



Mini Review

Integrated Nutrient Management (INM) in Soil and Sustainable Agriculture

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Abstract

The world vision of no hunger target, food security, and zero poverty followed by raising standards of living of rural people through agricultural transformation is the greatest challenges faced by the agricultural planners worldwide. Due to the alarming state of population growth and cultivable land scarcity, change in agronomic practices which could bring a significant effect on crop production and productivity is urgently needed. The concept of using different sources of plant nutrients combined to check nutrient depletion, maintain soil health, and crop productivity, called INM, has a bright solution in this area. Recently several researchers introduced that integrated use of inorganic fertilizers, organic fertilizers, green manure, and bio-fertilizers is becoming an effective practice not only for increasing crop production and productivity but also for the better crop and soil health. In addition, INM helps to increase the activity of soil microorganisms and improves the soil physical, chemical and biological properties. So, INM create an economic eco-friendly environment by reducing the dependence on inorganic chemical fertilizers and improving the soil fertility, optimizing crop yield, maximizing profitability and ultimately making the agriculture sustainable. Lastly, INM is one of the good agricultural practices which needs to be followed by every conscious individual in order to maintain soil health, nutrient balance and to make the agriculture and environment more sustainable.

Introduction

Integrated nutrient management refers to the maintenance of soil fertility and of plant nutrient supply at an optimum level for sustaining the desired productivity through management of all the sources of organic, inorganic and biological components in an integrated manner. Efficient use of all the nutrient sources including organic sources, recyclable wastes, mineral fertilizers and bio-fertilizers should therefore be promoted through integrated nutrient management (Roy *et al.*, 2006). The aim of Integrated Nutrient Management (INM) is to integrate the use of

natural and man-made soil nutrients to increase crop productivity and preserve soil productivity for future generations (FAO, 1995). Balanced supply of fertilizers is needed to promote the plant growth, improve the crop yields and enhance the soil fertility. The key component of the INM goal is to reach the most effective and homogeneous combination that could lead to good management and be an effective target of the fertilizers, sufficient and balanced use of their quantity and quality, and be straightforwardly up taken by plants for higher yield without jeopardizing soil

native nutrients or polluting the environment. It is ultimately viable to achieve such a target through the wise application of integrated nutrient management (INM) approach, which is known as a balanced mixture of organic, inorganic, and bioorganic microorganisms in combinations in different practices (Janssen,1993).

The main challenges facing by agriculture planners and farming decision makers in the coming few years lies in vision world without hunger and zero poverty intensified by rising standards of living of rural regions, where the majority of poor people live and their full dependence on agriculture for living to fulfill their food demands (Wheller *et al.*, 2013). Due to the alarming state of world population and scarcity of land, crop production and productivity should be increased in order to meet the objective zero hunger. The most important factor for increment of crop production is soil fertility management. For increasing the soil fertility, there will be high pressure for the farmers to use chemical fertilizers resulting more financial investment leading to the increase in cost of production. The integration of high yielding varieties (HYV) and chemical fertilizers increase the agricultural production and productivity. The HYV generate dramatic increases in yields through transformation of chemical energy of fertilizers into biomass with higher grain: straw proportion. But this approach fails in long run. The dependence in inorganic fertilizers has created a condition of huge economic loss to the poor farmers.

The consequences of huge number of long-term experimentations undoubtedly show that- even suggested rates of NPK application, based on soil test basis, the yield of crops does not seems satisfactory due to the deficiency of several micronutrients in the soil. Long term application of N fertilizers results in soil acidity which rendered to soil infertility where crops fail to respond with further application of N fertilizers (Upendra *et al.*, 2019). At many other sites application of N even causes the deficiency of P and K that reduce the crop yields. The soil analysis from these sites clearly shows that the unbalanced use of chemical fertilizer over a long period leads to deficiency of several other micronutrients. Excesses of potash and nitrogen in particular area can encourage weeds (Huhnke, 1982). So, mismanagement use of fertilizers always leads to soil degradation, nutrient deficiency, and quick soil runoff (Selim, 2018). High use of N fertilizers makes the soil acidic resulting the unavailability of several major nutrients for the plants. It is therefore imperative to supply the plant nutrients in an integrated manner to maintain soil fertility for sustaining the desired level of crop production and productivity through a judicious combination of chemical fertilizers and organic sources like organic manures, farmyard manures (FYM), compost, green manures, crop residues, recyclable waste, vermi-compost, legumes and bio-fertilizers. Generally, soil pH of 6.0-7.5 is acceptable

for most plants as most nutrients become available in this pH range. Nitrogen, phosphorus, and potassium are the primary nutrients needed in fairly large quantities. Calcium, magnesium, and sulphur are secondary nutrients required by the plant in lesser quantities. Zinc, boron, copper, molybdenum, manganese and other micronutrients are required by plant in very small amounts (Fig 1). Most of the secondary and micronutrient deficiencies are easily corrected by keeping the soil at optimum pH value. Soil pH also affects activity of soil microorganisms. The population of bacteria that decompose soil organic matter declines and their activity is hindered in highly acidic soil.

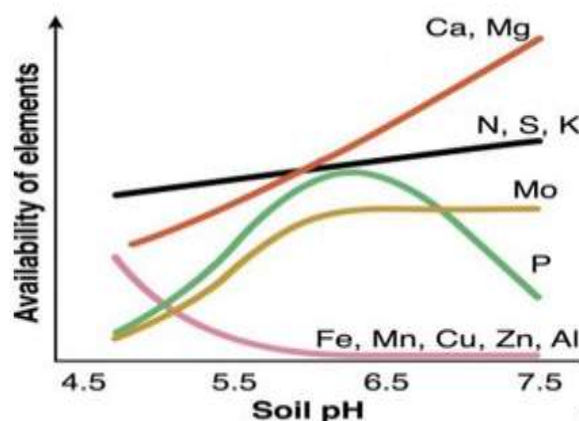


Fig. 1: Relation between soil pH and nutrient availability in soil. [Source: Government of Western Australia, (Department of Primary Industries and Regional Development)]



Fig. 2: Factors improving the availability of micronutrients in soil. [Source: Siddiqui *et al.* (2015)]

Proper balance of both macro and micronutrient is necessary for the growth and development of plants. Integrated nutrient management balances both the macro and micronutrients. In recent years, due to the massive use of inorganic fertilizers and decrement in soil pH, most of the soil is devoid of micronutrients. Mostly, micronutrients in soil are gained from the decomposition of organic

matters. So, integrated nutrient management is a simple approach which helps in overcoming the soil fertility constraints (Fig. 2).

Integrated nutrient management uses the balanced quantities of organic and inorganic fertilizers in combination with specific microorganisms to make nutrients more available and most effective for maintaining high yields without exposing soil native nutrients and polluting the environment. In conclusion, integrated nutrient management is a tool which can offer good options and economic choices to supply plants with sufficient amounts of most macro and micronutrients and also can reduce the dose of chemical fertilizers, create favorable soil physiochemical conditions and healthy environment, eliminate the constraints, safeguard the soil nutrient balance in the long run to an optimum level for sustaining the desired crop productivity, and find safety methods to get rid of agriculture wastes (Selim *et al.*, 2017).

Concepts of INM

INM enhances all aspects of nutrient cycling including N, P, K and other macro and micronutrient inputs and outputs, with the objectives of orchestrating nutrient demand by the crop and its release in the environment. This practice combines both old and modern techniques of fertilizer use and nutrient management.

Under INM practices, the losses through leaching, runoff, volatilization, emissions, and immobilization are diminished, while high nutrient-use efficiency is attained (Zhang *et al.*, 2012). There is now a larger appreciation that INM can not only increase crop productivity but also at the same time preserve soil resources. INM integrates/combines the objectives of production with ecology and environment, i.e, optimum crop nutrition, optimum functioning of the soil health, and minimum nutrient losses or other adverse effect on the environment. So, Integrated Nutrient Management (INM) is an integral part of sustainable agricultural system. It is a way of disposing organic wastes safely and also an effective method of recycling wastes into good-quality compost. To maximize the potential of crop yields and maintain crop yields and soil fertility levels, comprehensive nutrient management strategies are essential to adapt to planting systems rather than individual crops (Mahajan *et al.*, 2002).

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. The overall objective of INM is to maximize the use of soil nutrients to improve crop productivity and resource-use efficiency. This concept has developed the use of renewable sources of plant nutrients taking into consideration the ecology, escalating cost of chemical fertilizers, loss of soil

productivity and yield instability (Singh, 1999). So, it can reduce plant requirements for inorganic fertilizers, resulting a reduced use of purchased fertilizer nutrients which aids in a significant saving of scarce cash resources for small farmers in developing countries (Chemonics, 2007). Basic concepts of INM includes:

1. Regulation of plant nutrient supply to an ideal level for nurturing the desired crop productivity.
2. Appropriate arrangement of chemical fertilizers, organic manures, crop residues, N fixing crops for the system of land usage, ecological, social and economic situations.
3. Integrated nutrient management system enhances the soil physical circumstances in terms of soil structure, aggregate stability, soil moisture retention and hydraulic conduction. Such enhancements in soil physical conditions support to soil fertility and productivity.

The INM is a soil fertility sustaining tradition because:

- It enriches the availability of both applied and native soil nutrients during the crop season.
- It orchestrates the nutrient requirement set by the plants both in time and space with supply of nutrients from soil and applied nutrient pool.
- It sustains and enriches physical, chemical, and biological, soil health.
- It arrests deprivation of soil, water and environmental quality by elevating or minimizing the not inevitable seepages of fertilizer nutrients to water bodies and atmosphere.

Components of INM

Major elements of INM can be grouped into three broad groups:

- ❖ Organic manures
- ❖ Bio-fertilizers and
- ❖ Inorganic fertilizers

Organic Manures

Organic manure is the organic material obtained from animal, human and plant residues, which comprises plant nutrients in intricate organic forms. The foremost organic sources are manures that are farm wastes, cattle shed waste, night soil, vermi-compost, slaughter house waste, fish meals, by products of agro-industries etc. Organic matter in turn releases the plant food in available from for the crops. These manures also enable a soil to hold more water and also help to improve the drainage in soils. They provide organic acids that help to dissolve soil nutrients and make them available for the plants.

Classification of Organic Manure

A. Bulky Organic Manures

- (i) FYM: (a) Cattle manure, (b) Sheep manure, (c) Poultry manure
- (ii) Compost: (a) Village/rural compost from farm-wastes (b) Town/urban compost from town refuses
- (iii) Sewage and sludge

B. Concentrated Organic Manures

1. Oil cakes:

(a) Edible oil cakes

- (i) Mustard cake, (ii) Groundnut cake,
- (iii) Sesame cake, (iv) Linseed cake

(b) Nonedible Oil Cakes

- (i) Castor cake, (ii) Neem cake, (iii) Sunflower cake

2. Slaughter house wastes

- (i) Blood meal, (ii) Bone meal

3. Fish meal

C. Green Manures

Green manuring is the practice of growing a short duration, succulent and leafy legume/non- legume crop and ploughing the plants in the same field before they form seeds. Green manures are crops grown specifically for building and maintaining soil fertility and structure, though they may also have other functions. They are normally incorporated back into the soil. Slow release of nutrient from decomposition of green manure may provide better time to uptake nutrient by plant possibly increasing nutrient uptake efficacy and crop production (Desaeger *et al.*, 2001). Green manuring crops prevents the leaching of soluble nutrients from the soil and checks the growth of weed. Green manuring crops especially legumes are widely known to provide N to soils through biological N fixation, and this can increase the soil N supply to subsequent crops (Drinkwater, 1998). These green manures are capable of fixing atmospheric nitrogen with N-fixing bacteria associated at their roots (Cherr, 2006). Green manuring technology is economically viable, environmentally sustainable, and socially acceptable in sustainable agricultural systems (Fageria, 2007). The various classification of Green manuring crops are:

- a. Leguminous plant (example: sun hemp, sesbania sp., mung bean, cowpea, berseem).
- b. Non-leguminous plant (example: pearl millet, maize, sunflower).
- c. Green leaf manures: Green leaves of trees like *neem*, *Pungamia*, *Gliricidia*, etc.

Biofertilizer

A biofertilizer is defined as a product which contains living microorganisms that, when applied to soil, seeds, or surfaces of plant, colonize the rhizosphere or the plant internal tissues and induce plant growth. Biofertilizers are typically bacteria or fungi capable of nitrogen fixation, phosphate solubilization, sulfur oxidization, plant hormone production, or decomposition of organic compounds (Verma *et al.*, 2018). The most common biofertilizers and biocontrol agents currently in use belongs to a group known as plant-growth-promoting rhizobacteria (PGPR) (Mimmo *et al.*, 2015; Paterson, 2017). PGPR colonize the rhizosphere of many plant species, where they induce beneficial effects for the host, for example, increased plant growth and reduced susceptibility to diseases caused by plant pathogens, such as nematodes, fungi, bacteria, and viruses (Kloepper *et al.*, 2004). Benefits of PGPR can include increased seed germination rate, root growth, yield, leaf area, chlorophyll content, nutrient uptake, protein content, hydraulic activity, tolerance to abiotic stress, shoot and root weights, and delayed senescence (Adesemoye and Kloepper, 2009). The commonly used biofertilizers are:

Nitrogen fixing biofertilizers: *Rhizobium*, *Azotobacter*, *Azospirillum*, *Blue green algae* (Umeha *et al.*, 2018).

Phosphorus solubilizing biofertilizers: *Pseudomonas striata*, *Bacillus polymixa*, *Aspergillus awamori* and *penicillium digitatum* (Sharma *et al.*, 2013).

Inorganic fertilizers

Industrially manufactured substances which contains essential plant nutrients in particular amounts and supplies nutrients when applied to the plants or soil. Examples: Urea, DAP, ammonium sulphate, muriate of potash, calcium ammonium nitrate, diammonium phosphate etc.

Conclusion

It is a well-known fact that, agriculture mainly depends on soil. The nutrient status of the soil is the main factor determining the production and productivity of the crop. The amount of nutrient plant can absorb determine the crop production. Sometimes, plant cannot absorb the required nutrient even if the nutrient status in soil is high due to the several other factors. So, these factors should be considered in integrated nutrient management. Flow of plant nutrient in plant and soil should be properly traced out. Concerned authorities should know the effect caused by the excessive use of synthetic chemical fertilizers on plant, soil and soil health. The modern concept of integrated nutrient management should be well distributed among the farmers indicating its benefits from different prospective. Research should be carried out on the use of different sources of organic matter, their effectiveness and reclamation of soil nutrients. Government should assist the farmers on balanced use of inorganic and organic fertilizers for better

production of healthy crop, maintenance of soil health, and sound environment.

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