Soil Management Practices to Promote Soil Health

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DOI: 10.29322/IJSRP.13.04.2023.p13602
http://dx.doi.org/10.29322/IJSRP.13.04.2023.p13602

Paper Received Date: 15th February 2023
Paper Acceptance Date: 27th March 2023
Paper Publication Date: 6th April 2023

Abstract

The health of the soil is a vital, dynamic living system that supports both ecosystem health and agricultural productivity. Root development, biomass accumulation, and plant water availability are influenced by soil physical properties such as soil aggregation, bulk density, and available water capacity. Soil chemistry, physics, and biology play a significant role in crop productivity. Maintaining soil health is now almost important for enhancing crop productivity because of the occurrence of multi-nutritional deficiency in soil. Food plants require water, oxygen, nutrients, and root support from healthy soil in order to grow and thrive. The following guidelines can be used to improve soil health: (1) Minimize disturbance; (2) Increase Soil Cover; (3) Increase Biodiversity; and (4) Increase the Presence of Living Roots.

Key words: bulk density, crop productivity, healty soil, principles to improve soil health, soil aggregation, soil physical,

1.Introduction

Over the past few years, the idea of soil quality or soil health has gained in favor. The ability of the soil to continue to serve as an essential living ecosystem that supports humans, animals, and plants is known as soil health. Agricultural management has an impact on soil health, therefore fertile soils are associated with good crop yields and minimal nutrient loss (Morguán-Coronado et al.,2020). Soil health is defined as the ability of a soil to function and provide ecosystem services and or the soil's fitness to support crop growth without degrading soil or otherwise harming the environment (Yang et al, 2020a). The interaction of chemical, physical, and biological soil variables affects soil quality. Biological indicators are frequently underrepresented, despite the fact that scientists and farmers frequently employ soil chemical and physical indicators to evaluate soil quality. According to certain theories, soil organisms are crucial to ecosystem functioning and are extremely sensitive to changes in the environment. To better understand soil reactions to aboveground biodiversity and management, as well as the interaction between soil biology, chemistry, and physics, it is therefore beneficial to include biological markers (Teixeira et al. 2021). The health of the soil is a vital, dynamic living system that supports both ecosystem health and agricultural productivity. While the provision of ecological services is encouraged by healthy soils, degrading soil can result in environmental stress and decreased productivity. Generally, soil health is thought to be the mix of physical, chemical and biological qualities that increase the ability of a soil to sustain human, plant and animal needs while maintaining or enhancing environmental quality . Assessing soil health requires a more comprehensive approach to testing than conventional soil quality work that focuses on a few individual parameters; ideally, it must encompass chemical, biological and physical indicators as well as trends and emergent properties (Mann et al, 2019)

2. indicators of the health of the soil

Crop productivity is largely influenced by the chemical, physical, and biological characteristics of the soil in addition to factors such as water, light, and temperature. The aggregation of the soil, the bulk density, and the amount of water that is available all have an impact on root development, biomass accumulation, and plant water availability (Mann et al. , 2019). The biota of the soil play a significant role in determining the availability of nutrients and soil tilth in unmanaged ecosystems, which influences plant production dynamics. Soil biota also have additional effects on plant productivity through their direct interactions with plants, and they change a crop's ability to withstand, compete with, or recover from stressors (Jernigan et al., 2020).

For instance, pH alters how crop nutrients are acquired while soil nutrient content affects crop growth rate and nutrient uptake. Similar to how root development, biomass accumulation, and plant water availability are influenced by soil physical properties like soil aggregation, bulk density, and water availability (Mann et al. , 2019). The biota of the soil play a significant role in determining nutrient availability and soil tilth in unmanaged ecosystems, which influences plant production dynamics. Crop productivity is greatly influenced by soil chemical, physical, and biological properties in addition to water, light, and temperature. Soil biota also exert additional influence on plant productivity through their direct interactions with plants and change a crop's capacity to resist, compete with, or recover from stressors. For instance, soil nutrient content affects the rate of crop growth and nutrient uptake, whereas crop nutrient acquisition is affected by pH (Miner et al. , 2020).

2.1. Qualities of Healthy Soil.

The ability of soil to sustain a vital living system within ecosystems and land-use boundaries, to sustain plant and animal productivity, to maintain or improve the quality of the water and air, and to promote plant and animal health is known as soil health. Table 1 lists the traits of healthy soils.

Table 1. Characteristics of healthy soils

Characteristic	Description
sufficient supply of nutrients	Although there needs to be sufficient nutrient supply for plant growth, at the end of the season there should not be too much nitrogen and phosphorous left in highly soluble forms or enriching the soil surface. Leaching and runoff of nutrients are most likely to occur after crops are harvested and before the following years' crops are well established.
Good soil tilth	Soil with good tilth is more spongy and less compact and allows roots to more fully develop than a soil with poor tilth. A soil that has a favorable and stable soil structure also promotes water infiltration
Sufficient depth	Soils with sufficient depth to a layer that can restrict drainage and(or) root development promote full root system development
Good internal drainage	Timely field operations can occur when soils dry quickly. Also, oxygen must be able to reach the root zone to promote optimal root health, and that is best with good drainage.
Low populations of parasites	Crop yields are higher when plants are not harmed by parasitic bacteria, fungi, or nematodes
High populations of plant-health promoting organisms	Organisms, such as earthworms and many bacteria, fungi, and nematodes help cycle nutrients and make them available to plants. Soil organisms also produce plantgrowth-promoting substance
Low weed pressure	Having few weeds is important so there is little competition with the crop for nutrients, water, and light.
No chemicals that harm plants	Harmful chemicals can occur naturally, such as soluble aluminum in acidic soils or excess salts in arid regions. Potentially harmful chemicals may be introduced by human activity, such as fuel-oil spills, or the application of sewage sludge that has high concentrations of toxic elements
Resistance to being degraded	Soils with good tilth and internal drainage and that have low populations of plant parasites can better resist the negative effects of compaction or periods of wet weather
Resilience	Healthy soils are able to recover quickly after unfavorable changes, such as compact

Magdoff, 2001; Yang et al (2020 b)

2.2. Principles to improve Soil Health

According to USDA-NRCS (2019), there are four principles that have been suggested for promoting soil health:

a. Reduce Disruption

Soil is disturbed in many different ways, from plows to hooves. Although some disruption is unavoidable, reducing disruption across your operation creates healthier soils. You can minimize soil disturbance by limiting tillage, maximizing chemical input, and rotating animals.

b. Increase Soil Cover

Generally speaking, dirt should always be covered. Both grazing operations and agricultural operations might include the planting of cover crops. To maximize soil cover year round, can do with: (1) Plant cover crops, (2) Use organic mulch, and (3) Leave plant residue.

c. Increase Biodiversity

Expanding your operation's diversity can disrupt disease cycles, promote plant growth, and create habitat by (1) Grow cover crops to increase soil cover all year long, (2)Use organic mulch, and (3) Leave plant residue.

d. Maximize Biodiversity

Expanding operation's diversity can disrupt disease cycles, promote plant growth, and provide habitat for pollinators and soil-dwelling species. Grow a variety of cover crops. Use a variety of agricultural rotations and incorporate livestock. Living roots decrease soil erosion and provide food for critters like earthworms and microorganisms that cycle the nutrients that plants need. Minimize fallow land; plant cover crops; and rotate crops in a variety of ways.

The following are methods for enhancing soil health (Magdoff, 2001):

We've discovered that the majority of businesses can produce good crops without using a lot of tillage, or even none at all. Less tillage can save time and money while reducing soil erosion throughout your operation.

• Cover Cropping

Cover crops nonetheless benefit your operation even though they are not normally harvested for a profit. Cover crop roots create channels in the soil that increase its capacity to absorb water. In addition to increasing soil organic matter, hold soil in place that might otherwise erode, and feed soil organisms that provide valuable nutrients to cash crops during the traditional growing season.

Animals that graze recirculate nutrients throughout the environment. You may replenish important nutrients and organic matter to your land and ultimately your soil by managing your cattle to graze where and when you choose.

• Rotation of crops

Crop rotation is an agricultural technique in which farmers cultivate crops from several plant families in the same field over several seasons in a carefully planned sequence. Cash crops and cover crops can both increase diversity. Different crop rotations can prevent pests and illnesses that are particular to certain plant species, boost the health of soil microbes that feed nutrients to your plants and ultimately lead to greater yields.

3. Soil Carbon Prospectif

As they provide all species with quick growth and better quality, organic fertilizers are crucial for the appropriate development of plants, vegetables, flowers, and fruits. They contain the nutrients required for more favorable development. Moreover, the organic matter provides soil bacteria with nutrition and energy. The high availability of NPK content, which can improve soil fertility, has been credited with the applicability and utility of organic fertilizers. Also, they serve as a substrate for soil microbes, enhancing microbial activity and, ultimately, the rate at which organic matter decomposes and releases nutrients for plant absorption. They enhance the soil's physical qualities and found that using organic fertilizer (farmyard manure) significantly increased soil carbon, nitrogen, pH, cation exchange capacity, and exchangeable Ca, Mg, and K which invariably enhance crop yield and productivity(Zayed et al, 2013).

Mineral fertilizers can be substituted with organic manure to improve soil structure and microbial biomass. Thus, using locally produced manures to grow vegetables may boost crop yields while using fewer artificial fertilizers (Naguib et al., 2012). A stronger microbial and root growth, fertilizer and water delivery, soil aggregation, and better pH and temperature management are all linked to improved SOC (soil organic carbon) accumulation. Nevertheless, there is relatively little evidence available about how management techniques affect SOC buildup in South Asian cropping systems based on rice. The temperate zone, where SOC breakdown is relatively slow, is the main focus of studies on SOC sequestration and sustainable crop production. Nevertheless, information about as a result, increased interest in soil quality and sustainable crop production calls for a thorough examination of current knowledge, research gaps, and crop production issues in the area (Ghimire et al, 2017)

A general or specialized soil characteristic, such as soil carbon (C) or soil aggregation, can be used to assess the health of the soil. As it relates to soil ecosystem services, soil C serves as the basis for many actions aimed at improving soil health. Globally, soil erosion and nitrogen supplies for soil have decreased as a result of soil C losses from farming and land usage. Setting possible soil health goals and measuring soil degradation can both be accomplished by establishing a baseline for soil health based on a general or specific soil attribute in undisturbed soil. Understanding a gap in soil health in a field can help decision-makers manage soil health, which will maximize efforts to improve soil health (Maharjan et al, 2020).

Remainder quantity and quality have a big impact on how quickly they decompose and are controlled in terms of soil C concentration. Rainfall during the dry season can further hasten microorganisms' breakdown. Ridge creation, according to farmers, boosts nutrient release and evenly distributes soil richness. Farmers now include wastes in ridges because of the beneficial qualities of both mulching and ridge-making. Tilling combines air and residues into the soil, where there are numerous microorganisms that are in the process of degrading. The practice of introducing wastes and oxygen in ridges has the dual effects of accelerating short-term decomposition and reducing soil organic matter accumulation over the long term. Farmers gave legumes favorable reviews for their use in rotation or intercropping systems. They discovered that intercropping or rotating legumes enhances soil fertility by replenishing nutrients, resulting in 'excellent' crop development for the next season. They said that this enhancement, which is related to higher nitrogen levels, could be seen in the crop's color, which was becoming more green than yellow. After 2 and 5 years, total N in treatment was higher than in conventional methods according to other studies (Hermans et al, 2021)

4. Influence Microorganism to Soil Health

All living cells include phospholipid fatty acids, which are also found in the cell membranes of microbes. Chain length, branching, and saturation can be used to distinguish between distinctive fatty acids, or sets of fatty acids, that have been connected to particular functional categories of microorganisms. Plant-associated soil microbes are essential to plant health and productivity and can provide significant advantages to plants. This happens both directly, as a result of mutualists and pathogens, and indirectly, as a result of modifications in biogeochemical cycle. Many plant functional features, including specific leaf area, nutrient uptake techniques, drought resistance, resilience, and resistance to disease invasions, can be changed by bacterial communities as well as by individual bacterial species. Rhizosphere microbial communities are essentially chosen by the plant's unique root exudates, and they can differ substantially between plant species as well as between cultivars of some plant species (Vink et al, 2021).

Microbial communities in the soil are especially susceptible to anthropogenic activity. For instance, excessive fertilization has harmful impacts on the environment, such as soil acidification, an increase in greenhouse gas emissions, and eutrophication of waterbodies due to P runoff. Conversely, crop diversity can affect the composition of soil microbial communities and promote ecological processes mediated by microorganisms, such as nutrient cycling (Yang et al, 2020a). It has been demonstrated that both of these ecosystem services are supported by soil invertebrates, a particular type of biota that includes a taxonomically wide variety of arthropods, including collembola and mites. Soil invertebrates improve the functioning of soil food webs and facilitate nutrient cycling in organic systems. Furthermore, soil invertebrates probably have a significant impact on the management of insect pests and plant pathogens in agroecosystems (Jernigan et al., 2020).

5. The Effect of Agrosystem Management on Soil Health

Physico-chemical soil characteristics, including texture, bulk density, pH, soil organic matter, moisture content, and drainage, as well as the functional relationships and diversity of soil organisms, influence patterns of soil function and establish the status of soil health (Adhikari et al., 2021). The soil biological system depends on soil organic matter as a source of energy for all living things in the soil. The variety of soil-forming elements that result in variation in the early circumstances of soil organic matter must also be taken into account. The decomposition process moves swiftly in tropical regions because of the high temperatures and rains, which causes the soil's organic matter content to drop quickly (Saurabh et al., 2021).

The characteristics of the organic matter pool, the availability of nutrients in the soil, and their management dictate how nutrients move through the soil system and are recycled. These factors are crucial for soil health and the closure of the soil health gap. Adhikari and others, 2021 Stabilizing the necessary amount of nutrients for the chosen crop depending on characteristics such soil type, crop varieties/hybrids, season. Soil testing as a thumb rule helps to know the status of plant nutrients present in the soil and fertilizer nutrient application for specific crops with specific doses (Leena et al., 2021). Conservation agriculture (CA), integrated soil fertility management (ISFM), and agroforestry methods, which improve soil health, have a favorable impact on crop output, which is frequently assessed, as well as other ecosystem services (ES) (Kihara et al (2020). Agroforestry is a strategy of land use management that involves growing trees or shrubs alongside crops, whereas ISFM refers to the combined use of mineral fertilizers, locally accessible soil amendments, and organic matter in crop production. It was suggested that management of agricultural soils must take into account environmental effects, such as greenhouse emissions, air and water quality, as well as productivity because soil health influences other ES (Lal, 2000).

It is necessary to use management techniques that support ecological processes in order to improve soil quality and crop productivity in order to create agroecosystems that can provide various ecosystem services with a reduced reliance on external inputs. Using conservation management approaches, especially in developing nations, has proved beneficial in maintaining or increasing crop yields while enhancing the effectiveness of the use of natural resources (Teixeira et al, 2021). Cropping systems, including crop diversity, crop rotation and intercropping, and related agronomic methods employed in agriculture impact soil health and quality from numerous geographical and temporal dimensions. Cropping systems were first created to optimize the yield from agro-systems, but modern agriculture is now more concerned with cropping systems' long-term environmental viability. In accordance with five essential function evaluation standards, namely nutrient cycling, water relations, biodiversity and habitat, filtering, buffering, and physical stability and support, soil health maintenance aims to ensure long-term stable high productivity and environmental sustainability of cropping systems (Yang et al., 2020b). More diverse cropping sequences and cover crops encourage more fungal-based community structures and increase microbial biomass, which results in higher levels of microbially produced organic matter(Ashworth et al.,2017).

Sustainable soil management techniques should boost productivity and resilience, particularly during climate-related disasters. Several agro-environmental elements, such as climate, past land use, or initial soil conditions, have an impact on yields and soil organic carbon. In fact, these variables even affect the temporal response of yields and soil organic carbon in cropping systems with excellent soil management practices. For instance, techniques aimed at boosting soil organic matter may result in short-term yield penalties (Guo, 2021). The anticipated gains in productivity and adaptability, however, would only become apparent in the middle to long term following a cumulative effect of ongoing organic matter assimilation. In light of this, a cropping system's climate-smartness could be determined by the synergies between raising SOC, improving soil, and increasing yield (Arenas-Calle et al, 2021).

For healthy plant growth, there must be an adequate supply of nutrients. By the end of the growing season, there shouldn't be an excessive amount of nitrogen and phosphorus in highly soluble forms or nourishing the soil surface. The likelihood of fertilizer leaching and runoff increases after crops are harvested and before the next crops are well-established (Shahane et al, 2021).

Conclusion

Agro-engineering, such as the use of green fertilizer on arable land and agroforestry on marginal and degraded land, is done for financial advantage. For future widespread application in managing soil health, this possibility and a number of additional possibilities for soil maintenance need to be found, assessed, and quantified. Crop residues, agro-industrial wastes, and untreated industrial or mineral wastes can all be used as soil amendments to improve soil quality and provide plant nutrition. Reviews have a strong emphasis on evaluating and quantifying modern agricultural practices in order to determine how well they contribute to promoting soil health across agroclimatic zones and for broader implications. additionally, creative methods of managing soil health are prioritized over the straightforward application of manure and fertilizers for plant nourishment.

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