NM STATE UNIVERSITY

Understanding Soil Health for Production Agriculture in New Mexico

Guide A-148

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INTRODUCTION

Soil health is the capacity of the soil to function effectively and provide ecosystem services on a sustainable basis (Doran and Parkin, 1994). An important ecosystem service that the soil provides is to support crop production, upon which humans and many animals depend for subsistence. A healthy soil will be able to support crop production on a sustained basis and be less prone to erosion.

Since soil is such an important component of the natural ecosystem, careful management of the soil is essential to sustain its utility. Conventional commercial farming depends heavily on the careful management of soil nutrients to promote adequate crop yields of food, feed, and fiber. This has resulted in the development of precise nutrient analytical methods with accompanying recommendations to address nutrient deficiencies in different soils that are used for farming. While this strategy has improved productivity over a long period of time, scientists are now finding that managing soil for nutrients alone may not lead to sustainable crop production in the long term. Other aspects of the soil, including aggregate stability, infiltration rate, salinity, sodicity, and mineralization potential, need to be addressed to attain the goal of sustainable crop production (Idowu et al., 2008).

SOIL BASICS

Soils are formed from underlying parent material, and the type of soil formed is mostly a reflection of the type of material that formed it. Apart from the parent material, other soil-forming factors include climate, topography (slope position), biological activity, and time. A typical soil is mostly composed of solid mineral particles of different sizes, and based on their relative sizes are classified either as sand (0.05–2 mm), silt (0.002–0.05 mm), or clay (<0.002 mm). The mineral particles (solid component) make up about 45% of the soil. In addition to the solid minerals, there is a relatively small quantity of organic materials (living and dead) in the soil (up to 5% in most mineral soils), which exerts tremendous influence on soil productivity. The solid portion of the soil is arranged such that voids or pores exist within its matrix. These pores are either filled with air or water. In a well-balanced soil the amounts of water and air are about 25% each.

The soil can be viewed as comprising three major components: chemical, physical, and biological. The chemical component relates to the nutritional aspect of the soil. Chemical issues address the sufficiency of both the macro- and micronutrients in the soil. There are 15 major elements needed by crops to grow successfully: carbon, hydrogen, oxygen, nitrogen, potassium, phosphorus, calcium, magnesium, sulfur, iron, manganese, boron, zinc, molybdenum, and copper. Other important chemical factors affecting crop growth and yield include soil pH, salinity, and sodicity.

Soil physical aspects include physical support for crops; hence, issues such as root growth and proliferation are closely related to the physical component of the soil. Other important soil physical functions include moisture retention and release, water infiltration and flow, soil density, and soil structure. Soil structure is closely related to soil aggregation potential and soil aggregate stability. The extent and stability of soil aggregates have significant effects on water and wind erosion (Legout et al., 2005).

Soil biological components, which include the living and dead organic entities in the soil, are the least known out of the three components. Living micro- and macro-organisms in the soil have great influence on soil function. The population and diversity of microorganisms in the soil is almost beyond comprehension. Studies have shown that one gram of soil can contain up to 10^9 bacteria (Whitman et al., 1998). Soil organisms are actively involved in processes such as nutrient cycling, nitrogen fixation, mycorrhizal associations, decomposition, and mineralization of the soil organic matter (Welbaum et al., 2004).

In order to sustainably manage soil health, attention must be given to all the aspects of the soil rather than focusing only on soil nutrient sufficiency. For example,

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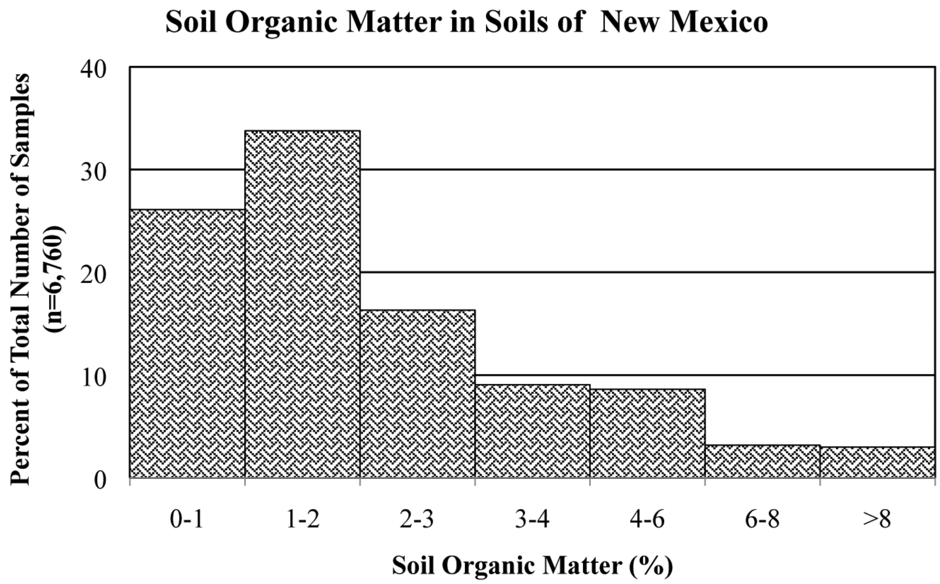

***Figure 1*. Histogram of soil organic matter levels of New Mexico soil samples analyzed at the NMSU Soil and Water Testing Laboratory between 2001 and 2010.**

a compacted soil will affect the root growth within the soil and limit the potential area that the root hairs can explore for water and nutrients. Mitigating compaction within a soil can help reduce the amount of supplemental nutrients needed for crop production. Therefore, soil health is an attempt to bring together the chemical, physical, and biological aspects of the soil with the understanding that they are interrelated and that they must operate in synergy for optimum and sustainable soil function.

BASIC PRINCIPLES FOR MANAGING SOIL HEALTH

Managing soil health is an important component for sustainable crop production. Soil health management is a paradigm shift from the way we look at the soil. In healthy soils, physical, chemical, and biological processes and functions drive the productivity of the soil. An important component of the soil that integrates these three aspects is the soil organic matter. Therefore, one of the most critical factors in soil health management is the maintenance of a good level of soil organic matter. The organic matter in the soil provides nutrition for the soil organisms. The diversity and functionality of soil organisms are highly affected by the quantity and quality of the soil organic matter (Carter, 2002). Soil management strategies should be focused on returning an amount of organic material that is sufficient to maintain or improve soil productivity and biological activity of the soil. The majority of soils in New Mexico have very low (Figure 1) soil organic matter levels, and such soils are prone to degradation and erosion (Figure 2). These soils will also need high fertilizer inputs to ensure adequate nutrients for crop growth and yield. The following are some suggested methods that can help improve soil health.

Reduce or Minimize Soil Tillage

Reduced or minimum tillage practices can lead to an accumulation of soil organic matter (Carter, 1992). Soil organic matter is rapidly lost through conventional plow-disk tillage practices. Conventional tillage, which involves turning over the entire plow depth, exposes large quantities of soil organic matter to oxidation. With reduced tillage practices, such as no-till, strip-till (Figure 3), or zone-till, smaller amounts of soil organic matter are exposed to oxidation, which leads to more organic matter in the soil profile over a long period of time. Reduced tillage can be challenging to implement, especially when new tillage tools become necessary, and may require considerable financial outlay. However, through careful thinking, planning, and consultation with experts, growers can work out adaptable reduced tillage practices on their farms, which can ultimately benefit soil health and sustainable productivity of the soil.

Cover Cropping and Green Manure

Using cover crops can benefit soil health and crop productivity in the long run (Fageria et al., 2005). Cover crops are planted between cash crops to protect the

Figure 2. **Soils in New Mexico typically have low organic matter contents and can be prone to degradation, such as cracking and crusting.**

Figure 3. **Strip tilling is one method to prevent loss in soil quality due to excessive tilling.**

Figure 4. **A cover crop grown between orchard rows.**

Figure 5. **A green manure crop.**

soil from erosion and improve soil health and fertility (Figure 4). The major challenge in the desert Southwest is selecting adaptable and appropriate crops that can survive with relatively less water and at the same time provide the needed benefit of soil cover.

Green manures are grown solely during the cropping season to supply soil fertility, suppress weeds, and improve soil health (Figure 5). Green manure systems may be important in organic production systems since those systems rely solely on organic sources of nutrients for crop production. There are several cover and green manure crops that can grow very well in New Mexico; however, availability of water is a major consideration in the adaptation and choice of cover crops/green manure.

Crop Rotation

Good crop rotation can mitigate soil-borne diseases and improve soil health (Abawi and Widmer, 2000). Rotation is the sequence of crop cultivation on the farm. It is usually a better farming practice to alternate crops of different families from season to season or year to year. For instance, cereals (small grains) can follow legumes such as alfalfa or beans since legumes can fix nitrogen, which will benefit the following cereal crop after the legume residue has been worked into the soil. Planning a rotation is farm-specific and is often based on many factors, including soil type, equipment, water availability, and markets.

Organic Amendments

Organic amendments can help build up the soil organic matter and consequently improve the overall soil quality (Tester, 1990). Many materials are available as organic amendments, including manure, compost, and guano, among others. Organic amendments vary in how much nutrients they can supply to the crop, and it is therefore important to know the nutrient composition of the amendment material. The amount of nutrients that can be made available from an organic amendment depends on the initial nutrient content in the material, its C:N ratio, its soil mineralization rate (which in turn is dependent on soil temperature and moisture), and existing levels of soil nutrient (based on soil test). It is a good practice to send the organic material to a laboratory for analysis so as to determine the quantity of amendment to add to the soil for meeting plant nutrient demands that can't be supplied by the soil itself. Note that adding large quantities of compost with only modest concentrations of nutrient elements can add significantly to the soluble salt level in the soil.

Chemical Amendments

Chemical amendments are often based on soil analysis, just as organic amendments should be. Soil analysis, along with fertilizer recommendations, will help a grower apply the correct amount of nutrients to the soil. Without soil analysis, either insufficient or excessive amounts of nutrients can be added, and this can reduce farm profit.

CONCLUSION

Planning a good soil health management system for a farm is a long-term strategy. It will take time before results will become evident. However, a careful and consistent management plan for improving soil health will lead to a soil that is more resilient to environmental stress and protected against degradation, which will guarantee sustainable crop yields.

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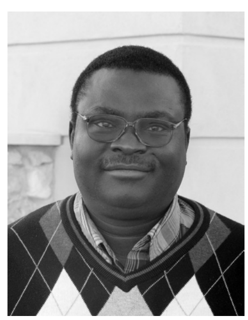

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