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Integrated Nutrient Management and Its Importance for Soil Physical, Chemical, and Biological Properties

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Abstract

An essential element performs unique biochemical or physiological functions that are required for normal growth and /or reproduction, in which it cannot be replaced by another element. Plants required at least 17 such elements, called micro and macro nutrient. Now a day have drastic effects on crop growth and yield, is urgently needed to report this aim. Replacement of a part of chemical fertilizers by organic manure through a simple technique of using minimum effective dose of sufficient and balanced quantities of organic and inorganic fertilizers in combination with specific microorganisms, called INM, has a bright solution in this area / agriculture approches. Recently, several investigators reported that integrated use of chemical fertilizers with organic manure is becoming a quite promising practice not only for maintaining higher productivity but also for greater stability to crop production. In addition, 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. So, the key component of the INM goal is to reach the eco-friendly practice through the harmonious properties of both sources by making a combination that can be used for decreasing the enormous use of chemical fertilizers and accreting a balance between fertilizer inputs and crop nutrient requirement, maintaining the soil fertility, optimizing the level of yield, maximizing the profitability, and subsequently reducing the environmental pollution. Lastly, INM is a tool that can offer good options and economic choices to supply plants with a sufficient amount of nutrients in need and can also reduce total costs, create favorable soil physiochemical conditions and healthy

environment, eliminate the constraints, safeguard the soil nutrient balance, and find safety methods to get rid of agriculture wastes.

Keywords: Elements, Fertilizer, Organic, INM

Introduction

Integrated nutrient management (INM) involves the use of manures, chemical fertilizers and biological agent achieve sustainable crop production and improved soil health. INM is the best approach for better utilization of available resources and to produce crops with less expenditure. In soils of India, NPS deficiencies are principal yield-limiting factors in crop production. INM, which entails the maintenance of soil fertility to an optimum level for crop productivity to obtain the maximum benefit from all possible sources of plant nutrients organics as well as inorganic in an integrated manner, it is essential to address the twin concerns of nutrient excess and nutrient depletion. INM is also beneficial for marginal farmers who cannot afford to supply all crop nutrients through costly chemical fertilization. This review article examines the concepts, objectives, procedures and principles of INM and its effect on soil. Most of the INM research work carried out with dominant crop rotations of major field crops grown in the subtropical states of India, sustainable production of prominent cropping systems, enhancing nutritional quality of products, improving soil health, and minimizing environmental pollution.

The main challenge in the forthcoming few years lies in the following question. Can agriculture provide the world population with all food needs which are expected to exceed 7.5 billion by the year 2020. With the view of an increase in land scarcity and water shortage, most of the agriculture plans depend on the use of chemical fertilizers and the production of new high-yielding crop varieties. Yet, both components are much expensive and will lead to higher pressure and more responsibilities for the financial investments and consequently will lead to an increase in the total costs. Meanwhile, the price of fertilizers increases, year by year, due to the higher amount of fertilizers needed in the second and third seasons as compared with that in the first season to maintain the current yield production at economical level. Despite the increase in the quantity of fertilizer application, a part of applied fertilizers and soil native nutrients were already consumed by the current and previous crops, especially in the case of intensive agriculture, where two to three crops are annually cultivated. Moreover, application of inorganic fertilizers is not a pragmatic option for many poor farmers in different regions worldwide, because many poor farmers do not have enough money to pay.

Integrated nutrient management is also defined as the technique of using the smallest effective dose of sufficient and balanced amounts of organic and inorganic fertilisers in conjunction with specific microorganisms to make nutrients more available and effective for maintaining high yields without exposing soil native nutrients or polluting the environment. Furthermore, many benefits can also be gained from using integrated nutrient management. INM has the potential to be the driving force behind efforts to turn marginal lands into productive ones, thereby achieving the strategic goal of expanding cultivated land.

Concept of INM

Integrated nutrient management is a practice that combines old and modern techniques of fertilizer use and nutrient management. The concept of INM is based on a variety of elements, including nutritional harmony, a balance between crop nutrient demands, what kind of nutrient is accessible in general in soil and in the farmer's hand, and knowledge and skills about the best nutrient. Additionally, it is a method and a way of disposing organic wastes safely and also an effective method of recycling wastes into goodquality compost. The key components of the INM concept include the following: increasing the farmer's awareness about the valuable use of INM practices, inviting them to forget the excessive use of chemical fertilizers, and encouraging them to focus on long-term plan for sustainable agriculture. Moreover, rather of focusing on just the profit that may be earned, growers must pay more attention to environmental issues and producing safe food. It's important to note that many buyers prioritize food safety above all else, regardless of price, and that following such procedures may boost a farmer's profits.

Objective

The main goal of integrated nutrient management is to maintain economic yield for a long time with minimal impact on native soil fertility and pollution, as well as to raise farmer awareness of an environmentally friendly technique (organic farming system) for producing healthy, contaminant-free food while ensuring satisfactory economic returns.

The main principles of INM

INM's key principles are listed below, and they include the following: (a) maximising the use of soil nutrients to enhance crop productivity and resource efficiency; as

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mentioned earlier, the overall objective of INM is to maximise the use of soil nutrients to improve crop productivity and resource efficiency. (b) spatially and temporally coordinating soil nutrient supply with crop requirement. The amount and timing of fertiliser applications must be in accordance with the crop's nutritional requirements, according to INM, in order to produce maximum yields and improve nutrient utilisation. N fertilisers used in small amounts and on a regular basis during seasons of high crop demand have the potential to decrease N losses. ***(c)*** reducing N losses, while improving the crop yield. Excessive applications of N fertilizer can result in increased leaching of nitrates into groundwater and more emission losses to the atmosphere. The principle of INM is to control the N losses and their harmful environmental effects while achieving high crop productivity. Crop N absorption, immobilisation, and residues in the soil, as well as N losses to the environment, such as ammonia volatilization, NOX emissions, denitrification, N leaching, and runoff, all affect the destiny of N in the field. In addition, INM promotes organic fertilisation systems, which offer enormous potential for agriculture's long-term sustainability as well as more direct environmental impact.Using organic manure together with other management practices, such as incorporation of crop residues and the development of conservation tillage (no-tillage or reduced-tillage practices), also reduce GHG emissions, improve the soil quality and increase C-sequestration, accompanying high crop yield.

Components of INM

Major components of integrated nutrient management are (i) integration of soil fertility restoring crops like green manures, legumes, etc.; (ii) recycling of crop residues; (iii) use of organic manures like FYM, compost, vermicompost, biogas, slurry, poultry manure, biological composts, Press mud cakes, Phospho-compost (iv) utilization of biological agent; (v) efficient genotypes; (vi) balanced use of fertilizer nutrients as per the requirement and target yields.

Impact of injudicious uses of chemical fertilizers

Intensive agriculture, despite boosting food output, has resulted in second-generation nutritional imbalance issues. Some examples of such issues are: (i) greater mining of soil nutrients to the extent of 10 MT every 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 (v) and overall deterioration in soil health.

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Soil quality and agricultural productivity

The environment that the soil offers for root growth determines the soil's capacity for generating crops, because roots require air, water, nutrients, and enough room to thrive. How well roots develop is determined by soil characteristics such as water storage capacity, soil reaction, depth, texture, and density. Changes in these soils have a direct impact on the plant's health. For example, bulk density, a measure of the compactness of a soil, it affects agricultural productivity. When the bulk density of soil increased beyond the critical level, it becomes more difficult for roots to penetrate the soil, thereby impeding root growth. Heavy farm equipment, erosion and the loss of soil organic matter can lead to increases in bulk density. These variations in soil quality have an impact on the plant's health and productivity, which can result in reduced yields and/or greater production costs (Tables 1, 2 and 3).

Effect of INM on soil physical properties

Soil physical properties are closely related with SOC and OM, thus, any soil management practice that enhances soil organic matter has direct bearing on soil physical properties and microbial biomass, for this, combined use of organic and inorganic nutrient sources might be the right proposition for these soils, primarily for the improvement of soil physical health. Significant improvement in the soil physical conditions of the soil was observed by many researchers under integrated application of organic manure and inorganic fertilizers. The addition of NPK fertilizers along with organic manure, lime and biofertilizers increased SOC, WSA, moisture-retention capacity, and infiltration rate of the soil while reducing bulk density, Incorporation of organic either in the form of crop residue, organic manure or amendment has a significant effect on BD of agricultural soils, soil aggregation, soil structure, soil moistureretention capacity and infiltration rate. The SOC, BD, WHC, WSA and fertility status of the soil improved by the integration of organics with inorganic, organic carbon and microbial biomass carbon increased in the treatments receiving an application of organic manures (particularly FYM), green manure and biofertilizers in conjunction with inorganic fertilizers (Table 1). Build up of organic carbon in soil was relatively higher in macro-aggregates compared to microaggregates.

Table 1. Integrated impact of nutrient management on soil physical properties

Crops	Response of integrated nutrient management	References

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Wheat	RDF + FYM @ 5 ton ha-1 significantly reduced BD	05
Maize	Significantly improved total porosity, HC, soil moisture content	06
Cotton-Wheat	Significantly improved in BD, total porosity, WSA, MWD	08
Pea-Wheat	Soil moisture conserves, significantly increased WSA, MWD	09
Soybean	Significantly decreased in bulk density	02
Tomato	Soil temperature, BD significantly reduced	10
Wheat-Soybean	Significantly reduced BD, increased MWD, SOC	03
Rice–Wheat	Increased MWD, total porosity, WHC	11
Maize–Mustard	Significantly increased WSA, WHC, and decreased BD	01

Effect of INM on soil fertility

Many researches observed a substantial increase in soil fertility status while the majority of agricultural soil fertility worsened day by day owing to the unbalanced application of mineral fertiliser. The application of organic manure with RDF increased the soil's SOC, and this combination had a substantial impact on crop growth, development, and productivity. Most of the research results clearly demonstrated that INM enhances the yield potential of crops over and above achievable yield with recommended fertilizers (Table 2), and results in better synchrony of crop N needs due to (a) slower mineralization of organics; (b) reduced N losses via denitrification and nitrate leaching; (c) enhanced nutrient use efficiency and recovery by crops, and (d) improvements in soil health and productivity, and hence could sustain high crop yields in various cropping systems ensuring long term sustainability of the system. Judicious application of mineral fertilizers and organic manure along with biofertilizers and micronutrients gave highest available NPK in soil as compared to other treatment combinations. According to *Kusro* stated that the organic carbon, mineralisable nitrogen and NH_4 + $^-$N showed statistically significant increase over control. Incorporation of FYM, GM and BGA, through an inorganic source in the treatment increased organic carbon, mineralisable N, NH_4 +$^-$N and reduced the bulk density.

Table 2. Integrated impact of nutrient management on soil fertility and crop productivity

Crops	Response of integrated nutrient management	References

Rice	Enhance available NPK in post harvest soil	14
Wheat	Increase the availability of OC, NPK	04
Maize	VC + RDF enhances 100 seed weight, grain yield	07
Cotton	INM significantly increased NPK uptake and sustain soil fertility	16
Green gram	Available NPK and humic substances were higher with INM	15
Chili	Highest available NPK and micronutrients, higher yield with INM	13
Pea-Wheat	Significantly higher yield with manure and NP	09
Wheat-Maize	Significantly increased SOC and TN, enzymatic activities	12
Cereal-Legume	GM with mineral fertilizer ensures higher crop productivity, soil fertility	17

Impact of biofertilizer on crop productivity

Biofertilizer is a substance which contains living microorganism which, when applied to seed, plant surfaces, or soil, colonizes the rhizosphere or the interior of the plant and promotes growth by increasing the supply or availability of primary nutrients to the host plant. Microorganisms are not always as effective in their natural environments as one might suppose, thus artificially reproduced cultures of efficient chosen microorganisms serve an important role in speeding up microbial activities in soil. Use of biofertilizers is one of the important components of INM, as they are cost effective and renewable source of plant nutrients to supplement the chemical fertilizers for sustainable agriculture. Several microorganisms and their association with crop plants are being exploited in the production of biofertilizers (Table 3). A number of microorganisms are considered as beneficial for agriculture and used as biofertilizers viz. Rhizobium, Azotobacter, Azospirillum, Cyanobacteria, Azolla, Phosphate and potassium solubilizing microorganisms. Silicate solubilizing bacteria, plant growth promoting rhizobacteria and these are also available as liquid biofertilizers.

Table 3. INM impact of mineral fertilization and biofertilizer on crop performance and soil health

Crops	Response of biofertilizers with mineral fertilization	References

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Soybean	RDF with biofertilizers resulted improve soil productivity,fertility and nutrient status	20
Wheat	Significant response of biofertilizers on growth and crop productivity	22
Sunflower	Significantly higher grain and biological yield with biofertilizer –N fertilization-FYM	21
Mungbean	Significantly enhanced crop productivity and soil fertility status with bioinoculants and mineral fertilization	23
Lentil	FYM and biofertilizer improve the soil health	19
Apple	Biofertilizers play a significant role in the crop production, help to build up the lost 60 micro flora and improve the crop yield and soil health	18

Strategies for further development of INM

The amount of benefits that INM techniques may provide to farmers, as well as the environmental benefits, is incredible. We have designed and synthesized various techniques and current opportunities that could be accessible and further enhanced by modification and changes in the implementation of site-specific INM practises by analysing numerous research papers. Future strategic development of INM under following points (i) combination of soil and plant analysis (ii) fine-tuned to the local environmental conditions (iii) mechanization due to serious labor shortage (iv) conservation tillage and rainwater-harvesting technologies (v) recycling of organic nutrient flows (vi) new technological innovations, and (vii) appropriate policy interventions.

Conclusion

INM entails using all available plant nutrients to optimize nutrient inputs, geographical and temporal matching of soil nutrient availability with crop demand, and decreasing nitrogen losses while increasing crop output. Agricultural input interaction leads to increased crop yield while minimising N losses and GHG emissions, judicious mineral and organic fertilisation with greater resource-use efficiency, and improved soil-plant-microbe-environmental sustainability. The balanced use of organic manures will be essential for crop production and environmental issues, which should be a top focus for INM practises,

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providing a "win–win" chance to boost crop output while also maintaining agricultural sustainability.

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