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Integrated Nutrient Management for Sustainable Food Production System

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Introduction

The increasing growth rate of a human population will necessitate significant increase in agricultural production in the worldwide, particularly in the developing countries like India. By the 2050, the major food grains gap has accelerated between food grain supply and demand, which is a serious concern to meet the rising demand for more food of higher quality. Therefore, the environmentally friendly method for sustainable agricultural production requires attention when emerging the issue of enhancing crop productivity. On the other hand, intensive cropping with use of indiscriminate synthetic fertilizers has resulted in the deterioration of soil health, environmental pollution and stagnation of productivity. In this scenario, the integrated nutrient management (INM) may be helpful in resolving these issues and also to enhance the soil fertility, which eventually increases the crop productivity. INM is a scientific approach that uses various sources of nutrients such as synthetic fertilizers, organic manures and biofertilizers containing living microorganism to maintain soil fertility and plant nutrient supply at an optimum level in order to sustain desired productivity. Selim (2020) reported that INM acts as a source of energy, organic carbon, and available nitrogen for the growth of soil microbes and improvement of physical properties of soil, and also have great residual effect on subsequent crops. An extensive literature survey revealed that INM enhances crop yields by 8–150% compared with conventional practices by increasing the input use efficiency, while improving

grain quality and soil health and sustainability (Wu and Ma, 2015). INM has been shown to considerably improves crop yields by minimizing nutrient losses to the environment and managing the nutrient supply, and thereby results in high resource-use efficiency, cost reductions, and improved resistance to biotic and abiotic stresses (Parkinson, 2013). Hence, INM can be considered an effective agricultural paradigm to ensure food security and improve environmental quality worldwide, especially in countries with rapidly developing economies like India.

The concept of INM

INM is an agronomic practice that aims to combine the beneficial properties from all possible sources of organic, inorganic and biological components/substances in a judicious, efficient and integrated manner to reduce the use of synthetic fertilizers and achieve nutrient application amount and timing to be in accordance with the crop nutrient requirements which led to maintain the soil fertility, restore soil health and provide continuous nutrient supply to plants in order to achieve an optimal level of yield. INM also synchronizes the nutrient demand by the crop and its release in the environment, hence, the losses through leaching, runoff, volatilization, emissions and immobilization are minimized, while high nutrient-use efficiency is achieved. Moreover, it also aims to optimize the soil conditions by improving its physical, chemical, biological and hydrological properties to enhance farm productivity and minimize land degradation.

Components of INM

The components of INM includes inorganic fertilizers, organic manures, crop residues/wastes, legumes and bio-fertilizers which have been shown in Fig. 1 and other management practices like suitable crop variety, use of optimum cultural management, soil and water use for efficient and suitable crop production.

Fig. 1 Components of integrated nutrient management

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Basic Principles of INM

- INM techniques must be reliable on the local agricultural system, such as field biological conditions (weeds, insects, and pathogen), soil properties, irrigation availability, climatic condition and nutrient resources.
- Fertilizer input application by using both organic and inorganic sources increase fertilizer use efficiency and reduces nutrient requirements, food contamination and environmental pollution.
- Matching the soil nutrient supply with crop demand spatially and temporally is essential to achieve maximum yields and improve the nutrient-use efficiency
- INM technique reduces the nutrient loss through leaching, evaporation and fixation while increases the crop profitability.
- In the long run, it enhances the soil physiochemical, biological and hydrological properties.
- Applying INM techniques must be to the root zone for the most crucial interactions between plants and soil take place, acts as a "bottleneck" that regulates nutrient conversions, solubility, availability, release and absorption from the soil to plant roots.

Major constraints in the adoption of INM:

Maintaining soil health and restoring soil productivity is critical to solving the problem of low soil productivity. Soil erosion, nutrient mining, structural deterioration, and loss of fertility are the main causes for declining the soil productivity and significant damage to sustainable agriculture. Serious efforts have been undertaken to promote more productive use of integrated nutrient management, which is a necessary component of the organic farming system. Significant attention must be paid to determining soil nutrient balance, including nutrients taken by the current crop, as well as the requirements of the following crop. Because rapid depletion of soil fertility and decline in soil organic matter is expected, continuous assessment of present soil fertility is required to evaluate nutrient loss through crop absorption, erosion, and leaching (Yu et al. 2014). In addition, there are Common constraints encountered by the farmers in adoption of INM technology (Kurbah, 2016):

- Non availability of improved seeds, water, FYM, biofertilizers and soil testing facilities
- Difficulties in growing green manure crops
- High costs of chemical fertilizers
- Lack of knowledge, awareness programmes and poor advisory services
- Soil conditions

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Advantages of INM:

Economic and environmental benefits of INM (Fig.2.).

- Fertilizer solubility and soil nutrient supplying capacity can be improved.
- Synchronizing the crop nutrient demand and nutrient release in the soil environment
- Enhance and maintenance of soil physiochemical and biological characteristics.
- The INM can bring about equilibrium between degenerative and restorative activities in the soil environment
- Reduce the pace of soil degeneration, water pollution, and ecosystem degradation through increasing carbon sequestration and reducing the nutrient losses Increase the farmer's returns by lowering total production expenses.
- Improve crop ability to withstand both biotic and abiotic stresses.

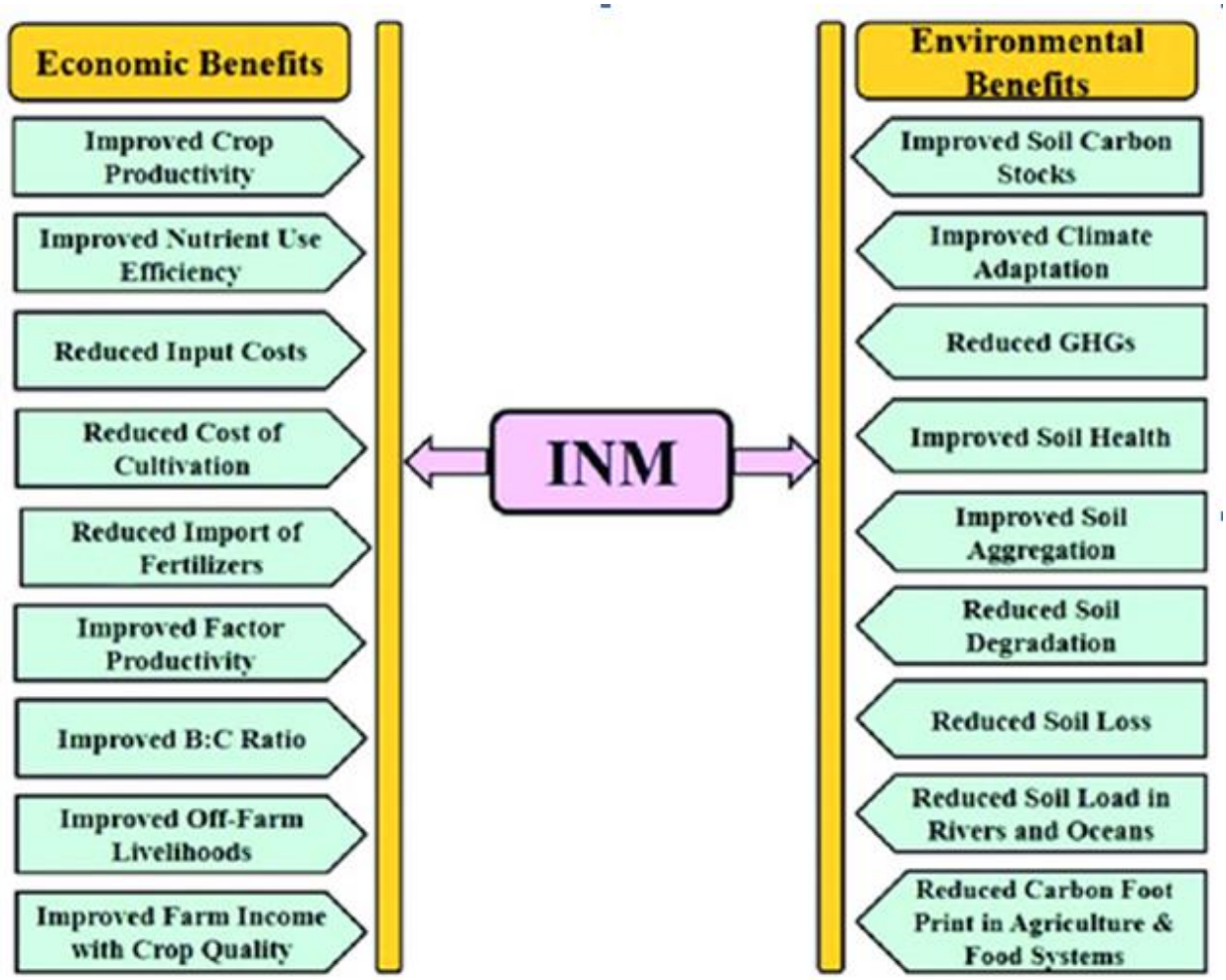

Fig. 2 Economic and environmental benefits of integrated nutrient management

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INM effect on Crop Yield

Many factors influence plant growth, in which application of recommended dose of integrated sources of fertilizers is an important factor for improving crop growth and nutrient uptake, as well as a crucial component in supporting the crop life cycle and yield potential (Selim, 2018). INM is critical for enhancing plant growth and development in terms of plant height, dry weight accumulation, leaf area, leaf area index, leaf area duration and crop growth rate, all of which have direct positive effects on crop yield per unit area. High crop yields can be attained even without applying NPK rates beyond the recommended dose due to the effect of INM on most crop growth metrics (Bairwa et al. 2013). Integrated use of manures and chemical fertilizers had significant positive effect on crop productivity through supplying all the nutrients and correcting the marginal nutrient deficiencies. A study releaved that the uptake of nutrients is found to be increased by the application of PSB and vermicompost with fertilizers than using the fertilizers or vermicompost alone (Mohammadi et al., 2017). The organic manures in addition to nutrients contain microbial load and growth-promoting substances which helps in improving the metabolic activity and plant growth. The application of integrated nutrient sources has increased the supply of nutrients, water holding capacity of the soil and providing a favorable soil environment to plant.

Conclusion:

INM is a tool that can provide eco-friendly options and a cost-effective way to provide crop plants with adequate amounts of most macro- and micronutrients. It can reduce the use of chemical fertilizers, create favourable soil physiochemical conditions and a healthy environment, protect soil nutrient balance in the long run, and generate an optimum level for sustaining desired crop productivity. An additional benefit can be gained if a portion of the applied organic manure is left with a large amount of crop residue after harvesting for the following crop; these materials will quickly decompose and turn to high quality compost, which can improve soil properties and contribute to soil organic matter building, which is the primary method of preventing soil erosion. Finally, agriculture experts and farmers should focus their attention on a simple integrated nutrient management technique that is an acceptable option, a cost-effective practice that farmers can easily implement, and an environmentally friendly approach that reduces fertilizer use and can give higher yields with better quality traits while maintaining a satisfactory profit margin.

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