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INTEGRATED NUTRIENT MANAGEMENT IS A KEY OF SOIL HEALTH MANAGEMENT

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Abstract

Widespread nutrient deficiencies and deteriorating soil health due to continues application of chemical fertilizer causes decreasing productivity & profitability. Integrated nutrient management means combined application of different sources of plant nutrients like organic, inorganic and bio-fertilizer for crop production without degrading the natural resources on long term basis. In other words, integrated nutrient management is the use of different sources of plant nutrients integrated to check nutrient depletion and maintain soil health and crop productivity. Soils which receive plant nutrients only through chemical fertilizers are showing declining productivity despite being supplied with sufficient nutrients. The physical condition of the soil is deteriorated as a result of long-term use of chemical fertilizers.

Introduction

Soil health, also referred to as soil quality, is defined as the continued capacity of soil to function as a vital living ecosystem that sustains plants, animals, and humans. This definition speaks to the importance of managing soils so they are sustainable for future generations. Soil isn't an inert growing medium, but rather is teaming with billions of bacteria, fungi, and other microbes that are the foundation of an elegant symbiotic ecosystem. Soil is an ecosystem that can be managed to provide nutrients for plant growth absorb and hold rainwater for use during dryer periods, filter and buffer potential pollutants from leaving our fields, serve as a firm foundation for agricultural activities, and provide habitat for soil microbes to flourish and diversify to keep the ecosystem running smoothly. Integrated nutrient management is the maintenance or adjustment of soil fertility and plant nutrient supply at an optimum level to sustain the desired crop productivity. Integrated nutrient management means combined application of different sources of plant nutrients like organic, inorganic and bio-fertilizer for crop production without degrading the natural resources on long term basis and to check nutrient depletion and maintain soil health. Soils which receive plant nutrients only through chemical fertilizers are showing declining productivity despite being supplied with sufficient nutrients. The physical condition of the soil is deteriorated as a result of long-term use of chemical fertilizers. Excess nitrogen use leads to groundwater and environmental pollution apart from destroying the ozone layer through N_2O production. High fertilizer cost and low purchasing power of the farming community have made it necessary to rethink alternatives. Chemical fertilizer, organic manure and biofertilizer available locally at cheaper rates. They enhance crop yield per unit of applied nutrients by providing a better physical, chemical and microbial environment. The available quantity of animal excreta and crop residues cannot meet the country's requirements for crop production. Therefore, maximizing the usage of organic waste and combining it with chemical fertilizers and biofertilizers in the form of integrated manure appears to be the best alternative.

Soil Health

Soil health has been defined as: "the capacity of soil to function as a living system. Healthy soils maintain a diverse community of soil organisms that help to control plant disease, insect and weed pests, and form beneficial symbiotic associations with plant roots, recycle essential plant nutrients, improve soil structure with positive repercussions for soil water and nutrient holding capacity, and ultimately improve crop production". To that definition, an ecosystem perspective can be added: A healthy soil does not pollute the environment; rather, it contributes to mitigating climate change by maintaining or increasing its carbon content FAO (2008). Soil contains one of the Earth's most diverse assemblages of living organisms, intimately linked via a complex food web. It can be either sick or healthy, depending on how it is managed. Two crucial characteristics of a healthy soil are the rich diversity of its biota and the high content of non-living soil organic matter. If the organic matter is increased or maintained at a satisfactory level for productive crop growth, it can be reasonably assumed that a soil is healthy. Healthy soil is resilient to outbreaks of soil-borne pests. For example, the parasitic weed, Striga, is far less of a problem in healthy soils Weber, (1996). Even the damage caused by pests not found in the soil, such as maize stem borers, is reduced in fertile soils Chabi-Olaye *et al.* (2006). 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.

Soil health indicator

Physical properties	**Chemical properties**	**Biological properties**
Bulk density	pH	Organic matter content
Rooting depth	Electrical conductivity	Microbial biomass carbon
Water infiltration rate	Cation exchange capacity	Microbial biomass nitrogen
WHC	Organic matter	Earthworms and enzymes
Aggregate stability	Mineralizable N	Disease supperessiveness
Surface and subsurface hardness	Exchangeable potassium	Active carbon
	Exchangeable calcium	Decomposition rate

Mishra and Jain, (2013)

What is INM?

- Integrated nutrient management is the maintenance or adjustment of soil fertility and plant nutrient supply at an optimum level to sustain the desired crop productivity.
- This is done through optimization of the benefits from all possible sources of plant nutrients in an integrated manner.
- Integrated nutrient management means combined application of different sources of plant nutrients like organic, inorganic and bio-fertilizer for crop production without degrading the natural resources on long term basis and to check nutrient depletion and maintain soil health and crop productivity.

Objectives

1. To maintain fertility and physico-chemical properties of soil.
2. To recycle and use of organic wastes.
3. Encouragement of the judicious use of chemical fertilizers, green leaf manures and bio fertilizers for higher productivity.
4. Creation of positive nutrient balance in soil.
5. To avoid over exploitation of natural resources.
6. Maximization of nutrient use efficiency.
7. Environmentally safe and eco-friendly sustainable agriculture
8. To utilize the potential benefits of green manuring.
9. To protect soil health and reduce expenditure on cost.
10. To meet the social and economic aspirations of the farmer with high productivity and profitability.

Why is INM needed?

The increasing use of chemical fertilizers to increase the production of food and fibre is causing concern for the following reasons:

1. Soils which receive plant nutrients only through chemical fertilizers are showing declining productivity despite being supplied with sufficient nutrients.
2. The physical condition of the soil is deteriorated as a result of long-term use of chemical fertilizers. It also aggravates the problem of poor fertilizer nitrogen use efficiency (NUE).
3. Excess nitrogen use leads to groundwater and environmental pollution apart from destroying the ozone layer through N_2O production.
4. High fertilizer cost and low purchasing power of the farming community have made it necessary to rethink alternatives.
5. Chemical fertilizer, organic manure and biofertilizer available locally at cheaper rates. They enhance crop yield per unit of applied nutrients by providing a better physical, chemical and microbial environment.
6. The available quantity of animal excreta and crop residues cannot meet the country's requirements for crop production. Therefore, maximizing the usage of organic waste and combining it with chemical fertilizers and biofertilizers in the form of integrated manure appears to be the best alternative

Component of integrated nutrient management

1. **Organic manure:**

- **FYM**

Compost	Vermicompost	Poultry manure
Piggery manure	Crop wastes	Urban and rural solid and liquid waste Wastes from agro based industries

2. **Inorganic fertilizers**
3. **Biofertilizer**

Soil Health Management Systems (SHMS) include the principles of Agro ecology. Choosing specific practices for your farm or ranch depends on farm/ranch objectives, types of soils, climate, and topography. The current and historical management of the soil's physical, biological, and chemical properties should be reviewed in developing a SHMS.

The five principles include the following:

1. Armor the soil:

Adding new organic matter (crop and forage residues) every year is the most important way to improve and maintain soil health.

- Bare soil is susceptible to wind and water erosion, evapo-transpiration, extreme surface temperatures and crusting.
- Ground cover protects soil, provides habitats for soil organisms, such as insects and earthworms that help build soil structure and increase porosity.
- Bare soils often have soil surface temperatures of 145 degree (20-30 degrees higher than the ambient air temperature).
- 113 degrees Fahrenheit is a general temperature at which soil microorganisms start to shut down activity.
- Cover crops provide additional organic matter, provide food for soil biology.
- Residues must be managed to prevent problems with delayed soil warming in spring, diseases, and seed/soil contact

2. Minimize disturbance:

Types of disturbances are physical, chemical, or biological.

- Major disturbances are tillage, inorganic salt fertilizers, pesticide/ herbicides, and livestock/wildlife.
- Understanding the effects of the disturbances and managing them accordingly can be detrimental or beneficial.
- Tillage (physical disturbance) and Over grazing (biological disturbance) destroys soil structure, speed the decomposition of organic matter, increases erosion, disrupts the habitat of soil organisms, and cause compaction
- Eliminating tillage and severe grazing events provide organic material for the soil biology, helping to increase structure, porosity, and nutrient cycling.
- Salt fertilizers, pesticides, and herbicides (chemical disturbances) contain compounds that decrease the soils biological diversity and activity.

3. Diversify crop types:

Crop types include Cool Season Grass, Warm Season Grass, Cool Season Broadleaf/Legumes, and Warm Season Broadleaf/Legumes.

- Crop/ Plant Diversity contribute unique root structures to promote porosity and nutrient cycling, high and low C: N ratio residues, and diverse plant exudates (organic acids) that attract diverse soil biology.
- A diversity of soil organisms can help control pest and reduce disease pressures.
- Nature thrives on diversity and is much more stable with highly diverse systems
- Diversity across the landscape attracts beneficial insects, increases soil microorganisms, provides wildlife habitat, and helps manage economic risks.

4. Keep a living root all year:Keeping a living root in the ground assists in harvesting solar energy year around, provides fresh residues to be added back to the soil, keeps soils shaded from soil surface evaporation, and provides root exudates to feed soil biology.

- soil microbiology prefer food in the following order: living roots, dead roots, fresh green organic residues, and dead residues
- roots exude organic acids that attract a diversity of micro-organisms that in turn attract larger soil organisms that prey on the smaller
- Living plants help to shade the soil surface reducing light for weed seeds to germinate
- Different plant species have specific characteristics that help enhance organic matter, fix nitrogen, increase water and nutrient availability, and attract beneficial insects

5. Integrate Livestock:

Livestock can be used to harvest, process, and distribute nutrients consumed from the forage and transfer biology across the farm or ranch.

- Livestock have diverse biology in their urine, feces, saliva, hair, and milk that can help increase diversity and develop a predator/prey relationship (balance) among the "herd below your feet"
- Livestock properly managed can provide hoof action that incorporates residues into the soil surface with minimum soil physical damage helping the soil microbes to easily decompose the residues.
- Livestock serve as an economic tool to offset the cost or profit from the Soil Health Management System

Management Practices used to facilitate Soil Health Management Systems:

Residue management- no till, strip till – A systems approach to managing crop residues and herbaceous weeds while maintaining planting conditions and yields. Disturbing less allows soil biology to form associations with plant roots and develop diverse soil organism populations to consume crop residues.

Crop Rotation – Crop rotations that include crop types and choosing crops that produce high amounts of residue, balance C: N ratios, scavenge nutrients, and fix or assimilate N, P, & K.

Some general principles for crop rotation developed at Cornell University (Gugino *et al.* 2007) include:

- Follow a legume forage crop with a high-nitrogen demanding crop such as sweet corn.
- Grow the same annual crop for only one year and don't rotate with closely related crop species to decrease likelihood of insects, nematodes and diseases becoming a problem.
- Plan the crop sequences that promote healthier crops. Some crops seem to do well following a particular crop; others may have an unfavorable effect.
- Use crop sequences that aid in controlling weeds. Rotating broad leaf and grass crops and using selective herbicides can help keep weed populations low.
- On sloping land or where erosion is a high risk, use perennial crops to protect the soil surface and provide continual cover.

Cover Crops- Planting grasses, broadleaves, legumes or multispecies cover crops (diverse mix of several crop types) between or with cash crops to meet a specific objective and improving the soil resource.

Prescribed grazing – A planned grazing system focused on meeting an intended objective. Examples-Recovery based grazing to increase forage quality and quantity, increased stock densities used to incorporate plant residues and increase manure distribution, multispecies grazing (ex-cattle and sheep/goat) to increase forage utilization and provide biological weed and brush control.

Nutrient and Pest Management- Using optimal nutrient and water management practices to grow healthy plants with large amounts of roots and residue. Using inorganic and organic fertility, herbicides and pesticides wisely with a planned objective and understanding of economic and environmental effects of the management decision.

Forage and Biomass Planting- Annual or perennial plantings intended to reduce the land use intensity while maintaining productivity

Range Planting- Planting native perennial species adapted to the ecological conditions to promote diversity, provide forage for livestock, soil resource protection, and wildlife habitat.

Conclusion

Widespread nutrient deficiencies and deteriorating soil health due to continues application of chemical fertilizer causes decreasing productivity & profitability. Adoption of site-specific balanced and integrated nutrient management involving major, secondary and micro nutrients, organic manures and bio fertilizers. Conducive policy environment for more investments in the fertilizer sector for sustained supplies of fertilizers. Utilizing all indigenously available nutrient sources to reduce dependence on imports. Developing new efficient fertilizer products/ approaches through state of art R & D applications. Effective soil testing service to back up precise fertilizer use. Creating awareness amongst farmers on benefits of balanced fertilization.

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