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Soil Health and Nutrient Management for Better Crop Yields

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Introduction

Soil is a critical resource— the way in which it is managed can improve or degrade the quality of that resource. Soil is a complex ecosystem where living microorganisms and plant roots bind mineral particles and organic matter together into a dynamic structure that regulates water, air, and nutrients. In an agricultural context, soil health most often refers to the ability of the soil to sustain agricultural productivity and protect environmental resources. A healthy soil provides many functions that support plant growth, including nutrient cycling, biological control of plant pests and regulation of water and air supply. These functions are influenced by the interrelated physical, chemical and biological properties of soil, many of which are sensitive to soil management practices.

Indiscriminate use of chemicals and fertilizers has led to a weakened ecology, thereby threatening long-term sustainability. However, the Indian farmer continued the practices in the quest of productivity. The resulting deterioration of soil and the depletion and contamination of water has had a direct spin-off on farmer's productivity and profitability, particularly in Northern India.

Healthy soil is the foundation for profitable, productive and environmentally sound agricultural systems. By understanding how the soil processes that support plant growth and regulate environmental quality are affected by management practices, it is possible to design a crop and soil management system that improves and maintains soil health over time. This information is for farmers and gardeners who want to understand the physical, chemical, and biological components of healthy soil and how to manage them.

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Need for Better Soil Management: The Current Issues

Year after year, we hear about the rich harvest the season has produced. However, despite the ever growing output, malnutrition and farmer income still remain contentious issues. The lack of understanding about imbalances in soil nutrients are the major reasons for this.

Some of the issues being faced in soil health:

- **Depleting soil organic matter:** Imbalanced use of fertilizers has had a declining effect on soil organic matter, which is an important factor in maintaining soil health. Farmers tend to depend on fertilizers and neglect organic manure, which invariably leads to this decline, especially in intensively cropped regions
- **Declining soil fertility:** Almost 95 percent of the soils in India are deficient in nitrogen and phosphorus. Potassium deficiency has become widespread with almost 50 percent of fields being deficient. The same deficiency exists with sulphur and other micronutrients particularly zinc.
- **Physical degradation in soil conditions:** Indiscriminate use of tilling, machinery used in harvesting, crop residue burning, and puddling leads to poor physical soil structure. This in turn affects future cropping and irrigation.
- **Soil compaction:** Soil compaction occurs when soil is exposed to excessive foot and equipment traffic while the soil is wet and plastic. This traffic compresses the soil, reducing pore space and increasing bulk density. Macropores are compressed more so than micropores, leading to poor water infiltration and drainage and increased runoff. Soil compaction increases soil hardness, making it more difficult for plant roots to grow through the soil. The reduction in pore space also affects habitat for many soil organisms that are very small, cannot move soil particles, and are restricted to existing pore space and channels in the soil.
- **Chemical degradation of soils:** Soils degrade chemically through diffusion and from local sources, leading to salinization, acidification, alkalization, and further soil toxification. Chemical fertilizers and pesticides have a major role in the process of soil chemical degradation.

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Soil Health and Nutrient Management: The Way Forward

As farm yields reduce, and cost of inputs keep rising, farmers are realizing the importance of improved soil health and nutrient management on their fields. Scientific practices have the ability to improve crop yields, reduce input costs, and have a host of environmental benefits.

Some of these practices include:

Balanced and integrated use of fertilizers and micronutrients:

All essential nutrients need to be applied in optimum quantities and in planned methods that are dependent on soil, crop, and climatic conditions. Timing and a judicious mix of nutrients will meet crop demands and will prevent excesses. Over-fertilizing of crops increases pest issues. Excess of nitrogen levels in plants can decrease resistance to pests, and result in crop damage.

This, of course, is only made possible with proper soil testing, outreach program, and policy initiatives. For instance, a reform of the Nutrient Based Subsidy Scheme could be extended to include urea as well as other nutrients. Use of organic nutrients should also be encouraged, since an important factor in maintaining soil organic matter.

Increase Organic Matter Inputs:

To maintain or increase soil organic matter levels, inputs of organic matter must meet or exceed the losses of organic matter due to decomposition. Healthy crops can be a valuable source of organic matter, and crop residues should be returned to the soil to the extent possible. Incorporation of cover crops or perennial crops and judicious additions of animal and green manure and compost can also be used to increase or maintain soil organic matter. Soil organic matter content can be monitored over time if you request an organic matter analysis when submitting soil fertility samples to your soil testing laboratory. Be sure that your organic matter comparisons over time are based on data from the same lab or from labs that use the same procedure for organic matter analysis, as results can differ significantly between analysis methods

Use Cover Crops:

Cover crops contribute numerous benefits to soil health. They keep the soil covered during the winter and other periods of time when crops are not growing, reducing the risk of erosion. The biomass produced by cover crops is usually returned to

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the soil, enhancing organic matter levels. Cover crops with taproots can create macropores and alleviate compaction. Fibrous-rooted cover crops can promote aggregation and stabilize the soil. Species of cover crops that host mycorrhizal fungi can sustain and increase the population of these beneficial fungi. Legume cover crops can add nitrogen to the soil through nitrogen fixation. Cover crops can retain nitrate and other nutrients that are susceptible to leaching losses.

Reduction in inversion Tilling:

Excess tilling is detrimental to soil health. Tilling tends to decompose organic matter, and disturb the soil aggregates, leading to reduction in soil health, increase in erosion, and reduced productivity. Tilling would only be required in order to increase organic input via residual crops or manure. Reduction in tillage may appear to be cumbersome and dependent on the individual field's status; however, the benefits to the farmer are significant in the long run.

Reduction in synthetic pesticides/insecticides and promoting beneficial organisms by providing habitat:

Indiscriminate use of synthetic pesticides and insecticides has adversely affected the environment and agricultural production. Harmful chemicals have found their way into the food chain and water table. Pesticide residue pollutes soil, groundwater and surface water, and affects livestock, crops, and humans. Use of agro-chemicals has been particularly rampant in commercial farming, as the damage to standing crops from pests is a continuing problem. Relying on pest-resilient plant varieties, crop rotation, biodegradable pesticides, and environment-friendly pesticides is the way forward. Newer concepts such as farmscaping could control the problem of pests through beneficial organisms and lead to a reduction in use of synthetic pesticides.

Rotate Crops:

Diverse crop rotations will help break up soilborne pest and disease life cycles, improving crop health. Rotations can also assist in managing weeds. By growing diverse crops in time and space, pests that thrive within a certain crop are not given a chance to build their populations over time. Rotating crops can also help reduce nutrient excesses.

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Manage Nutrients:

Carefully planning the timing, application method, and quantity of manure, compost, and other fertilizers will allow you to meet crop nutrient demands and minimize nutrient excesses. Healthy, vigorous plants that grow quickly are better able to withstand pest damage. However, overfertilizing crops can increase pest problems. Increasing soluble nitrogen levels in plants can decrease their resistance to pests, resulting in higher pest density and crop damage.

Maintaining a soil pH appropriate for the crop to be grown will improve nutrient availability and reduce toxicity. Maintaining adequate calcium levels will help earthworms thrive and improve soil aggregation.

Using diverse nutrient sources can help maintain soil health. Manure and compost add organic matter as well as an array of nutrients, but using just compost or manure to meet the nitrogen needs of the crop every year can result in excessive phosphorus levels in the soil. Combining modest manure or compost additions to meet phosphorus needs with additional nitrogen inputs from legume cover or forage crops in a crop rotation can help balance both nitrogen and phosphorus inputs.

Preserving soil moisture:

Water shortages due to shrinkage in groundwater availability is a major issue affecting soil health especially in monsoon dependent arid regions of north India. Crops are starved or stressed for water due to low rainfall, high temperatures, and inconsistent or poor irrigation. Methods or systems that promote moisture guard against droughts and have a cyclical effect on soil health and fertility.

Techniques such as strip tillage, no tillage, mulching, cover cropping, contouring, etc., have been shown to increase moisture retention in soil.

Conclusion

The 4R's of nutrient management are referred to when talking about proper nutrient application and soil health. Soil health is in harmony with nutrient management and they are mutually interdependent. The 4R's refer to the right source, right rate, right time, and right place, and act as a guide in farming and nutrient practices. Balanced nutrient management must look at factors such as nutrients present in the soil, nutrient removal by crop, fertilizer

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input costs, investment and profitability, agricultural methods, soil moisture, physical condition of soil, and soil degradation conditions such as salinity, alkalinity, and acidity.

Considering the diversity in physical and moisture conditions prevalent in India, a blanket recommendation for soil management and health is not possible. A region-specific approach is the need of the hour and will go a long way in maintaining a balance between soil health and ecology preservation, ultimately resulting in increases in crop productivity. Educating farmers through outreach programs is necessary, and this can be achieved through regular capacity building and concerted policy efforts.

The resulting benefits will be a reduction in soil erosion, better soil nutrition, improved water quality, and greater biodiversity. The spin-off will be better crop yields, fulfilling the vision of increasing farmer's income.