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Soil Health - An Issue of Concern for Environment and Agriculture

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Abstract

Soil, as air and water, is a fundamental resource required for meeting the diverse needs of humans. Environmental pollution influences both soil and agriculture that are the two valuable resource essential for our sustenance. Soil is assumed as an inexhaustible resource that is used continually for increasing agricultural production. The soil today has virtually turned lifeless in places with increasing development and industrialization. Soil, microflora, fauna, nutrients and associated habitat has the potential to influence the soil ecosystem, agriculture, environment and economy. Soil and its living organisms are an integral part of ecosystems and environment, playing a critical role in maintaining soil health, ecosystem functioning and productivity.

Keywords: Soil; Environment; Agriculture; Contamination

Introduction

The development process has ushered in the challenges of soil contamination, microbial and biodiversity loss. It is time to recognize the interdependence of economic and social development with the protection of the environment and reduction of the human impact. Environmental problems, which may have global impacts, are complex and often interrelated with socio-economic factors. Problems of soil contamination, pollution and degradation, loss of biodiversity do not recognize political borders and pose major threats to human safety, health and productivity. The need to take actions to sustain soil and its immediate environment becomes pressing and challenging task in today's environment. One of the important dimensions of the efforts for environmental protection is raising public awareness and participation. There is need to provide a information on soil toxicology, soil contamination, soil management, technologies and impacts on human health along with the required approaches to answer the challenges [1-4].

Soil Health for Agriculture

Characteristic features of healthy soil are mentioned below.

- Good soil tilth
- Sufficient depth
- Sufficient supply of nutrients
- Small population of plant pathogens and pests
- Good soil drainage
- Large population of beneficial organisms
- Low weed pressure
- Free of chemicals and toxins that may harm the crop
- Resistant to degradation
- Resilience when unfavorable conditions occur (Table 1).

Some of the factors causing low fertility in soil are:

- Soil erosion
- Continuous cultivation without use of inorganic or organic nutrients
- Deforestation and overgrazing
- Insufficient nutrient replacement
- Effect of salts in soil [1-7].

Guidelines for Organic Fertility Management

Soil fertility can be viewed as a function of the biological, physical and chemical characteristics of soil. An organic fertility program should consider all of these interrelated factors to optimize and sustain crop production.

Soil testing is useful for monitoring and analysis of soil organic content that influences the physical and biological quality of soil. Soil testing helps to estimates the level of nutrients present in the soil that are available to plants. It helps to determine the quantity and type of soil amendments needed for better crop yields. Soil fertility in organic farming is complex as the nutrient source comprising of compost, manure makes it challenging to maintain nutrient balance. Hence, excessive levels of certain nutrients (like phosphorus) may occur. Monitoring nutrient trends over a period of time enables farmers to adapt their nutrient management strategies to optimize yield and minimize adverse environmental impact. In general, the aim should be to maintain nutrient elements within the **optimum** range as reported on the soil test. When a nutrient is above optimum range it should not be amended until the excess is used up by crops. It is important to keep in mind that factors other than nutrients may limit crop potential, because simply adding more nutrients will not solve all problems.

Organic content management is an essential part of organic agriculture. Additions of compost, animal or green manures are needed to feed soil microbes, but organic growers need to carefully monitor soil test reports while supplementing and adding organic amendments to the soil. Organic matter management is essential because the by-products of decomposition of organic amendments bind soil particles

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Indicator	Time to test	Healthy Condition
Earthworm presence	When soil is moist	>10 worms/ft3 castings in tilled clods
Color	When soil is moist	Topsoil remains darker than subsoil
Presence of plant residues	Anytime	Residue on most of soil surface
Conditions of plant roots	Late spring or during rapid growth	Roots extensively branched, white, extended into subsoil
Degree of subsurface compaction	Before tillage or after harvest	A stiff wire goes in easily to 2x plow depth
Soil tilth or friability	When soil is moist	Soil crumbles easily
Signs of erosion	After heavy rainfall	No gullies, runoff from field clear
Water holding capacity	After rainfall during growing season	Soil holds moisture at least a week w/o signs of drought stress
Water infiltration	After rainfall	No runoff; soil surface does not remain excessively wet
pH	Same time each year	Near neutral and appropriate for crop
Nutrient holding capacity	Similar time of each year	N, P, and K stable and sufficient content

Table 1: Some indicator and tests for healthy soil.

to improve the physical condition or structure of soil and because the organic matter is the storehouse of nutrients in the soil. Many nutrients, especially N, P, K, S, Cu, and Zn are released when organic matter decomposes. Decaying organic matter in the soil releases nutrients randomly. When the release of nutrients or mineralization is low when soil is cool, fertilizing with soluble forms of nutrients may benefit crops. For this reason phosphorus and nitrogen should be placed near the roots of crops early in the growing season. We should use peanut or soybean to provide some available P and N, respectively or use a commercial organic fertilizer blend.

Nitrogen 10 to 90% of the N contained in compost, manure, plant and animal byproducts may be available to plants. These releases of N vary with drainage, soil conditions and may not be meeting crop needs of short season crops. Many annual crops need N most intensely about three to four weeks after transplanting, or just before the period of maximum growth. Therefore, side dressing or spreading a rapidly available source of N along the crop row will release nutrients is most efficient technique.

Limestone It raises the soil pH and provides calcium (Ca) and varying amounts of magnesium (Mg). The selection of dolomitic or calcitic lime should be based on soil test levels of Ca and Mg. Sulfur is used when the pH of the soil is high.

Calcium is typically supplied in sufficient quantities by lime applied to manage soil acidity. When liming is not required and soil Ca tests below optimum, the best alternative source of Ca for organic producers is gypsum.

Magnesium is best applied as dolomitic lime, but when liming is not required, other Mg sources are Sul-Po-Mag or Epsom salts. Sul-Po-Mag is the better choice if potassium is also required. However, Epsom salts can be applied as a foliar spray to temporarily alleviate Mg deficiency. Dissolve 15 lbs per 100 gal water and spray at weekly intervals.

Phosphorus is low in many New England soils, and can limit crop growth, especially early in the season. Soils testing below optimum in available phosphate (P_2O_5) usually require substantial applications of phosphate. Compost and manures are an excellent source of readily available P_2O_5. Maintain a pH of 6 to 7 with limestone to maximize P_2O_5 availability. Compost and manures tend to contain less P_2O_5 than N or K_2O, but repeated applications of moderate rates will raise P levels substantially. Repeated use of these materials has resulted in excessive soil levels. Nutrient levels should be monitored with regular soil tests. Some growers use large amounts of rock phosphate to try to build fertility. Over time this can lead to levels much above optimum. To allow P levels to come down, no amendments containing P should be applied including compost. This is unfortunate since compost is an important part of good soil management.

Potassium is very slowly available (several years) from granite dust and greensand, which are applied at 3 to 5 tons to the acre to build up K reserves. Wood ashes contain soluble K, but must be used with caution because they will raise the pH rather rapidly and can be caustic. The liming effect of 1 pound of ashes is roughly equal to 1/4 to 1/2 of a pound of limestone. No more than one 1 of ashes per acre should probably be applied at once unless a detailed analysis of the material has been performed and only then if called for by low pH, low K and sufficient Mg. Sul-Po-Mag is the K fertilizer of choice when Mg is also needed. Potassium sulfate from natural sources is a better choice when K is needed but Mg is not.

Micronutrients are generally sufficiently supplied to plants by regular additions of organic amendments. Wood ash is another excellent source of micronutrients. Some seaweed extracts may also supply micronutrients. In soils low in boron (B), remedial applications are widely recommended for crops that readily suffer from B deficiency, such as crucifers. In this case, 1 to 2 lb/acre of B should be applied to the soil. It is difficult to apply such a small amount uniformly, but boron can be ordered as part of a fertilizer blend. Most boron products are soluble and can sprayed evenly over the soil. Several forms of B are OMRI listed, including Solubor, Fertibor and Biomin Boron. It is advisable to monitor B levels with soil tests and tissue tests (for perennial fruits).

Microorganisms present in the soil play a vital role. Bacteria feed on organic matter, store and cycle nitrogen, and decompose pesticides. Fungi Up to 3,000 species of fungi are in the soil. Some feed on dead organic matter like crop residues that are more difficult to break down–others are parasites that attack other microbes. Some fan out from the root to get more nutrients and hold more water for the plant, delivering nutrients to the plant in exchange for carbon. Protozoa eat bacteria, fungi, and algae. When they eat bacteria, their main food source, they unlock nitrogen that's released into the soil environment slowly. They convert organic nitrogen to inorganic nitrogen that's available to plants. Mites decompose and shred organic matter as an important part of the nitrogen cycle. Nematodes are microscopic worms that are an important part of the nitrogen cycle. Most are non-pathogenic and don't cause disease. They eat other organisms in the soil. Earthworms expel partially decomposed organic matter, produce nutrient-rich casts, and make lubricated tunnels that aid soil structure and water movement in the soil.

Capacity of a soil to function within ecosystem boundaries to sustain biological productivity, maintain environmental quality and promote plant and animal health. In the context of agriculture, it may refer to its ability to sustain productivity. A healthy soil would ensure proper retention and release of water and nutrients, promote and sustain root growth, maintain soil biotic habitat, respond to management and resist degradation Governed by a number of physical, chemical and biological attributes and processes. Expressed by different quantitative and qualitative measures of these attributes as also by outcomes that are governed by the soil such as productivity, nutrient and water use efficiencies and quality of produce. Soil pollution is the contamination of soil by harmful substances.

Pollution occurs when contaminants overload the storage and processing of substances in the soil. Soil lacking in nutrients leads to less nutritious foods due to the contamination. Point-source contamination is the cause of pollution in landfills, radioactive waste dump sites, drainage from mining, and vehicular emissions/spills. Nonpoint-source contamination is caused by chemicals, medication, and microbes. Soil pollution may be shallow, from the surface to a depth of 3 feet. The soil can move through only the top 6 inches of soil. Any deeper contamination is caused through seepage and flow of water. The process of removing toxic substances is called remediation. Current techniques include excavation of contaminated soil, washing the soil, and changing the properties of contaminants to make them less toxic. Agriculture chemicals such as pesticides, fungicides and herbicides. The contents of landfills being carried by rain into the soil and water. Industry pollution heavy metal and chemical pollutants being released. Feedlots damage soil health through excess manure. Sewage sludge from treatment facilities. Water pollution, caused by water running over polluted soil. Air pollution produced by volatile compounds produced by the polluted earth. Plant contamination through the soil where the vegetation is grown. Animals who eat the plants get the chemical in their body, which can lead to health issues if eaten. Reduction of soil health, such as the slowing of plant growth and acidity. Cancer can be caused by pesticides commonly used on agricultural lands. Neurological problems can be caused in children by lead in the soil.

Tissue damage and irritation can be caused by mercury in the soil take measurements periodically over time to monitor changes or trends in soil quality; compare measured values to a standard or reference soil condition. Improve soil health by reduce disturbance, work soil when dry, avoid compaction, add organic materials, mulch soil surface, cover crops.

Methods to improve soil health are:

- Strengthen the nutrient cycle
- Conservation of soil, water
- Better ways to water harvesting, recycling and irrigation
- Use lime in case of high rainfall
- Use water soluble fertilizers
- Promote bio-fertilizers
- Ensure sufficient carbon content in soil
- Avoid compaction
- Use manure and fortified compost [8-15]

Conclusion

Agriculture is the backbone of economy but it lacks political good will based on funding, policies, land, fertilizer. There is need of institutions to undertake research but that requires enhancement of capacity in terms of human resource and infrastructure. A number of proven technologies are available but the need to develop others led to agricultural intensification. Information on soil health should be scattered to the various institutions. Unfortunately, there is poor uptake of technologies and recommendations by the farmers. Farmers are generally aware of the need to replenish the soils but are hampered by socio-economic constraints. Role of private sectors is critical in delivery of inputs. Widespread nutrient deficiencies and deteriorating soil health are the cause of poor soil health, reduced productivity & profitability. Adoption of site-specific balanced and integrated nutrient management system involving major, secondary and micro nutrients, organic manures, bio-fertilizers and amendments can improve the present state of soil health. Simultaneously, conducive policy on environment safety, investments in the fertilizer sector for sustained supplies of fertilizers, utilizing indigenously available nutrient sources to reduce dependence on imports, developing new efficient fertilizer products and approaches through research & development applications, effective soil testing service to back up precise fertilizer use, spreading awareness amongst farmers on benefits of balanced fertilization can bring significant improvement in soil health for safe environment and better agricultural productivity. Although many indicators and indices of soil quality and soil health have been proposed, a globally acceptable and applicable definition and methodology of assessment of soil quality or soil health are still not in place. While analysis of physical, chemical and biological characteristics of soil simultaneously is required to evaluate sustainability/ unsustainability of different management practices, most studies in developing countries have looked at physical and chemical characteristics only that needs to be changed.

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