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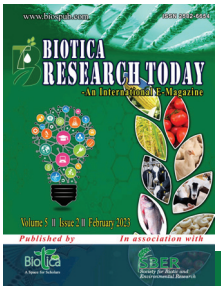

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# Organic, Inorganic and Integrated Nutrient Management Approach for Sustainability

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## Abstract

One of the most important challenges facing humanity today is to conserve/ sustain natural resources, including soil and water, for increasing food production while protecting the environment. When tackling the problem of improving crop yield, the rising food demands of a growing human population and the requirement for an environmentally appropriate plan for sustainable agricultural development. The goal of an integrated nutrient management (INM) is to achieve harmony in the concurrent, legal, and effective application of chemical fertilizers. INM takes environmental concerns into account by adjusting fertilizer application to crop needs and soil conditions in order to avoid both excessive applications that raise the possibility for loss to water or air and insufficient applications that cause the degradation of soil fertility. INM has a lot of potential for supplying the expanding nutritional needs of intensive agriculture. Without decreasing the standard, it can also help maintain production sustainability.

**Keywords:** Food security, INM, Soil fertility, Sustainability

## Introduction

Global food production must increase by 70% by 2050 to keep pace with increasing demand. To meet this challenging target, an average annual increase in cereal production of 43 million metric tonnes year$^{-1}$ is required as demand predicted and cereal production will need to rise to over 4 billion metric tonnes by 2050. Indian agriculture is currently dealing a diminishing water table, nutritional imbalances, salt and soil degradation, an increase in pests, environmental pollution, and decreased profitability. The "green revolution," which promoted intensive use of high-yielding crop varieties along with other inputs like chemical fertilizers and irrigation water, was both successful in increasing food production and difficult to combat the risk of imbalance fertilization, the main factor in soil degradation and a decline in soil fertility. The current global demand for fertilizer nutrient use is about 117 Mt of N, 45 Mt of $P_2O_5$, and 35 Mt of $K_2O$ (FAO, 2020). Rising prices of fertilizer, stagnation in crop prices, and increasing concerns about environmental degradation with nutrient loss have kept the fertilizer sector under tremendous pressure of enhancing nutrient use efficiency (NUE). Further, low uses of organic amendments and secondary nutrients and micronutrients have aggravated the fertility of soils. With a rapidly degrading natural resource base, the current agricultural paradigm, which demands an increased use of fertilizers, pesticide, and fresh water combined with increased land expansion, is not sustainable. Increased crop production and productivity cannot come at the expense of the environment. Utilizing inorganic fertilizer has significant financial and environmental consequences, especially for low-input smallholder farming systems. In their ongoing efforts to close the food and population gaps, the nation's researchers and policymakers have considered several soil and plant nutrient management options, primarily the INM, the balanced use of chemical-based fertilizers and the sourcing and processing of all organic manures, biofertilizers, as well as the Integrated Farming System, which improved both cropping systems and livestock management. The primary goal of nutrient management is to provide optimum nutrition to the crops while minimizing the nutrient losses from the soil. INM is actually the technical and managerial component of achieving the objective under farm situations. It takes into account all aspects of crop and soil management, including the control of all other inputs including water,

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agrochemicals, and amendments. Thus INM is a crucial component in cropping system.

## Integrated Nutrient Management

The main aim of sustainable agriculture is successful management of resources, satisfy the changing human needs, maintain or enhance the quality of environment and conserve natural resources. INM is an integral part of sustainable agriculture which requires the management of resources in a way to fulfill the changing human needs without deteriorating the quality of environment and conserving vital natural resources as depicted in Figure 1.

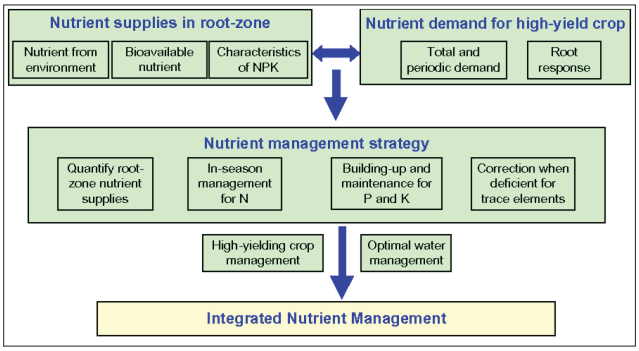


Figure 1: Conceptual model illustrating the principles of Integrated Nutrient Management (INM) [Adapted from Zhang *et al*. (2012)]

4. Assess the productivity and sustainability of INM practices. INM methods require locally appropriate technologies and farmers' participatory involvement in the testing and analysis.

## Research Studies on Effects of Organic, Inorganic, and Integrated Nutrient Management

The continuous cropping and integrated use of organic and inorganic fertilizers enhanced soil carbon sequestration and crop yields. Hence, balanced application of NPK fertilizers with FYM will be the best choice for high crop yields (Singh *et al.,* 2015).

Dotaniya *et al.* (2022) results shown that INM modules dramatically increased soil organic carbon and improved soil health in terms of physical and chemical qualities, in addition to higher crop performance and productivity when compared to using only inorganic fertilizer. Integrated use of 100% (RDF) along with organic sources of nutrients resulted in significantly higher siliqua/ branch, seeds/ siliquae and seed yield of mustard as compared to application of 100% RDF (NPK) alone (Singh *et al.,* 2018).

## Programs and Policies Executed by GOI for Sustainable Agriculture

This article briefly discusses the convergence of numerous policy programmes that the GOI has started to ensure the effective usage of available resources. In order to promote the wise management of already-existing resources, the National Mission of Sustainable Agriculture (NMSA) was established as part of the National Action Plan on Climate Change (NAPCC) in 2010. In order to fully use adaptation of climate-smart practices and technology, the Paramparagat

## Why is Integration Important for Sustainable Agriculture?

- Eliminate nutritional deficits.
- Higher productivity and crop intensity.
- The nutritional requirements of high producing types cannot be met by only using organic sources.
- It became important to use organic sources and mineral fertilizers.
- Alternative energy sources to farmers.
- Crops that get green manure can flourish during a 40-50 day lean phase.
- There is a need to combine organic and mineral sources to enhance plant nutrition.

## Advantages

- Boosts the availability of both applied and natural soil nutrients.
- Synchronizes the crop's nutritional requirements with the availability of nutrients from both natural and applied sources.
- Provide appropriate nourishment to crops and reduces the negative impacts brought on by nutritional imbalance and hidden deficiencies.
- Enhances and maintains the soil's natural physical, chemical, and biological processes.

## Research Gaps

- Incompatibility between farmers' methods and the INM techniques developed at research stations.
- Soil testing and the manure's nutrient release behaviour are not used to inform INM recommendations for various crops.
- It is necessary to determine the nutrient balance/ flow analysis in relation to soil fertility management strategies, with a focus on INM at the farm level.
- Farm residual nutrient release characteristics in connection to product quality to create decision support systems.
- Biofertilizers were frequently left out of INM as a component.
- Encouragement of Integrated Farming Systems (IFS) is necessary to sustain rural livelihoods, especially for small and marginal farmers.

## Some Essential Components of an Entire INM Strategy

1. Determine soil nutrient availability and nutrient deficiency in crop plants. While soil sampling and laboratory determinations are usually used for assessing soil nutrient availabilities, there are two general ways to detect nutrient deficiencies.

2. Systematically appraise the constraints and opportunities in the current soil fertility management practices, and how these relate to nutrient diagnosis, such as the insufficient or excessive use of N fertilizers.

3. Determine the farming practices and technologies that balance the nutrients which are necessary under different climates and soil types.

Krishi Vikas Yojana (PKVY) initiative was carried out in collaboration with the Indian Council of Agricultural Research (ICAR) and state governments of India. In order to safeguard the health of the soil for future agriculture, the Government of India (GOI) introduced the Soil Health Card (SHC) programme in 2015. Its primary goal is to analyze soil samples from farmers' fields and make appropriate fertilizer recommendations. In addition, Neem-Coated Urea (NCU) was made available to Indian farmers in order to slowly supply nitrogen (N) by decreasing nitrogen (N) losses and excessive urea fertilizer addition. Programs like the National Project on Organic Farming (NPOF) and National Agroforestry Policy (NAP) were introduced in 2004 and 2014, respectively, to provide farmers with greater profits and ecosystem services through the addition of plant nutrients in the form of organic amendments, an increase in the storage of soil carbon, and protection of the soil from erosion loss. Organic agricultural methods have already been widely implemented and pushed in states like Andhra Pradesh, Himachal Pradesh, Sikkim, *etc*.

## Way Forward

Improved technologies involved effective nutrient management strategies are the need of the hour to accomplish the targeted food grain production while balancing the stability of the agriculture system, farmers' income, and feed the over-exploiting population of the country. Future research should be taken up urgently to fill the existing knowledge gap.

It is crucial to educate farmers about fertilizer management, nutrient flows, and use efficiency.

1. To control soil productivity, it is essential to strengthen the database of nutrient recommendations specific to soil type, cropping system, and climatic regions.

2. To secure the nation's food security, efficient contemporary technologies are essential.

3. Technology evaluation ought to take into account the resources that are close at hand.

4. Determining the policy interventions required to promote soil management techniques that aid in generating the highest agricultural yields and the most effective use of nutrients.

5. To maintain production rates, creating site-specific, holistic land management strategies.

6. Putting in place a strategy for paying farmers for improving ecosystem services produced by switching to sustainable agriculture.

7. The integration of sustainability into the agricultural ecosystem must be purposeful and goal-driven.

## Conclusion

The key steps in INM are using all possible sources of nutrients to optimize nutrient inputs, spatial and temporal matching of the soil nutrient supply with crop demand and reducing N losses while improving crop yield. Efficient and effective modern technologies should be taken up to ensure food security. The methodology adapted for INM should also be site-specific and must be tailored to local circumstances, as there is no "one-size-fits-all" solution to the complex problems of smallholder farmers in diverse agricultural systems. Thus, INM practices be a viable nutrient management option in the Indian subcontinent. Improved technologies involved with effective nutrient management strategies are the need of the hour to accomplish the targeted food grain production while balancing the stability of the agriculture system, farmers' income, and feed the ~1.4 billion population of the country.

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