
**E-ISSN:** 2618-0618
**P-ISSN:** 2618-060X

NAAS Rating (2025): 5.20
www.agronomyjournals.com
2025; SP-8(7): 429-431
Received: 09-05-2025
Accepted: 11-06-2025

**Elumle Priyanka**
Young Professional-II, KVK, Bellampalli (PJTAU), Telangana, India

**Rajputh Raghuvaran Singh**
Young Professional-II, KVK, Palem (PJTAU), Telangana, India

**Myakala Rajesh Kumar**
Young Professional-I, KVK, Palem (PJTAU), Telangana, India

**M Venu**
Young Professional-II, DAATTC, Yadadri Bhuvanagiri (PJTAU), Telangana, India

**Corresponding Author:**
**Elumle Priyanka**
Young Professional-II, KVK, Bellampalli (PJTAU), Telangana, India

# Enhancing soil fertility through Integrated Nutrient Management (INM) for sustainable crop production

**Elumle Priyanka, Rajputh Raghuvaran Singh, Myakala Rajesh Kumar and M Venu**

**DOI:** https://www.doi.org/10.33545/2618060X.2025.v8.i7Sf.3445

**Abstract**
Soil fertility is a critical factor influencing crop productivity and long-term agricultural sustainability. Integrated Nutrient Management (INM) is a comprehensive approach that combines organic, inorganic and biological inputs to optimize soil fertility while maintaining environmental health. This article explores the role of INM in enhancing soil nutrient availability, microbial diversity and crop productivity through sustainable practices such as balanced fertilization, organic amendments, biofertilizer applications and mulching techniques. The integration of organic sources (compost, farmyard manure, green manure), inorganic fertilizers and microbial inoculants (e.g., nitrogen-fixing and phosphate-solubilizing bacteria) has been shown to improve soil structure, moisture retention and nutrient cycling. Mulching, a crucial component of conservation agriculture contributes to temperature regulation, reduced nutrient leaching and improved organic matter decomposition. Further, supporting soil fertility. Research findings indicate that adopting INM practices enhances soil physical, chemical and biological properties leading to improved crop yields and resilience against climate variability.

**Keywords:** Integrated Nutrient Management (INM), soil fertility, organic amendments, inorganic fertilizers, biofertilizers

## 1. Introduction

Modern agriculture once hailed as a revolution of abundance has increasingly become a source of ecological concern. A silent crisis of soil degradation is unfolding, marked by declining organic matter, nutrient imbalances, erosion and loss of soil microbial diversity (Lal, 2015) [3]. This degradation is largely driven by over-reliance on synthetic fertilizers, monocropping and intensive tillage which have accelerated the deterioration of soil health and now threaten the very foundation of global food security (Shabani *et al*., 2024) [5]. Soil fertility is a critical determinant of both agricultural productivity and environmental sustainability (Lal, 2015) [3]. The continued depletion of essential nutrients through intensive cropping, imbalanced fertilization and poor soil management has led to declining crop yields and broader environmental degradation (Mateusz *et al*., 2020) [4]. In response to this, Integrated Nutrient Management (INM) has emerged as a holistic approach that integrates organic, inorganic, and biological nutrient sources to enhance soil fertility and promote sustainable crop production (Dhaliwal *et al.*, 2023) [2].

INM focuses on balanced fertilization, organic matter management, and biofertilizer applications to optimize nutrient availability and maintain long-term soil health. Unlike conventional nutrient management, which often relies heavily on synthetic inputs, INM seeks to synergize the benefits of both organic and inorganic sources. This integration improves nutrient-use efficiency and reduces the risks of nutrient leaching, soil acidification, and environmental pollution (Shabani *et al*., 2024; Buragohain *et al*., 2017) [5, 1]. Moreover, by enhancing soil biodiversity and structure, INM contributes to climate resilience and long-term fertility, addressing both the symptoms and root causes of soil degradation (Dhaliwal *et al.*, 2023) [2]. It empowers farmers to achieve higher productivity without compromising ecological integrity, making it central to the vision of sustainable agriculture and global food security. This article explores various advanced INM strategies, their impacts on soil properties and practical recommendations for implementation across diverse cropping systems and agro-ecological zones.

## 2. Principles of Integrated Nutrient Management (INM)

The concept of INM is based on the efficient use of multiple nutrient sources to maintain soil fertility and ensure long-term sustainability. The key principles include:

1. **Synergistic Use of Organic and Inorganic Inputs:** Combining organic matter (compost and farmyard manure) with synthetic fertilizers to improve nutrient availability and reduce chemical dependency.
2. **Site-Specific Nutrient Management (SSNM):** Applying nutrients based on soil test results and crop requirements to enhance nutrient use efficiency.
3. **Use of Biofertilizers:** Incorporating microbial inoculants like **Azotobacter, Rhizobium, and phosphate-solubilizing bacteria** to enhance nutrient mobilization.
4. **Soil Conservation Practices:** Mulching, cover cropping, and reduced tillage to prevent nutrient losses and improve soil organic matter.
5. **Nutrient Recycling:** Utilizing crop residues, green manure, and compost to maintain soil nutrient balance.

## 3. Strategies for Enhancing Soil Fertility through INM

### 3.1 Organic Amendments and Their Role in Soil Fertility

The use of organic matter is essential for improving soil structure, microbial activity and nutrient retention. Common organic amendments include:

- **Farmyard Manure (FYM):** Improves soil organic carbon levels and enhances microbial activity.
- **Compost:** Provides a slow-release source of essential nutrients and improves soil aeration.
- **Green Manure:** Leguminous plants like *Sesbania* and *Crotalaria* improve nitrogen fixation and organic matter content.

### 3.2 Inorganic Fertilizers and Their Optimized Use

While chemical fertilizers play a crucial role in crop nutrition, their excessive use can lead to soil degradation and nutrient imbalances. INM promotes the judicious use of fertilizers through:

- **Balanced Fertilization:** Applying nitrogen (N), phosphorus (P) and potassium (K) in appropriate proportions.
- **Micronutrient Management:** Supplementing soil with essential micronutrients like zinc, iron and boron.
- **Slow-Release Fertilizers:** Using coated or controlled-release fertilizers to minimize nutrient leaching.

### 3.3 Biofertilizers and Microbial Inoculants

Biofertilizers are essential components of INM, enhancing nutrient availability through microbial activity. Common biofertilizers include:

- **Rhizobium and Azotobacter:** Enhance biological nitrogen fixation in leguminous and non-leguminous crops.
- **Phosphate-Solubilizing Bacteria (PSB):** Convert insoluble phosphorus into plant-available forms.
- **Mycorrhizal Fungi:** Improve root absorption of phosphorus and water.

### 3.4 Mulching and Soil Amendments for Nutrient Conservation

Mulching is an effective INM practice that enhances soil fertility by:

- **Regulating Soil Temperature:** Protecting soil from extreme heat and moisture loss.
- **Improving Soil Moisture Retention:** Reducing evaporation and enhancing root zone moisture availability.
- **Suppressing Weeds:** Preventing nutrient competition with crops.
- **Enhancing Microbial Activity:** Decomposing mulch material enriches soil organic matter.

## 4. Impact of INM on Soil Health and Crop Productivity

### 4.1 Soil Chemical Properties

- **Increased Organic Matter:** Improves cation exchange capacity (CEC) and nutrient holding capacity.
- **Improved pH Balance:** Reduces soil acidity and alkalinity, making nutrients more available to plants.
- **Enhanced Nutrient Availability:** Balanced INM application prevents nutrient depletion and enhances soil fertility.

### 4.2 Soil Physical Properties

- **Improved Soil Structure:** Organic amendments enhance soil porosity and aeration.
- **Better Water Retention:** Increased organic matter improves moisture-holding capacity.
- **Reduced Soil Erosion:** Mulching and conservation tillage protect topsoil from erosion.

### 4.3 Soil Biological Properties

- **Increased Microbial Diversity:** Biofertilizers and organic amendments support beneficial microbes.
- **Enhanced Enzyme Activity:** Promotes nutrient mineralization and decomposition of organic matter.
- **Reduced Soil-Borne Pathogens:** Beneficial microbes suppress harmful pathogens improving plant health.

### 4.4 Crop Yield and Nutrient Use Efficiency

INM practices significantly improve crop productivity by ensuring a steady nutrient supply, reducing input costs and enhancing stress tolerance. Research findings indicate that integrating organic and inorganic nutrient sources leads to:

- Higher grain and biomass yield.
- Increased nutrient uptake efficiency.
- Improved crop resistance to drought and pests.

## 5. Challenges and Future Prospects of INM

### 5.1 Challenges in INM Adoption

- **Limited Awareness Among Farmers:** Many farmers lack knowledge of INM benefits and implementation strategies.
- **High Initial Costs:** Organic amendments and biofertilizers require investment and management expertise.
- **Inconsistent Quality of Organic Inputs:** Variability in compost and manure composition affects nutrient content.
- **Slow Nutrient Release from Organic Sources:** Organic amendments take time to break down and release nutrients.
- **Logistical Constraints:** Availability and transportation of organic materials can be challenging.

### 5.2 Future Prospects and Recommendations

- **Policy Support and Subsidies:** Governments should promote INM through incentives and training programs.
- **Advancements in Precision Agriculture:** Sensor-based soil nutrient monitoring can optimize INM applications.
- **Research on Locally Available Organic Inputs:** Identifying region-specific organic amendments can enhance INM adoption.

- **Farmer Training Programs:** Extension services should focus on educating farmers about INM benefits and best practices.
- **Integration with Climate-Smart Agriculture:** INM should be adapted to climate-resilient farming strategies.

## 6. Conclusion
Integrated Nutrient Management (INM) is a sustainable approach to enhane soil fertility while maintaining agricultural productivity and environmental health. By integrating organic amendments, inorganic fertilizers, biofertilizers. INM ensures long-term soil sustainability and efficient nutrient use. The adoption of INM practices can significantly improve soil physical, chemical, and biological properties, leading to higher crop yields and resilience against environmental stress.

For INM to be widely adopted, farmer awareness, policy support and advancements in precision agriculture must be prioritized. The future of sustainable crop production depends on integrating scientific innovations with traditional soil fertility management practices, ensuring a balanced and productive agricultural system.

## 7. References

1. Buragohain S, Das M, Das D, Paul S, Das K, Baruah KK. Effect of 10 years of biofertiliser use on soil quality and rice yield in an Inceptisol in Assam, India. Soil Res. 2017;56(1):49-58.
2. Dhaliwal MS, Kaur G, Singh A, Kaur J, Singh J. Long term impact of biofertilization on soil health and nutritional quality of organic basmati rice. Front Environ Sci. 2023;11:1031844.
3. Lal R. Restoring soil quality to mitigate soil degradation. Sustainability. 2015;7(5):5875-5895.
4. Mateusz M, Górski A, Frąc M. Biofertilizers in agriculture: An overview on concepts, strategies and effects on soil microorganisms. Adv Agron. 2020;162:31-87.
5. Shabani A, Kumar A, Rajendiran S, Shekhawat MS, Ameen M, Kalhapure A, *et al*. Enhancing sustainable crop production through integrated nutrient management: A focus on vermicompost, bio enriched rock phosphate, and inorganic fertilisers. Front Agron. 2024.