AgriScope
Monthly e-Magazine on Agriculture and Interdisciplinary Sciences
Visit at us: www.agriscope.in
Email at us: agri4scope@gmail.com
ISSN: 3139-6488

Integrated Nutrient Management : A Key to Sustainable Soil Health and Vegetable Production

Anchal[1] and Ayush Vashist[2]
[1]M.Sc. Student, Department of Vegetable Science, COHF, Neri, Dr. YSPUHF,Nauni, Solan, Himachal Pradesh, India
[2]M.Sc. Student, Department of Soil Science and Water Management , COHF, Neri, Dr. YSPUHF,
Nauni, Solan, Himachal Pradesh, India
Email: ayushvashisht12103@gmail.com

Article ID: 29008

1. Introduction

Vegetables are a key part of a healthy diet because they provide important vitamins, minerals, dietary fibre and antioxidants that keeps the body healthy. Vegetable cultivation not only provides nutritious food but also helps farmers earn more money, creates job opportunities and supports the growth of the horticulture industry. India is the second largest country in the world when it comes to growing vegetables. Every year, it produces over 221 million tonnes of vegetables from about 11.88 million hectares of land (Ministry of Agriculture and Farmers Welfare, 2025). This shows how important vegetable farming has become in providing enough food and good nutrition for the growing population.

Vegetable crops deplete soil nutrients rapidly due to their fast growth, limited root depth, and high biomass output. To boost yield, farmers frequently apply chemical fertilizers. While such fertilizers have greatly enhanced productivity, their prolonged and unbalanced use—especially without sufficient organic inputs—has led to nutrient imbalances, reduced soil organic matter, degraded soil structure, lower microbial activity and environmental contamination. These issues pose serious risks to sustained soil fertility and the long-term viability of vegetable farming (Chaudhari et al., 2023; Verma and Yadav., 2024).

Integrated Nutrient Management (INM) has emerged as an efficient and effective solution to the problems as it focuses on the judicious use of inorganic fertilizers along with organic manures. It includes the use of crop residues, green manures and biofertilizers to supply nutrients to the soil and crops in a balanced manner. The use of these nutrients increases the use efficiency of inorganic fertilizers and promotes sustainable agriculture by improving the physical, chemical and biological properties of the soil. Apart from this, INM practices have also improved the yield,

ISSN: 3139-6488

quality, nutrient content and profitability of vegetable crops while conserving the natural resources (Chaudhari et al.,2023; Verma and Yadav.,2024).

In the context of climate change, soil degradation and the need for sustainable and healthy food, INM has gained significant importance for the effective production of vegetables. This article focuses on the concept, components, benefits and future scope of integrated nutrient management (Himanshu et al., 2026; Muradi et al., 2026).

2. What is Integrated Nutrient Management?

Integrated Nutrient Management focuses on the judicious use of chemical fertilizers in combination with organic and bio-fertilizers to maintain soil health and ensure good crop production. The main objective of INM is not only to increase crop yield but also to maintain soil productivity for future generations. In contrast to conventional fertilizer practices that mainly depend on inorganic fertilizers, INM integrates organic manures, biofertilizers and chemical fertilizers to meet crop nutrient requirements while enhancing soil quality (Chaudhari et al., 2023; Verma and Yadav., 2024).

3. Components of Integrated Nutrient Management

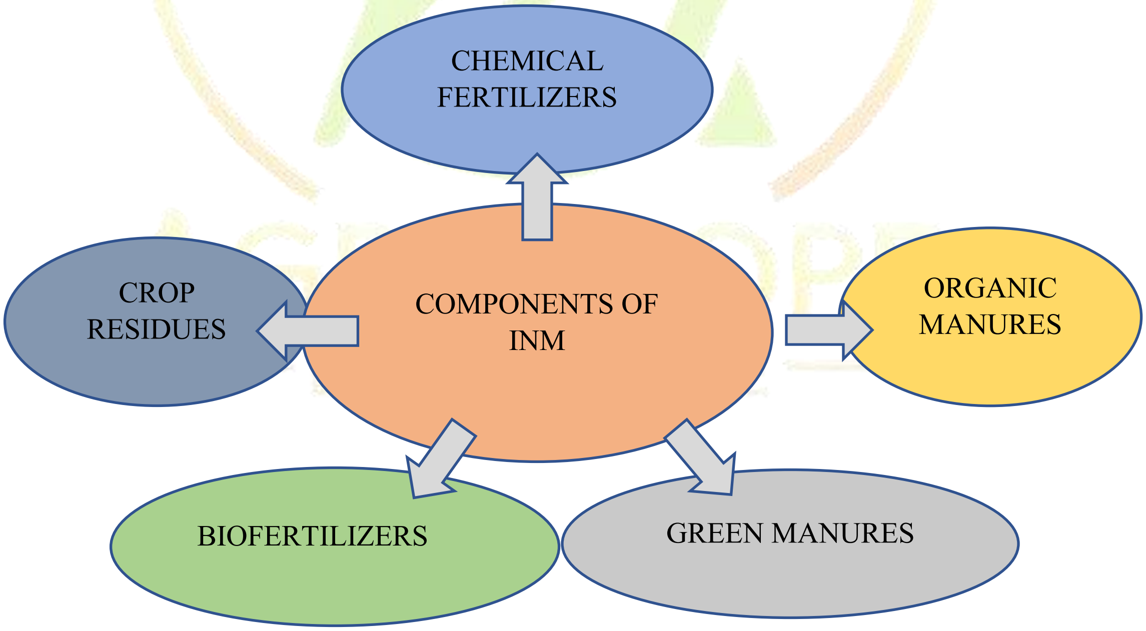

Fig. 1- Components of Integrated Nutrient Management.

3.1. Chemical fertilizers

Chemical fertilizers play a key role in integrated nutrient management (INM) by providing essential nutrients—nitrogen (N), phosphorus (P) and potassium (K)—in forms that plants can easily absorb. The application of chemical fertilizers in INM is done in judicious manner as per the soil test reports and this avoid nutrient loss and pollution. In addition, the use of chemical fertilizers as a component of INM is combined with organic manures and fertilizers for enhanced nutrient utilization (Chaudhari et al., 2023).

3.2. Organic manures

The organic manures like farmyard manure, compost, vermicompost, poultry manure, crop residues etc. helps in improving the organic carbon content in the soil. They also enhances the soil structure, increases water holding capacity and accelerates the activity of micro-organisms in the soil. In addition, organic manures provides a steady supply of nutrients that improve the fertility of soil (Chaudhari et al., 2023; Verma and Yadav., 2024).

3.3. Green manures

Green manures are cultivated specifically for incorporation into the soil at the flowering stage and serve to improve the fertility of the soil. They improve the soil structure, add organic matter to the soil, fix atmospheric nitrogen, improve the activity of other microorganisms and hence increase the availability of nutrients in the soil and reduce the dependency on chemical fertilizers (Chaudhari et al., 2023).

3.4. Biofertilizers

Biofertilizers are fertilizers that contain nitrogen fixing microorganisms which promote nutrients absorption, enhance growth of plants, improve soil structure and increase biological activity in the soil thus reducing the need for chemical fertilizers. Common biofertilizers used in vegetable production include:

- Azotobacter – fixes atmospheric nitrogen.
- Azospirillum – promotes root growth and nitrogen fixation.
- Phosphate Solubilizing Bacteria (PSB) – converts insoluble phosphorus into available forms.
- Potassium Solubilizing Bacteria (KSB) – enhances potassium availability.

- Arbuscular Mycorrhizal Fungi (AMF) – improve phosphorus uptake, water absorption and stress tolerance (Kumar et al., 2022).

3.5. Crop residues

The plant materials left in the field after harvest such as stems, leaves, roots etc are called as crop residues. The incorporation of these residues into the soil promotes nutrient cycling, enhances soil organic matter, stimulates microbial activity and ensure sustainable vegetable production further (Ali et al., 2024; Kamboj et al., 2024).

4. Role of Integrated Nutrient Management in Improving Soil Health

Integrated Nutrient Management plays a crucial role in improving soil health. It enhances physical, chemical and biological properties of soil which in turn increases nutrient availability, boosts soil fertility and supports sustainable vegetable production (Ali et al., 2024; Kamboj et al., 2024).

Physical Properties

- Improves soil structure and aggregation.
- Increases porosity and water-holding capacity.
- Enhances soil aeration and infiltration.
- Reduces soil compaction and erosion.
- Promotes healthy root growth (Ali et al., 2024; Kamboj et al., 2024).

Chemical Properties

- Increases soil organic carbon content.
- Improves availability of macro and micronutrients.
- Enhances cation exchange capacity (CEC).
- Maintains favourable soil pH.
- Improves nutrient use efficiency and reduces nutrient losses (Kamboj et al., 2024; Sande et al., 2024).

Biological Properties

- Increases beneficial soil microbial populations.
- Enhances microbial biomass and enzyme activity.
- Promotes biological nitrogen fixation and phosphorus solubilization.
- Accelerates decomposition of organic matter.

- Improves nutrient cycling and soil fertility (Kamboj et al., 2024; Verma and Yadav., 2024).

5. Role of Integrated Nutrient Management in Vegetable Production

5.1. Enhanced Growth and Yield

The integrated nutrient management approach ensures the supply of balanced plant nutrients by combining the use of inorganic fertilizer with organic and biological sources, resulting in improved vegetative and reproductive growth, improved root development and photosynthetic performance, thereby increasing vegetable yield. The combined application of organic and inorganic fertilizers sustains productivity during intensive vegetable production ((Kamboj et al., 2024; Verma and Yadav., 2024).

5.2. Improved Quality of Vegetable Produce

In addition to improving crop yield, INM also improves the nutritional and market value of the vegetables. The availability of nutrients in balanced amount improves the size, colour, firmness and shelf life of the produce while increasing the vitamin C content, total soluble solids (TSS), sugars and antioxidants. Hence, the vegetables are of better quality and fetch higher prices in the market than those obtained from plants grown solely with chemical fertilizers (Verma and Yadav., 2024).

5.3. Efficient Nutrient Utilization and Profitability

The combined use of chemical fertilizers with organic manures and biofertilizers increases the nutrient use efficiency because it synchronizes the nutrient supply with plant demand and reduces the loss of nutrients. It lowers the use of chemical fertilizers and thus reduces the cost of cultivation. This ultimately improves the benefit-cost ratio and increases the profitability of the vegetable crops (Kamboj et al., 2024; Chaudhari et al., 2023).

5.4. Sustainable Vegetable Production

The integrated use of organic and biological inputs ensures conservation of natural resources, minimizes environmental degradation and supports long term productivity of vegetable based cropping systems. Thus, INM plays crucial role in sustainable and profitable vegetable production (Ali et al.,2024; Sande et al.,2024).

Crop	*Integrated Nutrient Management Practice (INM)*	*Major effects observed*
Tomato (Solanum lycopersicum L.)	***50% Recommended dose of fertilizer (RDF) +AgroResidue Vermicompost (5 t ha^{-1})***	***Improved plant growth, chlorophyll content, flowering, fruit number and fruit yield.***
Chilli (Capsicum annuum L.)	***75%fertilizers+Poultry manure(5 t ha^{-1}) + Biofertilizers + $MgSO_4$(2%)***	***Increased plant height leaf area, branching, fruit yield, and nutrient uptake.***
Brinjal (Solanum melongena L.)	***100% NPK + 25% N through vermicompost***	***Enhanced fruit size, fruit number and marketable yield.***
Cucumber (Cucumis sativus L.)	***RDF + Vermicompost (5 t ha^{-1}) + Azotobacter (5 kg ha^{-1}) + PSB (5 kg ha^{-1})***	***Increased fruit yield and improved nutrient use efficiency.***
Cauliflower (Brassica oleracea var. botrytis)	***100%RDF + Azospirillum (5 L ha^{-1}) + PSB (5 L ha^{-1}) + KMB (5 L ha^{-1})***	***Improved curd development, quality and marketable yield.***
Cabbage (Brassica oleracea var. capitata)	***FYM (50%) + Azotobacter (50%)***	***Enhanced head development, leaf growth and earliness.***
Onion (Allium cepa L.)	***FYM(20tha^{1})+Vermicompost (5t ha^{-1}) + Poultry manure (2 t ha^{-1}) +100% Recommended NPK***	***Increased bulb size, bulb yield, neck thickness and plant vigour.***

Table 1. Effect of Integrated Nutrient Management on Major Vegetable Crops (Ali et al., 2024)

6. Challenges in Adoption of INM

Though INM has been proved to be beneficial but still its adoption is limited due to following reasons:

- Limited awareness and technical knowledge about INM among farmers.
- Scarcity of bio fertilizers.
- High cost for transportation of bulky organic matter.
- Limited availability of laboratories for soil analysis.
- Slow release of nutrients from organic sources.

- Insufficient extension services and supportive policies for promoting large scale adoption of INM (Ali et al., 2024; Kamboj et al., 2024; Verma and Yadav., 2024).

7. Future Prospects

The future of sustainable vegetable production is closely linked to the widespread adoption of integrated approaches such as integrated nutrient management (INM) combined with precision farm management, digital soil health technologies, nano-fertilizers, fertigation and artificial intelligence (AI)-driven nutrient management advisory systems. The future of nutrient management in vegetables will rely on the extensive use of INM coupled with climate-smart technologies to improve nutrient use efficiency, to increase vegetable yield, quality and to reduce environmental degradation (Ali et al., 2024; Kamboj et al., 2024).

Additionally, government-led programs such as the Soil Health Card Scheme, organic farming, balanced fertilization, and farmer training initiatives will promote the adoption of INM at a larger scale. Continued research and the development of site-specific nutrient management approaches will further strengthen the role of INM for profitable, sustainable and climate-resilient vegetable production (Verma and Yadav., 2024).

8. Conclusion

Integrated Nutrient Management (INM) is a nutrient management practice that focuses on improving crop production through the effective use of inorganic fertilizers combined with organic manures, biofertilizers, green manures and crop residues**.** INM is a sustainable and efficient nutrient management approach that can be used to provide balanced nutrition to crops. In the context of vegetable production, INM has tremendous potential for improving plant growth, yield, enhancing produce quality and promoting resource use efficiency while reducing environmental pollution. Its adoption also helps in promoting environment-friendly agricultural practices that conserve natural resources and prevent nutrient losses.

Considering the current environmental issues such as degradation, pollution and global warming, INM is necessary for sustainable vegetable production. Advancing knowledge on INM together with intensification of soil testing services and utilizing new innovations in combination with INM approaches will enhance its impact on vegetable production. Therefore, integrated nutrient management is a key to achieve high-value, environment friendly vegetable production (Kamboj et al., 2024); Verma and Yadav., 2024).

AgriScope
Monthly e-Magazine on Agriculture and Interdisciplinary Sciences
Visit at us: www.agriscope.in
Email at us: agri4scope@gmail.com
ISSN: 3139-6488

References

1. Ali, A., Niu, G., Masabni, J., Ferrante, A., & Cocetta, G. (2024). Integrated nutrient management of fruits, vegetables, and crops through the use of biostimulants, soilless cultivation, and traditional and modern approaches—A mini review. *Agriculture*, 14(8), 1330.
2. Chaudhari,V. M., Barot, D. C., Solanki, K. S., & Patel, N. K. (2023). Integrated nutrient management in vegetable crops: A review. *The Pharma Innovation Journal*, 12(8), 2289–2295.
3. Sharma, H., Kumar, S., Chauhan, M., Kumar, R., & Yasmin. (2024). Soil fertility, growth and yield of broccoli (*Brassica oleracea* L. var. *italica*) as influenced by integrated nutrient management practices. *International Journal of Advanced Biochemistry Research*, 8(5S), 421–427.
4. Kamboj, D., Choudhary, R., Diwakar, A. K., & Maurya, S. (2024). Integrated nutrient management for improving the soil sustainability and crop productivity: A review. *Journal of Advances in Biology & Biotechnology*, 27(11), 1053–1062.
5. Ministry of Agriculture and Farmers Welfare. (2025). *Horticulture statistics at a glance* 2025. Government of India.
6. Muradi, K. B., Chaithra, B. S., Suresh, K., Bhrundha, K., Athira, G., Laxmi, P. S., Keerthana, M. V., Nandu, P. K., Totawar, H. M., & Choudhari, B. K. (2026). Sustainable integrated nutrient management in horticultural and vegetable crops: Mechanisms, innovations and global food security: A review. *International Journal of Research in Agronomy*, 9(3), 527–542.
7. Sande, T. J., Tindwa, H. J., Alovisi, A. M. T., Shitindi, M. J., & Semoka, J. M. (2024). Enhancing sustainable crop production through integrated nutrient management: A focus on vermicompost, bio-enriched rock phosphate, and inorganic fertilisers—A systematic review. *Frontiers in Agronomy*, 6, 1422876.
8. Verma, A. K., & Yadav, M. K. (2024). An overview of the effect of integrated nutrient management on vegetable crops. *AGBIR*, 40(4), 1222–1225.