GNITED MINDS
Journals

Journal of Advances in Science and Technology

Vol. VIII, Issue No. XVI, February-2015, ISSN 2230-9659

NUTRIENT MANAGEMENT: ROLE OF ORGANIC MATTER IN SOIL FERTILITY

AN INTERNATIONALLY INDEXED PEER REVIEWED & REFEREED JOURNAL

Nutrient Management: Role of Organic Matter in Soil Fertility

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Abstract – Soil organic matter – the product of on-site biological decomposition – affects the chemical and physical properties of the soil and its overall health. Its composition and breakdown rate affect: the soil structure and porosity; the water infiltration rate and moisture holding capacity of soils; the diversity and biological activity of soil organisms; and plant nutrient availability. Many common agricultural practices, especially ploughing, disc-tillage and vegetation burning, accelerate the decomposition of soil organic matter and leave the soil susceptible to wind and water erosion. However, there are alternative management practices that enhance soil health and allow sustained agricultural productivity. Conservation agriculture encompasses a range of such good practices through combining no tillage or minimum tillage with a protective crop cover and crop rotations.

Keywords: Soil, Health, Plant, Nutrient, Organic Matter, Agricultural, Productivity, Etc.

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INTRODUCTION

It maintains surface residues, roots and soil organic matter, helps control weeds, and enhances soil aggregation and intact large pores, in turn allowing water infiltration and reducing runoff and erosion. In addition to making plant nutrients available, the diverse soil organisms that thrive in such conditions contribute to pest control and other vital ecological processes. Through combining pasture and fodder species and maturing with food and fiber crop production, mixed crop–livestock systems also enhance soil organic matter and soil health. This document recognizes the central role of organic matter in improving soil productivity and outlines promising technologies for improved organic matter management for productive and sustainable crop production in the tropics.

On the basis of organic matter content, soils are characterized as mineral or organic. Mineral soils form most of the world's cultivated land and may contain from a trace to 30 percent organic matter. Organic soils are naturally rich in organic matter principally for climatic reasons. Although they contain more than 30 percent organic matter, it is precisely for this reason that they are not vital cropping soils.This soils bulletin concentrates on the organic matter dynamics of cropping soils. In brief, it discusses circumstances that deplete organic matter and the negative outcomes of this. The bulletin then moves on to more proactive solutions. It reviews a "basket" of practices in order to show how they can increase organic matter content and discusses the land and cropping benefits that then accrue.

REVIEW OF LITERATURE:

When plant residues are returned to the soil, various organic compounds undergo decomposition. Decomposition is a biological process that includes the physical breakdown and biochemical transformation of complex organic molecules of dead material into simpler organic and inorganic molecules (1-3). The continual addition of decaying plant residues to the soil surface contributes to the biological activity and the carbon cycling process in the soil. Breakdown of soil organic matter and root growth and decay also contribute to these processes. Carbon cycling is the continuous transformation of organic and inorganic carbon compounds by plants and micro- and macro-organisms between the soil, plants and the atmosphere. Decomposition of organic matter is largely a biological process that occurs naturally. Its speed is determined by three major factors: soil organisms, the physical environment and the quality of the organic matter (4). In the decomposition process, different products are released: carbon dioxide (CO2), energy, water, plant nutrients and resynthesized organic carbon compounds. Successive decomposition of dead material and modified organic matter results in the formation of a more complex organic matter called humus (5). This process is called humification. Humus affects soil properties. As it slowly decomposes, it colours the soil darker; increases soil aggregation and aggregate stability; increases the

CEC (the ability to attract and retain nutrients); and contributes N, P and other nutrients.

Soil organisms, including micro-organisms, use soil organic matter as food. As they break down the organic matter, any excess nutrients (N, P and S) are released into the soil in forms that plants can use. This release process is called mineralization. The waste products produced by micro-organisms are also soil organic matter. This waste material is less decomposable than the original plant and animal material, but it can be used by a large number of organisms. By breaking down carbon structures and rebuilding new ones or storing the C into their own biomass, soil biota plays the most important role in nutrient cycling processes and, thus, in the ability of a soil to provide the crop with sufficient nutrients to harvest a healthy product. The organic matter content, especially the more stable humus, increases the capacity to store water and store (sequester) C from the atmosphere.

1. Natural factors influencing the amount of organic matter:

The transformation and movement of materials within soil organic matter pools is a dynamic process influenced by climate, soil type, and vegetation and soil organisms. All these factors operate within a hierarchical spatial scale. Soil organisms are responsible for the decay and cycling of both macronutrients and micronutrients, and their activity affects the structure, tilt and productivity of the soil. In natural humid and sub humid forest ecosystems without human disturbance, the living and non-living components are in dynamic equilibrium with each other. The litter on the soil surface beneath different canopy layers and high biomass production generally result in high biological activity in the soil and on the soil surface.

➢ **Temperature:**

Several field studies have shown that temperature is a key factor controlling the rate of decomposition of plant residues. Decomposition normally occurs more rapidly in the tropics than in temperate areas. The relatively faster rate of decomposition induced by the continuous warmth in the tropics implies that high equilibrium levels of organic matter are difficult to achieve in tropical agro-ecosystems. Hence, large annual rates of organic inputs are needed to maintain an adequate labile soil organic matter pool in cultivated soils. Soils in cooler climates commonly have more organic matter because of slower mineralization (decomposition) rates.

➢ **Soil Moisture and Water Saturation:**

Soil organic matter levels commonly increase as mean annual precipitation increases. Conditions of elevated levels of soil moisture result in greater biomass production, which provides more residues, and thus more potential food for soil biota. Soil biological activity requires air and moisture. Optimal microbial activity occurs at near “field capacity”, which is equivalent to 60-percent water-filled pore space (6). On the other hand, periods of water saturation lead to poor aeration. Most soil organisms need oxygen, and thus a reduction of oxygen in the soil leads to a reduction of the mineralization rate as these organisms become inactive or even die. Some of the transformation processes become anaerobic, which can lead to damage to plant roots caused by waste products or Favourable conditions for disease-causing organisms. Continued production and slow decomposition can lead to very large organic matter contents in soils with long periods of water saturation (e.g. peat soils, and tea crops in India).

2. Practices that influence the amount of organic matter:

Any form of human intervention influences the activity of soil organisms (7,8) and thus the equilibrium of the system. Management practices that alter the living and nutrient conditions of soil organisms, such as repetitive tillage or burning of vegetation, result in a degradation of their microenvironments. In turn, this results in a reduction of soil biota, both in biomass and diversity. Where there are no longer organisms to decompose soil organic matter and bind soil particles, the soil structure is damaged easily by rain, wind and sun. This can lead to rainwater runoff and soil erosion, removing the potential food for organisms, i.e. the organic matter of the topsoil. Therefore, soil biota are the most important property of the soil, and “when devoid of its biota, the uppermost layer of earth ceases to be soil”.

3. Practices That Increase Soil Organic Matter:

Increased concern about the environmental and economic impacts of conventional crop production has stimulated interest in alternative systems. Central to such systems is the need to promote and maintain soil biological processes and minimize fossil fuel inputs in the form of fertilizers, pesticides and mechanical cultivation. All activities aimed at the increase of organic matter in the soil help in creating a new equilibrium in the agro-ecosystem. For a system of natural resource management to be balanced, and thus sustainable, it must be able to withstand sharp climatic fluctuations, and to evolve steadily in response to social changes and changes in the costs and availability of inputs of land, labour and knowledge. The more diverse and complex an agricultural system is the more stable and sustainable it will be in the face of unpredictable vagaries of climate and market. Thus, annual crops, woody perennials and nonwoody perennials may be combined in various ways with livestock or trees, or both, in what are now commonly called agrosilvipastoral systems.

- **Increased Plant Productivity:**

Plant productivity is linked closely to organic matter (9). Consequently, landscapes with variable organic matter usually show variations in productivity. Plants growing in well-aerated soils are less stressed by drought or excess water. In soils with less compaction, plant roots can penetrate and flourish more readily. High organic matter increases productivity and, in turn, high productivity increases organic matter.

- **Increased Fertilizer Efficiency:**

Generally, these constraints are tackled by applying chemical fertilizers and lime. However, the application of inorganic fertilizers on depleted soils often fails to provide the expected benefits (15). This is basically because of low organic matter and low biological activity in the soil. The chemical and nutritional benefits of organic matter are related to the cycling of plant nutrients and the ability of the soil to supply nutrients for plant growth. Organic matter retains plant nutrients and prevents them leaching to deeper soil layers. Microorganisms are responsible for the mineralization and immobilization of N, P and S through the decomposition of organic matter (10-13). Thus, they contribute to the gradual and continuous liberation of plant nutrients. Available nutrients that are not taken up by the plants are retained by soil organisms (14). In organic-matter depleted soils, these nutrients would be lost from the system through leaching and runoff.

CONCLUSION:

The maintenance of soil organic matter levels and the optimization of nutrient cycling are essential to the sustained productivity of agricultural systems. Both are related closely to the bioturbating activities of macro fauna and the microbially-driven mobilization and immobilization processes, which the activities of large invertebrates also encourage. Maintaining soil organic matter content requires a balance between addition and decomposition rates. As changes in agricultural practices can engender marked changes in both the pool size and turnover rate of soil organic matter, it is important to analyse their nature and impacts. Crop production worldwide has generally resulted in a decline in soil organic matter levels and, consequently, in a decline of soil fertility. Converting grasslands and forestlands to arable agriculture results in the loss of about 30 percent of the organic C originally present in the soil profile. On reasonably fertile soils with reliable water supply, yields in long-term arable agricultural systems have been maintained at very high levels by applying substantial amounts of fertilizer and other soil amendments. In low-input agricultural systems, yields generally decline rapidly as nutrient and soils organic matter levels decline. However, restoration is possible through the use of fallow lands, mixed crop–livestock and agroforestry systems, and crop rotations. Traditional mound-board plough and disc-tillage cropping systems tend to cause rapid decomposition of soil organic matter, leave the soil susceptible to wind and water erosion, and create plough pans below the cultivation depth. By contrast, reduced- or zero-tillage systems leave more biological surface residues, provide environments for enhanced soil activity, and maintain more intact and interconnected large pores and more soil aggregates, which are better able to withstand raindrop impact. Water can infiltrate more readily and rapidly into the soil with reduced tillage and this helps protect the soil from erosion. In addition, organic matter decomposes less rapidly under reduced-tillage systems. No-tillage systems have proved especially useful for maintaining and increasing soil organic matter.

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