

Integrated Nutrient Management: The Key to Sustainable Crop Productivity

Kamal^{1*} and Monika¹

¹Department of Agronomy, CCS Haryana Agricultural University, Hisar-125004, Haryana, India.

Corresponding Author

Kamal

Email: kamalkhroad@gmail.com



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ABSTRACT

Integrated Nutrient Management (INM) is a holistic approach that combines the judicious use of chemical fertilizers with organic manures, crop residues, and biofertilizers to achieve sustainable crop production. Continuous and imbalanced use of inorganic fertilizers has resulted in soil degradation, declining nutrient use efficiency, environmental pollution, and rising input costs. INM aims to maintain soil fertility, improve nutrient use efficiency, enhance soil biological activity, and ensure stable crop yields over the long term. By integrating multiple nutrient sources, INM not only meets the immediate nutrient requirements of crops but also improves soil health and resilience under changing climatic conditions. This article highlights the concept, components, role, benefits, and challenges of Integrated Nutrient Management in achieving sustainable and climate resilient agriculture.

INTRODUCTION

Modern agriculture has played a crucial role in ensuring food security, but excessive and imbalanced use of chemical fertilizers has led to serious problems such as soil degradation, declining nutrient use efficiency, environmental pollution, and increased cost of cultivation. Continuous dependence on

inorganic fertilizers alone is no longer sustainable. To overcome these challenges, Integrated Nutrient Management (INM) has emerged as a holistic and sustainable approach for maintaining soil fertility and achieving higher and stable crop productivity (Patel *et al.*, 2026; Ram *et al.*, 2026).

Integrated Nutrient Management focuses on the judicious and combined use of chemical fertilizers, organic manures, crop residues, and biofertilizers to supply essential nutrients to crops while preserving soil health (Shah *et al.*, 2026).

WHAT IS INTEGRATED NUTRIENT MANAGEMENT?

Integrated Nutrient Management is a strategy that aims to optimize nutrient availability to crops through the balanced use of inorganic fertilizers along with organic and biological sources. The main objective of INM is to ensure efficient nutrient use, reduce nutrient losses, and maintain long-term soil productivity.

COMPONENTS OF INTEGRATED NUTRIENT MANAGEMENT

1. Chemical Fertilizers

Chemical fertilizers provide readily available nutrients and play an important role in meeting the immediate nutrient demand of crops, especially during critical growth stages.

Role in INM:

- Quick nutrient supply
- Higher crop response
- Essential for intensive cropping systems

2. Organic Manures

Organic manures such as farmyard manure (FYM), compost, vermicompost, and green manure improve soil physical, chemical, and biological properties.

Benefits:

- Improve soil organic carbon
- Enhance soil structure and water-holding capacity

- Supply macro- and micronutrients slowly

3. Crop Residue Recycling

Incorporation or retention of crop residues adds organic matter to the soil and improves nutrient recycling.

Advantages:

- Reduces nutrient removal from soil
- Improves soil microbial activity
- Minimizes residue burning

4. Biofertilizers

Biofertilizers such as *Rhizobium*, *Azotobacter*, *Azospirillum*, phosphate solubilizing bacteria (PSB), and mycorrhiza enhance nutrient availability through biological processes.

Benefits:

- Fix atmospheric nitrogen
- Solubilize unavailable phosphorus
- Improve nutrient uptake efficiency

ROLE OF INM IN SUSTAINABLE CROP PRODUCTION

1. Improvement in Soil Fertility

INM maintains soil nutrient balance by preventing nutrient depletion and improving soil organic matter content, leading to sustained soil fertility.

2. Enhanced Nutrient Use Efficiency

The combined application of organic and inorganic sources improves nutrient synchronization with crop demand, reducing losses through leaching and volatilization.

3. Higher and Stable Crop Yields

Integrated nutrient supply ensures continuous availability of nutrients throughout the crop

growth period, resulting in improved yield stability.

4. Better Soil Biological Activity

Organic inputs and biofertilizers stimulate beneficial soil microorganisms, which play a vital role in nutrient cycling and soil health.

ECONOMIC AND ENVIRONMENTAL BENEFITS

- Reduced fertilizer cost through partial substitution of chemical fertilizers
- Improved profitability due to higher yields and better input efficiency
- Reduced environmental pollution by minimizing nutrient losses
- Sustainable production system suitable for long-term agriculture

INM AND CLIMATE RESILIENT AGRICULTURE

Integrated Nutrient Management contributes to climate smart agriculture by:

- Enhancing soil carbon sequestration
- Improving soil moisture retention
- Reducing greenhouse gas emissions associated with excessive fertilizer use

Thus, INM plays a vital role in improving resilience of cropping systems under changing climatic conditions.

CHALLENGES IN ADOPTION OF INM

Despite its advantages, adoption of INM faces certain constraints:

- Limited availability of quality organic manures
- Lack of awareness among farmers

- Inadequate knowledge about biofertilizer use
- Labor requirement for organic input preparation

Strengthening extension services and farmer training is essential to overcome these challenges.

CONCLUSION

Integrated Nutrient Management is a scientifically proven, economically viable, and environmentally sound approach for achieving sustainable crop productivity. By combining chemical fertilizers with organic and biological sources, INM not only improves crop yields but also restores soil health and ensures long-term agricultural sustainability. Widespread adoption of INM practices is essential for meeting future food demands while protecting natural resources for coming generations.

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