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Integrated Nutrient Management Practices for Sustainable Agriculture

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Nowadays, the global food demands of an expanding human population, as well as the need for an eco-friendly strategy for a sustainable soil-plant-microbes-environmental system, necessitate significant attention when addressing the issue of increasing agricultural productivity. Chemical fertilisation is a possible way to increase crop productivity, but because of injudicious use of chemical input in agricultural systems, which has detonated the soil, food, environment, and human health, chemical fertilisation is also increasing their prices in the twenty-first century. Organic manures, on the other hand, cannot meet all of a crop's nutrient requirements. Taking the foregoing facts into account, integrated nutrient management (INM) was developed. In this section, we discuss the role of INM in addressing these concerns, which has been proposed as promising strategy for dealing with these issues.

Introduction

Concerns are growing about agriculture's long-term viability. Over- and under-application of fertilisers, as well as poor resource management, not only harmed soil health but also raised environmental concerns. Harsh climatic conditions, population pressure, and land scarcity are all problems in developing countries limitations and ignoring conventional soil management practises have frequently reduced soil fertility. Growing population and consumption, as well as a reduction in available land and other productive units, are putting unprecedented strain on current agriculture and natural resources to meet rising food demand. Providing food for humans under sustainable systems is a significant challenge in the developing world and is critical for poverty alleviation. It is well understood that conserving, restoring, and improving soil and water resources is critical to ensuring humanity's freedom from hunger and malnutrition, mitigating climate change, improving the quality and quantity of fresh water resources, enhancing biodiversity, generating ligno-cellulosic feed stock for biofuel production, and improving the income and living standards of rural populations dependent on agriculture. Food supply and agriculture production are essential components of human development in many ways. To avoid this challenge, farmers tended to overuse certain inputs, such as chemical agricultural inputs, which have already begun to degrade the soil-plant-microbe environmental system. To meet the world's future food security and sustainability needs, food production must increase significantly while agricultural environmental impact must decrease dramatically. Farmers, researchers, the fertiliser industry, and governments all play critical roles in this context.

Concept of INM

INM primarily refers to the integration of old and new methods of nutrient management into an ecologically sound and economically optimal farming system that utilises the benefits of all possible sources of organic, inorganic, and biological components-substances in a judicious, efficient, and integrated manner. The concept encompasses key areas such as soil fertility maintenance/adjustment, optimum plant nutrient supply, sustaining desired level of

productivity, optimising benefits from all possible nutrient sources, and addressing environmental concerns. This can be accomplished by combining all available nutrient sources and scientifically managing them for optimal growth, yield, and quality of various crops and cropping systems.

Sustainability

In recent years, the importance of sustainable agriculture has grown to become one of agriculture's most pressing issues. Agriculture's sustainability has faced some of the most significant challenges in recent years. Major challenges include: (1) rapid human population growth and increased demand for agricultural land and resources, (2) overdependence on fossil energy and increased non renewable resource monetary and environmental costs, (3) global climate change, and (4) globalisation . These dominant issues are pushing agriculturists to create more sustainable management systems like never before. Agriculture will need to move beyond the past emphasis on productivity to include improved public health, social well-being, and a healthy environment in order to meet the food and nutritional needs of a growing population.

The primary goal of sustainable agriculture is to increase food production in a sustainable manner while also improving food security. Maintaining and improving the capacity of higher potential agricultural lands to support an expanding population must be prioritised. However, conserving and rehabilitating natural resources on lower potential lands is also required in order to maintain sustainable man/land ratios .

Components of INM

1. **Organic nutrient sources:** Plant nutrient sources that are organic include legume cultivation in cropping green manures, crop residues, and organic FYM, compost, vermicompost, and biogas press, slurry, phosphor-compost, bio-compost mud, oil cakes, manure and biofertilizers.
2. **Fertilizers:** Fertilizers remained the most important component of INM. Because of the need to supply large amounts of nutrients in intensive cropping with high productivity, the reliance on fertilisers has been steadily increasing. Despite this, fertiliser consumption is not only insufficient but also unbalanced.
   Some of these issues are: I increased mining of soil nutrients to the tune of 10 MT per year, depleting soil fertility; (ii) emerging deficiencies of secondary and micronutrients; (iii) decline of the water table and its quality of water; (iv) decreasing organic carbon content; and (v) overall deterioration in soil health.
3. **Legumes as Green Manures:** Green manuring with legumes enriches soil N through atmospheric N fixation. Green manure decomposes and solubilizes N, P, K, and micronutrients in the soil. It also reduces nitrogen leaching and gaseous losses. Furthermore, green manuring improves the physical, chemical, and biological properties of soil. The most important common green manure crops are sunnhemp (Crotolaria juncea) and dhaincha (Sesbania aculeata).
4. **Crop Residues:** Crop residues have a variety of competitive uses and may not always be available as an ingredient in INM; however, in regions such as North-West India where mechanical harvesting is practised, a significant amount of residues are left in the field, which can contribute to nutrient supply. There are large amounts of residues from other crops i.e. potato, sugarcane, vegetables, and so on that is essentially wasted in most cases.
5. **Biofertilizers:** When applied to seed, plant surfaces, or soil, biofertilizer colonises the rhizosphere or the interior of the plant and promotes growth by increasing the supply or availability of primary nutrients to the host plant. Rhizobium, Azotobacter, Azospirillum, Cyanobacteria, Azolla, Phosphate, and potassium are all microorganisms that are beneficial to agriculture and are used as biofertilizers. Similarly, fungi likeVesicular

Arbuscular Mycorrhizae (VAM) increase nutrient uptake particularly that of P due to increased contact of roots with larger soil volume.

Impact of INM on Soil Health

- Soil physical properties are closely related to SOC and OM; therefore, any soil management practise that increases soil organic matter has a direct impact on soil physical properties and microbial biomass; for this, a combination of organic and inorganic nutrient sources may be the best option.soils, primarily for the purpose of improving soil physical health.
- Many researchers observed a significant improvement in soil physical conditions when organic manure and inorganic fertilisers were applied together. The addition of NPK fertilisers, as well as organic manure, lime, and biofertilizers, increased the soil's SOC, WSA, moisture-retention capacity, and infiltration rate while decreasing bulk density.
- Organic incorporation, whether as crop residue, organic manure, or amendment, has a significant effect on agricultural soil BD, soil aggregation, soil structure, soil moisture retention capacity, and infiltration rate.
- The majority of the research results clearly demonstrated that INM increases crop yield potential above achievable yield with recommended fertilisers
- When compared to other treatment combinations, careful application of mineral fertilisers and organic manure, along with biofertilizers and micronutrients, resulted in the highest available NPK in soil.
- The use of FYM ensures higher levels of sustainability by addressing the hidden hunger for micro and secondary nutrients, which could otherwise become a limiting factor. FYM application, in addition to acting as a nutrient storage facility, also acts as a conditioner to improve the physical condition of the soil.

Principles of INM

The main principles of INM:

1. As previously stated, the overall goal of INM is to maximise the use of soil nutrients in order to improve crop productivity and resource-use efficiency.
2. Matching soil nutrient supply with crop demand in space and time.
3. Reducing N losses while increasing crop yield. Excessive N fertiliser application can result in increased nitrate leaching into groundwater and increased emission losses to the atmosphere. The INM principle is to control N losses and their negative environmental effects while achieving high crop productivity.
4. Using organic manure in conjunction with other management practises, such as crop residue incorporation and the development of conservation tillage (no-tillage or reduced-tillage practises), reduces GHG emissions, improves soil quality, and increases C-sequestration, resulting in high crop yield.

Conclusion

It is abundantly clear from the preceding discussion that INM is critical to meeting Indian agriculture's growing nutrient demands. INM contributes to long-term production sustainability while minimising environmental impact. The integrated use of green manures, organic manures, and fertilisers under a dominant cropping system has a great potential to offset the high fertiliser requirements, achieve maximum yields, and sustain crop productivity over time. Despite constraints related to the availability of adequate quantities of organic manures due to alternate uses, efforts should be made to exploit potentials of organic resources that are available after meeting competitive demands. Some fertiliser estimates Working in a participatory mode is required to improve the production and economic viability of millions of smallholder farms that are currently struggling with declining soil fertility and poor plant nutrient management.