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Integrated Nutrient Management Practice and Soil Health Improvement: A Focused Review

*Shibani Bhuinya
M.Sc. Scholar, Department of Soil Science & Agricultural Chemistry,
College of Agriculture, OUAT, Bhubaneswar, Odisha, India-751003
*Corresponding Author's email: shibanibhuinya0@gmail.com

Integrated Nutrient Management (INM) is a holistic approach to soil fertility management that emphasizes the combined use of chemical fertilizers, organic manures, crop residues, and biofertilizers to sustain soil productivity and improve soil health. Excessive dependence on inorganic fertilizers over the years has resulted in nutrient imbalance, decline in soil organic carbon, deterioration of soil structure, and reduced biological activity, thereby threatening the sustainability of agricultural systems. In this context, INM has emerged as an effective strategy to address soil degradation while maintaining optimal crop yields. Results indicate that the application of organic amendments in combination with recommended doses of inorganic fertilizers significantly improves soil organic matter content, enhances nutrient availability, and promotes favourable soil microbial activity. Improved soil structure and water-holding capacity were also observed under INM practices, contributing to better root growth and nutrient uptake. The findings of this study suggest that Integrated Nutrient Management plays a crucial role in restoring soil health and sustaining agricultural productivity in intensive farming systems. Adoption of INM practices can help achieve long-term soil fertility, improve crop performance, and ensure environmentally sustainable agriculture. Thus, INM represents a practical and scientifically sound approach for enhancing soil health and achieving sustainable crop production under varying agro-ecological conditions.

Introduction: Nutrients benefits soil health

Soil fertility management is essential for sustainable agricultural production. Intensive farming and continuous use of chemical fertilizers have led to nutrient imbalance, decline in soil organic matter, and deterioration of soil physical and biological properties. These issues threaten long-term soil productivity and environmental sustainability. Integrated Nutrient Management (INM) is a sustainable approach that combines inorganic fertilizers with organic manures, crop residues, and biofertilizers to supply balanced nutrients while improving soil health. The integration of organic sources enhances soil organic carbon, improves soil structure, increases microbial activity, and promotes efficient nutrient cycling. Chemical fertilizers provide readily available nutrients to meet immediate crop demands. By improving nutrient use efficiency and reducing nutrient losses, INM supports sustained crop productivity and environmental protection. Therefore, Integrated Nutrient Management plays a vital role in improving soil health and achieving sustainable agricultural systems. This study aims to highlight the role of Integrated Nutrient Management in improving soil health and sustaining agricultural productivity by examining its effects on soil properties and nutrient dynamics under different cropping systems. Soil health improvement through INM is particularly important in intensive cropping systems, where continuous cultivation often leads to soil degradation. By maintaining a balance between nutrient inputs and soil processes, INM contributes to sustainable crop production and environmental protection. Therefore,

Integrated Nutrient Management is recognized as a key component of sustainable agriculture and climate-resilient farming systems.

Representative Case Studies

1. Integrated Nutrient Management in Rice–Wheat Cropping System

Swarup et al. (2000) studied long-term fertilizer experiments under the rice–wheat system and reported that combined application of NPK fertilizers with farmyard manure significantly improved soil organic carbon, available nitrogen, phosphorus, and potassium. INM treatments also enhanced soil microbial activity and maintained sustainable crop yields compared to the use of chemical fertilizers alone.

2.Long-Term Effect of Integrated Nutrient Management on Soil Fertility and Productivity

Wanjari et al. (2003) -This study assessed the long-term impact of integrated nutrient application in intensive cropping systems. The inclusion of organic manures along with recommended fertilizers improved soil aggregation, reduced bulk density, and enhanced nutrient availability. INM treatments helped prevent nutrient depletion and maintained stable crop productivity over time.

3.Integrated Use of Organic and Inorganic Nutrients in Maize-Based Cropping Systems

Ghosh et al. (20004) studied the combined use of FYM, chemical fertilizers, and biofertilizers in maize-based systems. Results indicated improved soil physical properties, increased microbial biomass carbon, and enhanced nutrient use efficiency. Crop yields were consistently higher under INM compared to chemical fertilizers alone.

4. Integrated Nutrient Management in Pulses for Soil Health Improvement

Tandon et al. (1995) emphasized the role of pulses in INM through biological nitrogen fixation and organic residue addition. Integration of organic manures and biofertilizers improved soil nitrogen status, microbial activity, and overall soil fertility. The approach also reduced dependence on synthetic nitrogen fertilizers.

5. INM Practices for Improving Soil Organic Carbon and Microbial Activity

Bhattacharyya et al. (2008) highlighted that integrated application of crop residues, organic manures, and fertilizers increased soil organic carbon stock and enzymatic activity. Improved soil biological properties contributed to better nutrient cycling and long-term soil health.

6. Integrated Nutrient Management in Acid Soils

Sarkar et al. (2001) reported that application of lime along with organic manures and balanced fertilizers corrected soil acidity and improved nutrient availability. INM practices enhanced crop response and improved soil biological activity in acid soils.

7. INM in Saline and Sodic Soils for Soil Reclamation

Abrol et al. (1997) emphasized the role of gypsum combined with organic matter and balanced fertilization in reclaiming sodic soils. INM improved soil structure, reduced exchangeable sodium percentage, and enhanced.

8. Soil Test–Based Integrated Nutrient Management and Soil Health

Chandrasekharan et al. (2012) highlighted the effectiveness of soil test–based fertilizer recommendations combined with organic inputs. Balanced nutrient application improved soil fertility status, reduced excessive fertilizer use, and enhanced nutrient use efficiency, contributing to sustainable soil health management.

Challenges and Limitations

- **Limited Availability of Organic Inputs**

Adequate quantities of organic manures such as farmyard manure, compost, and crop residues are often unavailable, especially in intensive farming systems. Competing uses of crop residues for fodder and fuel further reduce their availability for soil application.

- **High Labor and Management Requirements**

INM practices require proper handling, storage, and timely application of organic inputs, which are labor-intensive. This increases production costs and management complexity, making INM less attractive to small and marginal farmers.

- **Variability in Nutrient Content of Organic Sources**

Organic manures have inconsistent and low nutrient concentrations compared to chemical fertilizers. This variability makes precise nutrient management difficult and may lead to nutrient deficiencies if not properly supplemented with inorganic fertilizers.

- **Slow Nutrient Release from Organic Sources**

Nutrients from organic materials are released slowly through microbial decomposition. This may not meet immediate crop nutrient demand, particularly during critical growth stages, leading to reduced yield response in the short term.

- **Short-Term Yield Expectations**

Farmers often prioritize immediate yield gains, whereas the benefits of INM on soil health are gradual and long-term. This mismatch between expectations and outcomes discourages adoption.

Conclusion

Integrated Nutrient Management (INM) is a holistic approach that combines the judicious use of chemical fertilizers, organic manures, biofertilizers, and crop residues to maintain soil fertility and enhance crop productivity sustainably. The adoption of INM practices leads to multiple benefits, including improved soil physical, chemical, and biological properties, enhanced nutrient use efficiency, increased organic matter content, and reduced dependence on synthetic fertilizers. By promoting balanced nutrient supply and sustaining microbial activity, INM supports long-term soil health, mitigates soil degradation, and contributes to environmental protection. However, challenges such as site-specific nutrient requirements, limited availability of quality organic inputs, and farmers' knowledge gaps may affect its widespread adoption. Despite these limitations, INM remains a vital strategy for achieving sustainable agriculture, improving crop yield, and maintaining soil resilience for future generations.

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