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Integrated Nutrient Management in Wheat Cultivation

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INTRODUCTION

Wheat (*Triticum aestivum* L.) is among the key staple food crops in the world, and a leading cereal crop in India. Since demand for wheat increases with population growth, it is essential to ensure increasing productivity in a sustainable manner. Yet, intensive production of wheat has resulted in degrading soil fertility and nutrient imbalance. To deal with this, Integrated Nutrient Management (INM) provides an integrated strategy to ensure soil health and maximum crop yield by combining the use of chemical fertilizers with organic manures and biofertilizers. INM protects the wise management of all sources of nutrients, enhancing nutrient use efficiency, reducing environmental degradation, and sustaining soil productivity for long term. It is one of the important pillars of sustainable agriculture as well as a requirement to achieve food security without threatening ecological balance.

Source: https://www.sciencedirect.com

2. Definition of Integrated Nutrient Management (INM)

Integrated Nutrient Management is defined as the judicious and balanced application of chemical fertilizers, organic manures, green manures, crop residues, and biofertilizers to nourish plants adequately with a concurrent increase in soil fertility and microbial activity. The primary aims of INM are:

- To sustain agricultural productivity.
- To sustain or increase soil fertility and biological integrity.
- To minimize reliance on chemical fertilizers.
- To minimize loss of nutrients and environmental degradation.

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This method becomes particularly critical in wheat, a nutrient-hungry crop that removes large amounts of nitrogen (N), phosphorus (P), and potassium (K) from the soil.

3. Wheat Crop Nutrient Needs

Wheat is a heavy feeder, and its nutrient need is variety-, soil-, climate-, and management practice-dependent. On average, to yield one tonne of wheat grain, the crop needs around:

- Nitrogen (N): 20–25 kg
- Phosphorus (P_2O_5): 8–12 kg
- Potassium (K_2O): 20–25 kg
- Sulphur, Zinc, and other Micronutrients: Needed in small but crucial quantities

Any of these nutrient deficiencies may check growth, lower grain quality, and decrease yield potential. Integrated and balanced nutrient supply is needed to fulfill these requirements.

4. Elements of INM in Wheat Cultivation

Source: https://core.ac.uk

4.1 Chemical Fertilizers

- Nitrogen is usually applied in split applications—half at planting and the remaining half at tillering and booting phases.
- Phosphorus and Potassium are applied as basal doses depending on the soil test values.
- Micronutrients such as zinc sulphate are applied in micronutrient-deficient soils, especially in sandy and alkaline soils.

4.2 Organic Manures

- Use of farmyard manure (FYM), compost, or vermicompost enhances soil structure, increases microbial activity, and provides macro- and micronutrients.
- FYM at 8–10 tonnes/ha helps maintain long-term soil health and water retention.

4.3 Biofertilizers

Biofertilizers are living microbes that increase nutrient availability through nitrogen fixation, solubilization of insoluble phosphorus, and promotion of plant growth by increased nutrient acquisition. They form a key part of Integrated Nutrient Management (INM) in wheat cultivation and provide an environmentally friendly option to chemical fertilizers.

Azotobacter and Azospirillum are free-living nitrogen-fixing bacteria which infect the rhizosphere and fix atmospheric nitrogen in a form accessible to plants. Their use by seed treatment or soil inoculation increases the availability of nitrogen, favors root growth, and increases early plant vigor.

Phosphate-Solubilizing Bacteria (PSB) are important for the release of phosphorus occluded in the soil through the excretion of organic acids, which makes it available to wheat plants. It enhances phosphorus use efficiency and promotes enhanced root and tiller growth.

Mycorrhizal fungi, particularly vesicular-arbuscular mycorrhizae (VAM), have a symbiotic relationship with wheat roots, increasing the rhizosphere zone. It increases phosphorus, zinc, and other micronutrient uptake, especially in phosphorus-depleted or alkaline soils.

4.4 Green Manuring and Crop Residues

Green manuring and crop residue management are essential practices under Integrated Nutrient Management (INM) that improve soil fertility and sustainability in wheat systems.

Green manuring consists of growing and plowing under certain quick-growing leguminous crops such as dhaincha (Sesbania aculeata) or sunhemp (Crotalaria juncea) ahead of wheat sowing. They are incorporated in the soil at the flowering stage, contributing beneficial organic matter, nitrogen, and micronutrients. Breakdown of green manure enhances soil structure, improves microbial life, and enhances the availability of nutrients, especially nitrogen, which is essential for wheat development.

In-situ placement of crop residues, particularly paddy straw, is a good method of recycling nutrients in rice-wheat cropping systems. Rather than burning, which causes air pollution and nutrient loss, placing paddy straw in the soil adds carbon and valuable nutrients such as potassium and sulfur to it. It also increases organic carbon content in the soil, enhances water retention capacity, and aids beneficial microbial communities.

5. Benefits of INM in Wheat Production

Integrated Nutrient Management (INM) is a sustainable method of nutrient provision in wheat farming that incorporates chemical fertilizers along with organic and biological sources. It helps to provide improved nutrient balance, soil health, and environmental safety, resulting in enhanced productivity and profitability.

Increased nutrient use efficiency is a key advantage of INM. By coordinating nutrient release with crop requirement, it reduces the loss of nutrients via leaching, volatilization, and fixation. It applies the nutrients in phased and targeted form to supply plants with necessary nutrients at times of their greatest needs, boosting overall fertilizer efficiency.

INM contributes notably to increased soil fertility. Organic manures and biofertilizers increase soil microbial activity, improve organic carbon content, and enhance cation-exchange capacity. All these changes help develop a better structure for improved aeration and water retention for enhanced root activity and continued crop growth.

Economically, INM is resource-saving and environmentally friendly, particularly for smallholder farmers. The application of locally available organic materials like farmyard manure, compost, and crop residues lowers the dependence on costly chemical fertilizers and saves on production expenses in the long run.

Environmentally, INM facilitates ecological security. Nutrient application in balance prevents groundwater pollution, lowers greenhouse gas emissions, and ensures minimal risk of soil degradation and nutrient toxicity.

Last but not least, INM ensures improved yield and quality of the crop. Wheat produced under integrated nutrient management tends to have better grain yield and higher quality factors like protein and micronutrient levels. This not only means more economic gain but also nutritional security.

6. Suggested INM Practices for Wheat

Sample of a suggested INM plan for wheat under irrigation:

Input	Quantity (per ha)	Timing
Farmyard Manure (FYM)	10 tonnes	15–20 days before sowing
Nitrogen (N)	120 kg	50% basal, 25% tillering, 25% boot stage
Phosphorus (P_2O_5)	60 kg	Basal
Potassium (K_2O)	40 kg	Basal
Azotobacter	500 g	Seed treatment
PSB	500 g	Seed treatment
Zinc Sulphate	25 kg	Basal (if deficient)

These suggestions should be modified based on soil analysis, climatic conditions, and local availability of resources.

7. Adoption Problems of INM

Despite the widely documented advantages of Integrated Nutrient Management (INM), adoption of INM in wheat farming is restricted due to a variety of practical as well as systemic issues.

- One of the key hindrances is the absence of awareness and technical information concerning the use of INM practices by farmers, such as the application of biofertilizers, composting, and crop residue management. Farmers have mostly stuck to chemical fertilizers because of familiarity and the instant effect it has.
- The poor availability of organic quality inputs and biofertilizers in village markets inhibits regular application. Moreover, infrastructure for production and large-scale distribution of these products is frequently lacking.
- Broken and fragmented land holdings render application and management of integrated nutrient systems unfeasible at low cost, particularly in the absence of mechanization and uniform practices.
- A technical constraint is the slow release of nutrients from organic sources in

comparison to rapid-acting chemical fertilizers, which detaches farmers pursuing short-run yield increases.

- Additionally, poor policy support, subsidies, and extension services limit farmers' ability to shift towards INM. Certification mechanisms for organic components and finite market incentives also discourage adoption.
- To address these limitations, a mix of farmer training, incentives from the government, demonstration plots, and public-private partnerships in input supply as well as knowledge transfer is necessary for increasing INM in wheat production.

8. CONCLUSION

Integrated Nutrient Management is a sustainable and efficient method for increasing wheat productivity without compromising long-term soil fertility and environmental sustainability. Through the integration of the advantages of chemical fertilizers, organic manures, and biofertilizers, INM reduces the cost of input, increases yields, and minimizes environmental risk. INM practices in wheat production should be promoted through farmer training, input availability, and facilitation by agricultural policies. INM promotion will not only provide greater wheat output but also sustain national food security and agricultural development.

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