respiration, Soil Quality

INTRODUCTION

The shortage of quality information at a scale relevant to decision-making on farms indicated the need for a system that could be used on-site when assessing soil properties that affect management, production and land degradation. This is what we have endeavored to deliver in *soil quality* Infiltration

Soil enzyme activities

Soil enzyme activities have been related to soil physio-chemical characters (Amador et al., 1997). Sources of soil enzyme activities, knowing the sources of specific soil enzyme activities would greatly enhance our understanding of which groups of organisms are directly accessing a given nutrient resource, thus providing greater insight into the pathways by which energy and nutrients flow through the soil food web.

Molecular methods are now at the stage where specific functional genes and their expression by the soil microbial biomass can be determined (Kelly, 2003).

Approaches to interpreting soil enzyme functional diversity:

Soil enzyme functional diversity can be analyzed and interpreted in a variety of ways, depending on the specific research questions. Functional diversity between nutrient resources could be based on specific enzyme activities against major C (cellulose), N (protein) and P constituents. Functional diversity within a nutrient group can be estimated by measuring cellulase and/or phenoloxidase for carbon, protease and amidase for nitrogen or phosphomono- and diesterases for phosphorus. Greater resolution of within group functional diversity could be gained by focusing within a given enzyme activity; e.g., proteolytic activities separated by inhibitor class.

The microbial biomass is affected by factors that change the water or carbon content of soil, and include soil type, climate and management practices. Rainfall is usually the limiting factor for microbial biomass in southern Australia (figure 2). Soil properties that affect microbial biomass are clay, soil pH, and organic C (figure 3). Soils with more clay generally have a higher microbial biomass as they retain more water and often contain more organic C (figure 1). A soil pH near 7.0 is most suitable for the microbial biomass.

Figure 1. The main soil properties affecting the microbial biomass and factors influenced by it.

Management of crop residues influences microbial biomass as they are one of the primary forms of organic carbon and nutrients used by the microbial biomass. Retaining crop residues rather than burning them provides a practical means of increasing the microbial biomass in soil by increasing the amount of organic carbon available to them (table 1).

Table 1. The effect of 17 years of retaining or burning stubble on microbial biomass carbon at different soil depths at Merredin, WA (Hoyle *et al.*, 2006b).

Soil Depth (cm)	Microbial biomass carbon (kg/ha)	
	Stubble retained	Stubble burnt
0 – 10	229	165
10 – 20	112	93
20 – 30	69	58

Tillage practices that are less disruptive to soil can increase the microbial biomass. Less disruptive tillage increases the microbial biomass by increasing labile carbon in soil (figure 2). These management practices also protect soil aggregates and do not break fungal networks, which are an important habitat for the microbial biomass in soil (Hoyle et al. 2006).

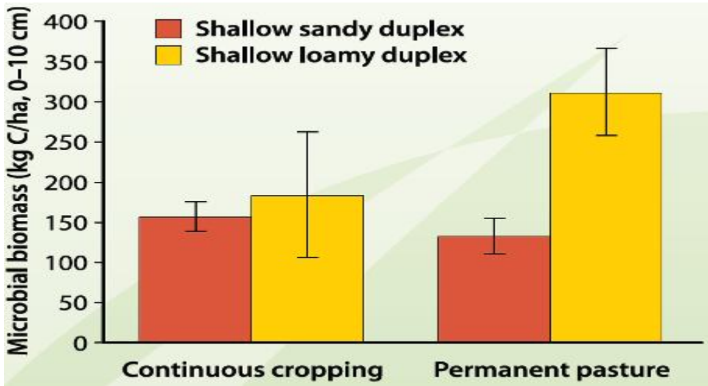

Figure 2. Microbial biomass in soils with different clay contents and under different management. Soils with more clay generally have a higher microbial biomass because they retain more water and often contain more organic carbon.

The type of crops in a rotation can affect the microbial biomass. The residues of legume crops can increase microbial biomass due to their greater N contents. Rotations that have longer pasture phases increase microbial biomass because soil disturbance is reduced (figure 4). This may not be the case in sandy soils, where the lack of clay means organic matter is broken down rapidly Murphy 1998. This leaves the microbial biomass? Starved?

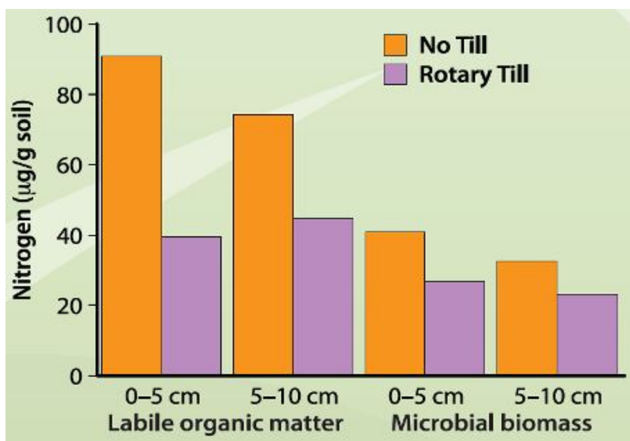

Figure 3. Increased nitrogen content in labile organic matter and the microbial biomass with no-till compared to rotary till in a 9-year field trial at Wongan Hills, WA (Cookson *et al.*, 2008).

Factors Affecting

Inherent - Infiltration rate is dependent on soil texture (percentage of sand, silt, and clay) and clay mineralogy. Water moves more quickly through the large pore spaces in a sandy soil than it does through the small pores of a clayey soil, especially if the clay is compacted and has little or no structure or aggregation (see Table 1).

Depending on the amount and type of clay minerals, many clayey soils develop shrinkage cracks as they dry, creating a direct conduit for water to enter the soil. These clay soils have high infiltration capacities as water moves into the shrinkage cracks, although at other times, when cracks are not present, their infiltration rate is characteristically slow.
Infiltration is the downward entry of water into the soil. The velocity at which water enters the soil is infiltration rate. Infiltration rate is typically expressed in inches per hour. Water from rainfall or irrigation must first enter the soil for it to be of value
Dynamic - A reflection of climate and landscape position, as well as management practices and crop demand, existing soil water content affects the ability of the soil to pull additional water into it. Pores and cracks are generally open in a dry soil. Many of them are filled in by water or swelled shut as the soil becomes wet, so infiltration rate is generally highest when the soil is dry. As the soil becomes wet, the infiltration rate slows to the rate at which water moves through the most restrictive layer, such as a compacted layer or a layer of dense clay. Infiltration is affected by crop and land management practices that affect surface crusting, compaction, and soil organic matter. Without the protective benefits of vegetative or residue cover, bare soil is subjected to the direct impact and erosive forces of raindrops that dislodge soil particles. Dislodged soil particles fill in and block surface pores, contributing to the development of surface crusts that restrict water movement into the soil. Compaction results from livestock and equipment traffic, especially on wet soils, and continuous plowing to the same depth, e.g. the creation of a plow pan below the tillage depth. Compacted or impervious soil layers have reduced pore space and restricted water movement through the soil profile.

A one inch layer of water is added to a six inch diameter ring to measure infiltration rate.

Fig 4. Measuring infiltration in soil.

Soil organic matter affects infiltration through its positive effect on the development of stable soil aggregates, or crumbs. Highly aggregated soil has increased pore space and infiltration. Soils high in organic matter also provide good habitat for soil biota, such as earthworms, that through their burrowing activities, increase pore space and create continuous pores linking surface to subsurface soil layers.

Management that reduces soil cover, disrupts continuous poor space, compacts soil, or reduces soil organic matter negatively impacts infiltration. Since tillage negatively affects all of these properties, it plays an important role in a soil's infiltration rate. Cookson, 2008.

Table 2. Steady infiltration rates for general soil texture groups invery deeply wetted soil. (Hillel, D. 1982. Introduction to soil physics. Academic Press, San Diego, CA)

Soil Type	Steady Infiltration Rate (in/hr)
Sands	> 0.8
Loams	0.2 - 0.4
Clays	0.04 - 0.2

Relationship to Soil Function

Infiltration is an indicator of the soil's ability to allow water movement into and through the soil profile. Soil temporarily stores water, making it available for root uptake, plant growth and habitat for soil organisms.

Problems with Poor Function

When water is supplied at a rate that exceeds the soil's infiltration capacity, it moves down slope as runoff on sloping land or ponds on the surface of level land. When runoff occurs on bare or poorly vegetated soil, erosion takes place. Runoff carries nutrients, chemicals, and soil with it, resulting in decreased soil productivity, off-site sedimentation of water bodies and diminished water quality. Sedimentation decreases storage capacity of reservoirs and streams and can lead to flooding. Davis and Bennett, 1927.

Restricted infiltration and pounding of water on the soil surface results in poor soil aeration, which leads to poor root function and plant growth, as well as reduced nutrient availability and cycling by soil organisms. Pounding and soil saturation decreases soil strength, destroys soil structure, increases detachment of soil particles, and makes soil more erodible. On the soil surface rather than in the soil profile, pounded water is subject to increased evaporation, which leads to decreased water available for plant growth. A high infiltration rate is generally desirable for plant growth and the environment. In some cases, soils that have unrestricted water movement through their profile can contribute to environmental concerns if misapplied nutrients and chemicals reach groundwater and surface water resources via subsurface flow. Conservation practices that lead to poor infiltration include:

- Incorporating, burning, or harvesting crop residues leaving soil bare and susceptible to erosion,
- Tillage methods and soil disturbance activities that disrupt surface connected pores and prevent accumulation of soil organic matter, and
- Equipment and livestock traffic, especially on wet soils that cause compaction and reduced porosity (Lowery et al. 1996)

Improving Infiltration

Several conservation practices help maintain or improve water infiltration into soil by increasing vegetative cover, managing crop residues, and increasing soil organic matter. Generally, these practices minimize soil disturbance and compaction, protect soil from erosion, and encourage the development of good soil structure and continuous pore space. As a short-term solution to poor infiltration, surface crusts can be disrupted with a rotary hoe or row cultivator and plow plans or other compacted layers can be broken using deep tillage. Long-term solutions for maintaining or improving infiltration include practices that increase soil organic matter and aggregation, and reduce soil disturbance and compaction. High residue crops, such as corn and small grains, perennial sod, and cover crops protect the soil surface from erosion and increase soil organic matter when reduced tillage methods that maintain surface cover are used to plant the following crop. Application of animal manure also helps to increase soil organic matter. Increased organic matter results in increased aggregation and improved soil structure leading to improved infiltration rates. Conservation tillage, reduced soil disturbance, and reducing the number of trips across a field necessary to produce a crop help leave continuous pore spaces intact and minimize the opportunity for soil compaction. Conservation practices resulting in infiltration rates favorable to soil function include:

• Conservation Crop Rotation
• Cover Crop
• Prescribed Grazing
• Residue and Tillage Management
• Waste Utilization

Measuring Infiltration

The Single Ring (Flooded/Pounded) Infiltrometer Method is described in the Soil Quality Test Kit Guide, Section I, Chapter 3, pp. 7 - 8. See Section II, Chapter 2, pp. 55 – 56 for interpretation of results. (Lowery et al. 1996).

Specialized equipment, shortcuts, and tips: To accurately assess infiltration and compare rates for different soils, the soils should be at similar moisture content when taking the measurement. It is recommended that measurements be taken at field capacity, defined as the water content of the soil root zone at which drainage (by gravity) becomes negligible. If the soil is already saturated, infiltration will not occur; wait for one or two days to allow for drying to measure infiltration rate.
Time needed: 60 minutes or more depending on soil conditions

SOIL TEXTURE

Density

Density is the weight per unit volume of an object. Particle density is the density of the mineral particles that make up a soil, i.e. it excludes pore space and organic material. Particle density averages approximately 2.65 g/cc (165 lbm/ft^3). Soil bulk density, a dry weight, includes air space and organic materials of the soil volume.

A high bulk density indicates either compaction of the soil or high sand content. The bulk density of cultivated loam is about 1.1 to 1.4 g/cc (for comparison water is 1.0 g/cc). A lower bulk density by itself does not indicate suitability for plant growth due to the influence of soil texture and structure, University of Florida. Date first printed: April 1990.

Color

Soil color is often the first impression one has when viewing soil. Striking colours and contrasting patterns are especially noticeable. The Red River (Mississippi watershed) carries sediment eroded from extensive reddish soils like Port Silt Loam in Oklahoma. The Yellow River in China carries yellow sediment from eroding loess soils. Mollisols in the Great Plains of North America are darkened and enriched by organic matter. Podsols in boreal forests have highly contrasting layers due to acidity and leaching.

Soil structure Quality Indicators

Soil Structure & Macropores Sand, silt and clay particles are the primary mineral building blocks of soil. Soil structure is the combination or arrangement of primary soil particles into aggregates. Using aggregate size, shape and distinctness as the basis for classes, types and grades, respectively, soil structure describes the manner in which soil particles are aggregated. Soil structure affects water and air movement through soil, greatly influencing soil's ability to sustain life and perform other vital soil functions. Soil pores exist between and within aggregates and are occupied by water and air. Macropores are large soil pores, usually between aggregates, that are generally greater than 0.08 mm in diameter.

Soil Porosity

The air space is needed to supply oxygen to organisms decomposing organic matter, humus, and plant roots. Pore space also allows the movement and storage of water and dissolved nutrients.

Soil moisture content

The amount of water remaining in a soil drained to field capacity and the amount that is available are functions of the soil type. Sandy soil will retain very little water, while clay will hold the maximum amount. Lowery et al. 1996.

ACKNOWLEDGMENTS

We are grateful to Semnan University for valuable help with the light microscopy analysis.

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