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INTEGRATED NUTRIENT MANAGEMENT (INM) FOR AGRICULTURE SUSTAINABILITY

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Abstract

Attainment of food security and zero-hunger goal are the major targets in front of global agricultural planners and these can be achieved only by improvement in the agronomic practices. Integrating the use of organic and inorganic fertilizers as well as green manure and bio-fertilizers is the best strategy to boost crop productivity. Combine the usage of organic manures with the right amounts of NPK fertilizer can help in stabilizing the crop nutrients and maintaining the soil health. This will also reduce the reliance on inorganic chemical fertilizers and build an economical and sustainable crop productivity. Integrated Nutrient Management (INM) is one of the sound agricultural practices that should be adopted by farmer to preserve soil health and to increase the sustainability of agriculture and the environment.

Keywords: Integrated Nutrients Management (INM), Organic manures, Chemical fertilizers, Crop production, Sustainability.

Introduction

The world without hunger and zero poverty are biggest challenges faced by agricultural planners and farming decision makers in the recent years (Wheller et al., 2013; Garg et al., 2019). According to ((UNCCD), 20 May 2022), 8.1 billion people will inhabit the planet by 2025, up from 7.2 billion now. There will be a greater need for food, fodder, shelter, energy, employment, etc. as a result of the population growth that is predicted to continue increase at an alarming rate. Here the main question arise can agriculture satisfy all of the world's food needs? As we know, due to overpopulation and unsustainable practices, agricultural land and fresh water availability are reducing day by day. Therefore, the majority of agriculture strategies for increasing the production will rely on the creation of new high-yield crop varieties and the application of chemical fertilisers. However, more application of chemical fertilizers is not only quite expensive but also degrade the soil quality (Singh, 2020). Also, to maintain the higher production, more fertilisers are required in

the successive seasons. As a result, fertilisers prices rise year over year. Which will leads to the rise in food prices and increase the pressure on the financial investments.

Since the ancient time, farmers know that application of organic manure can restore the soil productivity. Therefore, farmers have been applying farmyard manure frequently and soon after crop harvest since the dawn of agriculture which improves the soil health and helps in maintaining the physical, chemical and biological properties of soil (Siavoshi and Laware, 2011; Rahmann et al., 2016; Selim et al., 2017; Selim et al., 2018).

The idea of combining various plant nutrition sources to prevent nutrient depletion, preserve soil health, and which increase crop production is known as INM. The term INM refers to the management of all sources of organic, inorganic, and biological components in an integrated way to maintain the soil fertility and plant nutrient supply at an optimal level for maintaining the productivity (Sharma et al., 2004). The term "Integrated Nutrient Management" (INM) can also be defined as maximising the advantages from all potential sources of plant nutrients in an integrated way in order to maintain the soil fertility and plant nutrient supply to an optimal level for maintaining the target crop yield.

Therefore, it encourage the efficient use of all nutrient sources such as organic waste, green manures, chemical fertilisers, and bio-fertilizers (Panta, and Parajulee, 2021). According to FAO (1995) INM integrates the use of both natural and synthetic soil nutrients to maximise crop productivity and safeguard soil fertility for future generations. Conjunction of fertilizers with certain microbes leads to the increase in nutrient availability and maintains high yields without causing degradation of soil quality and environmental pollution. INM can serve as a motivating force and a source of support to make marginal lands productive ones, which can result in increase in agricultural land (Neilsen et al., 2020).

The main objective of INM is to find the most efficient and homogenous combination that might result in appropriate management, effective use of fertilisers, adequate and balanced use of their quantity and quality, and direct uptake of nutrients by plants for increased production without endangering soil (Panta, and Parajulee, 2021).

The main goal of integrated nutrient delivery and control is to create a crop with a neutral nutrient supply that retains and also improves the health of the soil fertility in long term. All crops have significantly different requirements of nutrients and that also depends on the on the weather and climatic condition (James, 2007). Fertilizers and manures are the crucial contributors in the rise of yield of food grains in India. The hybrid varieties leads to dramatic increases in production through the metamorphosis of chemical energy of fertilizers and manures (Urmila and Garg, 2011).

For land-short countries like India, the sustainable use of fertilizers is the best approach for land conservation, because excessive use of chemical fertilizers leads to the reduction in soil fertility and deficiency of certain elements (Shukla, 2019). The deficiency of S and or Zn or Fe or Mn or B started incipient and restraining crop production after different periods (Shukla, 2019). In soils of low pH, Alfisols of Palampur and Ranchi, the use of N fertilizer alone decreased the pH of the soil beyond and unfavourably affected the crop productions due to deficiency of Ca and toxicity of Al (Devkota, 2022). At several sites it was observed that application of excessive N aggravated the deficiency of K that reduced crop production (Bar-Tal, 2011; Shukla, 2019; Elhanafi et al., 2019; Li et al., 2022). The deficiency of K became a limiting factor within a few years when N and P were

used alone. However, the production of crops substantially improved where the application of 10-15 tonnes of farmyard manure/ha along with proposed rates of NPK was utilized (Devkota, 2022). This accentuates the necessity of an integrated nutrient supply and use of congenial combination of fertilizers, manures and bio-fertilizers to capitalize on nutrient use proficiency and decrease their losses and seepage to accomplish the goals of upgrading and sustaining productivity (Panta, and Parajulee, 2021).

Concept of INM

INM refers to combining the traditional and contemporary methods of managing nutrients into an ecologically sound and sparingly optimal farming system. Intending to synchronise nutrient demand and improves all facets of nutrient cycling. INM methods result in high nutrient-use efficiency while reducing losses from leaching, runoff, volatilisation, emissions, and immobilisation. Additionally, it tries to improve farm productivity by strengthening the soil's physical, chemical, biological, and hydrological properties (Sharma et al., 2007; Sethi et al., 2001). There is now a greater understanding of how INM can protect soil resources while simultaneously and virtually imperceptibly increasing crop productivity. A thorough INM approach includes several crucial elements such as:

- Find out whether crops are lacking in nutrients or nutrient-rich. There are two broad techniques to identify nutrient shortages: soil sampling and laboratory analysis and visual analysis. Laboratory analysis is more reliable and accurate that's why it is frequently employed to assess soil nutrient availability (Nathan, 2016).
- The difference between fertiliser input and output can be used to compute the soil nutrient budgets for a specific period. It will be possible to propose appropriate INM technology once these factors have been identified (Carter, 2017).
- Evaluate INM techniques' productivity and sustainability.
- Expanding farmers' awareness of the advantages of INM methods.
- Encouraging them to consider their excessive reliance on inorganic fertilizer, and encouraging them to concentrate on long-term agricultural planning.

Goal of INM

The goal of INM is to conceptualize the usage of natural and synthetic fertilisers in optimized ratio, so that crop productivity improves in an ecologically manner, without affecting the soil productivity of future generations (Potter et al., 1991; Sood et al., 2011). Sustainable agriculture provides the concept that utilizes the output and profits, particularly for maintaining the health of the soil. INM have faith in numerous factors, comprising applicable nutrient submission and protection and the relocation of information about INM procedures to farmers and researchers (Selim et al., 2018; 2016; Zhang et al,. 2012).

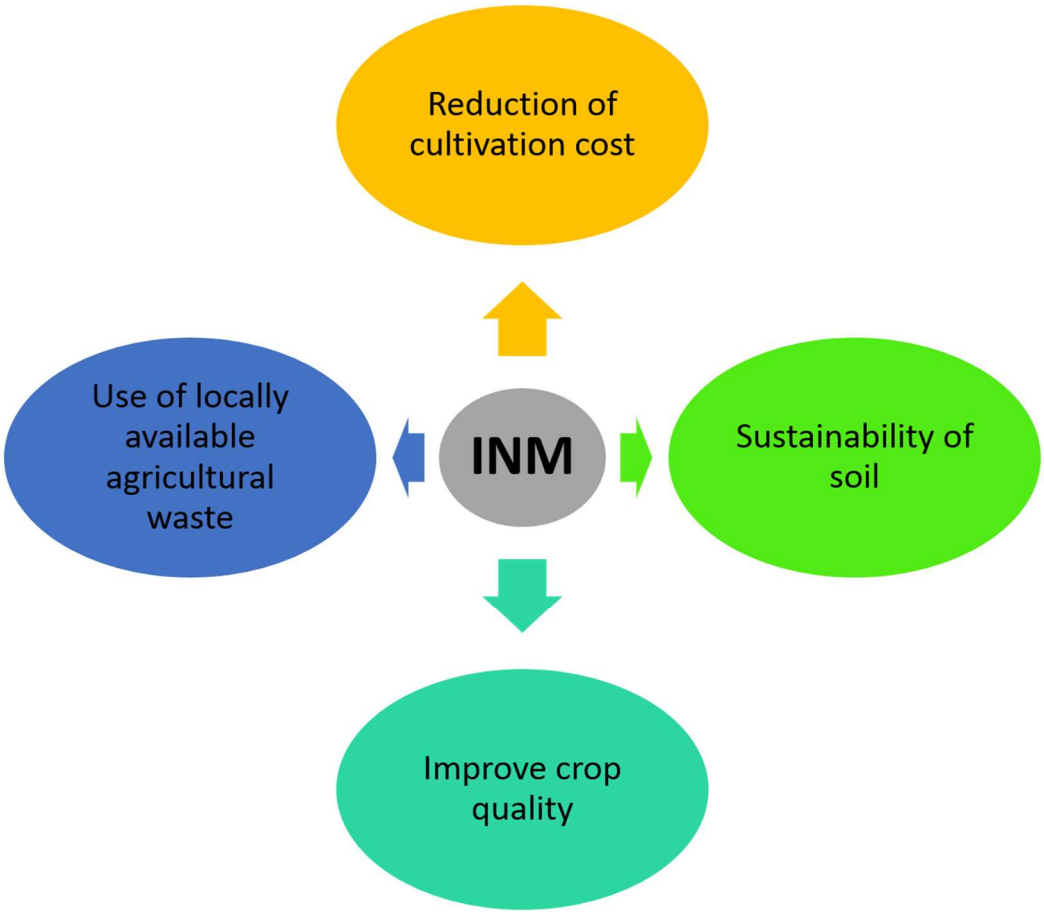

Figure 1. Objectives of Integrated Nutrient Management.

INM's fundamental ideas include:

1. Controlling the supply of nutrients from soil to crop at the appropriate level to promote the desired crop productivity.
2. Proper placement of N-fixing crops, organic manures, crop wastes, and chemical fertilisers according to the land use system and the ecological, social, and economic conditions.

Principles of INM

INM is primarily based on the management of the rhizosphere and root zone in a way that maximises the biological potential for raising crop productivity and effectively using resources. In cropping systems, interactions between individual plant roots and the rhizosphere could lead to the development of a rhizosphere continuum in the root zone (Singh, 2011). The rhizosphere, a vital interface where plants, soil, and microbes intracts. It is a "bottleneck" that controls nutrient conversions, availability, and movement from soils to plants.

Therefore, the rhizosphere's chemical and biological activities regulate the mobilisation and acquisition of soil nutrients together with microbial dynamics and profoundly affecting the productivity and sustainability of cropping systems (Zhang et al. 2012).

The roots can react to and/or sense changes in soil nutrient availability, including nutrient delivery intensity and composition, as plant growth progresses (Sethi, 2011). Several adaptive changes in root

morphology and root physiology are a result of these reactions. Through the production of mycorrhizal hyphae, mycorrhizal connections can also increase the spatial availability of P and increase the area that can absorb nutrients. The most popular method for controlling root growth in the environmental condition is nitrogen fertiliser (Datta, 2011). There are two ways that roots respond to N supply. First, in systems with uniform N supplies. Second, lack of N lengthens roots, producing longer axial roots (primary, seminal, and nodal roots). This aids the roots' exploration of a wider area (Selim et al., 2018).

The main tenets of INM are listed below and include the following:

A. The overall goal of INM is to maximise the utilisation of soil nutrients to improve crop production and resource-use efficiency by utilising all potential sources of nutrients to optimise their input.
B. To improve the soil's physical makeup and water-holding ability, which are crucial to hold and exchange nutrients. Chemically speaking, organic fertilisers boost the soil's ability to buffer pH variations, increase cation exchange capacity, decrease phosphate fixation, and act as a reservoir for all nutrient types (Sharma et al., 2007).
C. The local farming system must be compatible with INM methods, such as soil texture, field biological conditions (weeds, insects, and diseases), and climate-accessible irrigation services, tools, and climatic circumstances (Potter et al.,1991).
D. In long-term, it optimizes the physiochemical (biological and hydrological qualities) of the soil.

Components of INM

INM does not requires higher outside resources but the locally available organic manures, green manures, compost, including vermicompost, agricultural residues, bio-fertilizers and small amount of chemical fertilizers are needed (Sood et al., 2011). In contrast of continously decreasing the fertility of the soil by using high amount of chemical fertilisers, INM can help to prevent the degradation of the soil by optimizarion of fertilisers quantity in a systematically. But this does not mean adding anything in any amount, rather a well-studied and effective balance of several nutrient sources that can provide the desired yields and sustain soil health for future generation (Kumar et al., 2007).

The mail elements of INM are:

1. **Organic manures**
2. **Biofertilizers**
3. **Inorganic fertilizers.**

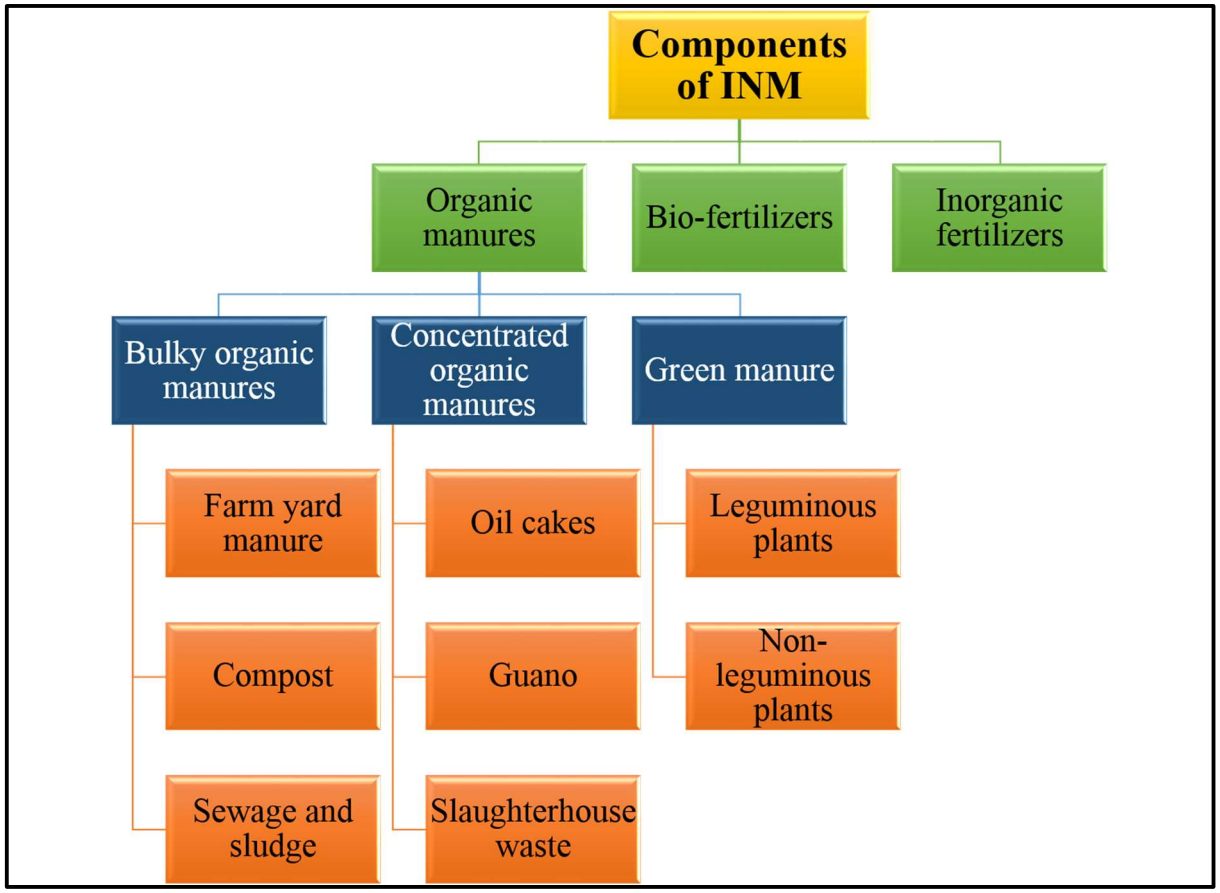

Figure 2. Structural presentation of components of INM.

1. **Organic manures:**

Natural products which contains plant nutrients in organic form and derived from sources such as human excreta, animal waste and plant residues are known organic manures.

A. Bulky organic manures

The organic manures having less percentage of nutrients and used in large volume such as farmyard manure, green manure, compost etc.

Table 1. Concentration of NPK in bulky and Concentrated Manures (Borah, 2019).

	Bulky manures				**Concentrated Manures**			
	Cattle dung	Vermicompost	Poultry manure	Farmyard manure	Meat meal	Coconut cake	Cotton seed cake (decorticated)	Groundnut cake
Nitrgen (%)	0.4	3	3.03	0.5	10.5	3	6.4	7.3
Phosphorus (%)	0.2	1	0.63	0.25	2.5	1.9	2.9	1.5

Potassium (%)	0.17	1.5	1.4	0.5	1	1.8	2.2	1.3

B. Concentrated organic manures

Concentrated organic manure consist of Neem cake, Cotton seed cake, Karanj cake, Mahua cake, Safflower cake. Coconut cake, Hoof and horn meal and Blood meal. Some of the benifits of using concentrated organic manure are (Sharma et al., 2007; Sethi et al., 2001):

- Presence of the limonoid content in neem cake organic manure, prevents the Nematods.
- Hoofs and Horn meals and blood meals used widely for the protection of leaf burn damage.
- Bones consist of Calcium Phosphate, so good source of Lime, Phosphoric acid and Nitrogen.

C. Green manures

The particular crops which are grown with the intention of being ploughed in the soil while the crop is still green are known as green manures. Most of the green manure crops are leguminous in nature.

2. Biofertilizers

These products contains living or latent cells of microbes which can mobilize nutrients and help plants in their uptake e.g. *Azotobacter, Azospirillum, Pseudomonas striata, Bacillus polymixa, Aspergillus awamori and penicillium digitatum* (Diacono et al., 2019; Mącik et al, 2020).

3. Inorganic fertilizers

The fertilizers that are made synthetic inorganic minerals and chemical and contains essential plant nutrients in particular amounts are known as inorganic fertilizers e.g. sodium nitrate, urea, ammonium sulphate etc. (Hera, 1995; Mahmoud et al., 2009).

Advantages of INM system

The INM strategy is important for increasing the productivity and sustainability of soil. In addition to minimising dependency on fossil fuels, which are required to produce chemical fertilisers, it also aims to provide balanced plant nutrition. The merits of INM are listed below.

- To ensure the sustainability of the soil
- To prevent soil degradation
- To boost the effectiveness of fertiliser use
- To utilize resource cycle and nutrient transportation within the farm effectively
- Increases the soil microorganism activities
- Increases the productivity and maintaining the quality of the soil
- Physically and ecologically matching soil nutrient supplies with crop demand in order to protect native soil health.

Conclusion and recommendation

Global agriculture planners are facing the challenge to fulfil the food requirement of future generation while the population is increasing drastically. So, getting higher yield per unit area and the more agriculture land are the primary alternatives for facing this challenge. The primary problem

in getting higher yield per unit area is the excessive use of chemical fertilizers that lead to the deterioration of soil health. In order to provide plant with enough nutrients, an effective method that is cost effective is Integrated Nutrients Management. It is a strategy that can provide valuable and cost effective option for providing plant with adequate levels of macronutrients and micronutrients. With the help of INM, farmers can also reduce the doses of chemical fertiliser, and improving the environment and soil health, protect the long term nutrients balance of the soil. INM can also help in the management of agricultural waste.

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