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Integrated nutrient management for sustainable crop production: A review

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Abstract
The increasing food demands of a growing human population and the need for an environmentally friendly strategy for sustainable agricultural development require significant attention when addressing the issue of enhancing crop productivity. Here we discuss the role of integrated nutrient management (INM) in resolving these concerns, which has been proposed as a promising strategy for addressing such challenges. INM has multifaceted potential for the improvement of plant performance and resource efficiency while also enabling the protection of the environment and resource quality. A comprehensive literature search revealed that INM enhances crop yields by 8-150% compared with conventional practices, increases water-use efficiency, and the economic returns to farmers, while improving grain quality, soil health and sustainability. Lower inputs of chemical fertilizer and therefore lower human and environmental costs (such as intensity of land use, N use, reactive N losses and GHG emissions) were achieved under advanced INM practices without compromising crop yields.

Keywords: integrated nutrient management, organic fertilizer, chemical fertilizers, sustainable agricultural development

Introduction

Fertilizers play a vital role in crop production and productivity but continuous indiscriminate use of chemical fertilizers badly influences production potential and soil health. Subsequently, most of the productive soils became unproductive due to poor soil fertility and area under problematic soils increased due to excessive use of fertilizer. The long term use of inorganic fertilizers without organic supplements damages the soil physical, chemical and biological properties and causes environmental pollution. The decline in crop yields due to continuous use of inorganic fertilizers has been observed throughout the world. Therefore, increasing need is being felt to integrate nutrient supply with organic sources to restore to soil health. The supplementary and complementary use of organic manures and inorganic chemical fertilizers augment the efficiency of both the substances to maintain a high level of soil productivity (Shambhavi and Sharma, 2008) [9]. However, due to paucity of organic sources and their inability to meet total nutrient requirement in sustaining high level productivity, to meet the demands of fast growing population of the state and to safe guard the soil health, their integrated use with chemical fertilizers is essential.

The primary goal of integrated nutrient management (INM) is to combine old and new methods of nutrient management into ecologically sound and economically viable farming systems that utilize available organic and inorganic sources of nutrients in a judicious and efficient way. Integrated nutrient management optimizes all aspects of nutrient cycling. It enhances the availability of applied as well as native soil nutrients, synchronizes the nutrient demands of the crop with nutrient supply from native and applied sources, provides balanced nutrition to crops and minimizes antagonistic effects resulting from hidden deficiencies and nutrient imbalance. It also improves and sustains the physical, chemical and biological functioning of soil and minimizes the deterioration of soil, water and ecosystem by reducing nutrient losses. Integrated nutrient management with FYM, vermicompost, green manures along with chemical fertilizers may be an option to restore the soil health and productivity. Continuous recycling of the green manures with organic amendments enhances the organic matter content and also supplements the nutrient pool of the soil (Balwinder *et al.*, 2008) [2]

Application of chemical fertilizers, organic manures and biofertilizers hold great promise in securing high level of crop productivity with good quality and also to protect soil health from deterioration and pollution hazards. Organic manures not only act as a source of nutrients and organic matter, but also increase size, biodiversity and activity of the microbial population in soil, influence soil structure, nutrient turnover and many other related physical, chemical and biological properties of the soil. Although the organic manures contain plant nutrients in small quantities as compared to the fertilizers but the presence of growth promoting substances like enzymes and hormones, besides plant nutrient make them essential for improvement of soil fertility and productivity (Bhuma, 2001) [3]. It is also found in minimizing soil, air and water pollution. Therefore, there is a need to develop suitable integrated nutrient management technology which will go a long way in building of soil fertility and productivity.

Development of an integrated nutrient management program

The steps needed for the practical integration of nutrient management are:

Assess the nutrient status and needs of the system.

- soil nutrients
- soil type and potential for proposed cropping
- proposed cultivations
- Establish an economic threshold.

- availability of inorganic amendments
- cost of nutrient input (chemicals, manures, and labor)
- expected yield
- potential financial return

Develop a nutrient management strategy.

- minimal inorganic chemical needs and optimal timing and placement
- nutrient supply from plant inputs
- nutrient supply from animal inputs
- nutrient inputs from other potential sources of nutrients

Such an integrated nutrient management program is a critical component of the type of integrated farming systems that are essential for the development of sustainable agriculture and natural resource management (Edwards, 1989; Edwards *et al.*, 1990) [5, 6].

The basic concept underlying the integrated nutrient management is to maintain or sustain level of soil fertility to ensure plant nutrient supply in at optimum level for obtaining the desired level of crop productivity. The combination of fertilizers, manures, crop residues, composts, and biofertilizers varied according to the land use system and ecological, social and economic conditions. The integrated plant nutrient supply and management system aims at sustainable productivity with minimum deleterious effects on soil health and environment conditions. The system enhances nutrient and water use efficiency, maintains soil health and therefore increases yields and reduces cost of cultivation (Sharma *et. al.*, 2008) [10].

Effect of integrated nutrient management on physico-chemical and biological properties of soil

Weber *et al.* (2007) [14] conducted studies on long-term basis and concluded that the addition of compost improved the soil physical properties by decreasing bulk density and increasing the soil water holding capacity. Adeleye *et al.* (2010) [1] studied the effect of poultry manure (0 t/ha and 10 t/ha) on physico-chemical properties of soil in Ondo, Nigeria. It was indicated that poultry man ure application improved soil physical properties and reduced soil bulk density, temperature and also increased total porosity and soil moisture retention capacity. It also improved soil organic matter, total N, available P, exchangeable Mg, Ca, K and lowered exchange acidity. Therefore, the use of poultry manure in crop production was recommended as it will ensure stability of soil structure and improve soil organic matter status and nutrients availability. Sur *et al.* (2010) [12] while assessing the status of the availability of N, P, K and cationic micronutrients in soils in relation to 'Green Express' cabbage (*Brassica oleracea* L. var. capitata) indicated that the adoption of INM practices, in general, helped to build up soil nutrient status with respect to N, P, K, Fe, Mn, Cu and Zn contents. The treatment receiving recommended levels of N, P and K, 4 t/ha organic manures and 0.5 kg/ha Zn as Zn-EDTA proved superior in augmenting soil fertility. However, the highest organic carbon content (0.88 %) was observed in the treatment where 4 t/ha organic manure was applied along with recommended levels of NPK and zinc at 0.5 kg/ha. The amount of cationic micronutrients (Fe, Mn, Cu and Zn) in soil increased in the treatments receiving organic manure @ 4 t/ha + Zn at 0.5 kg/ha as Zn-EDTA and organic manure at 10 t/ha + Zn at 0.5 kg/ha + NPK as basal application. Ceronio *et al.* (2012) [4] analyzed soil properties after growing cabbage for two years under different organic regimes viz. chicken manure, kraal manure and compost and found their significant influence on nutrient status of the soil. Of the three manures, compost significantly affected most of the chemical properties of the soil, increasing the phosphorus, potassium, sulphur, calcium, total carbon and total cation content of the soil. Increased soil pH and decreased acid saturation was also noticed. They concluded that though two years were relatively short period, yet compost and kraal manure improved the chemical properties of soil more than chicken manure.

Effect of integrated nutrient management on plant nutrient contents and nutrient uptake

Ouda and Mahadeen (2008) [8] conducted a greenhouse experiment to study the effect of organic and inorganic fertilizers on yield and quality of broccoli (*Brassica oleracea* L. var italica*)* with four levels of manures and three levels of inorganic fertilizers. Leaf macro-nutrients (N, P and K) and micro nutrients (Fe, Mn and Zn) contents increased with the application of either organic manure or inorganic fertilizer compared to control. Zhang *et al.* (2008) [16] conducted a field experiment to study the effect of N, P and K nutrition on absorption and distribution in broccoli. The results showed that the plant accumulated more nutrients during initial period. During whole growth stage, broccoli absorbed K more than N and P. The content of NPK decreased 19.6%, 10% and 9% in leaves from bud period to harvest and the content of NPK in curd increased by 23.1%, 15.9% and 11.1% respectively in harvest period. Yildirim *et al.* (2011) [15] investigated the effects of root inoculations with biofertilizers on plant growth, nutrient uptake and yield of broccoli in comparison with manure (control) and mineral fertilizers application under field conditions. Bacterial inoculations with manure significantly increased yield, plant weight, head diameter, N, P, K, Ca, S, P, Mg, Fe, Mn, Zn and Cu content of broccoli. Bacterial inoculations with manure significantly increased uptake of macro and micronutrients by broccoli.

Effect of integrated nutrient management on benefit- cost (B: C) ratio

Sharma *et al.* (2005) [11] conducted a field experiment to study the response of broccoli (*Brassica oleracea* L. var. *italica* cv. Palam Smridhi) to integrated use of chemical fertilizers and FYM. There were eight treatments (0, 50, 75,100, 125, and 150% of RD of NPK along with FYM at 20 t/ha, 100% NPK alone and a control. The highest net returns (Rs 132 220/ha) were recorded in 150% NPK+20 t FYM/ha with benefit cost ratio of 3.27. Khan *et al.* (2009) [7] studied the response of organic and inorganic manures on yield and economic feasibility in broccoli var. Aishwarya. The application of vermicompost 2.5 t/ha plus half NPK (75:60:60 kg/ha) recorded maximum net return (Rs 136552) and B.C ratio (4:1). They concluded that productivity of broccoli could be managed profitably with combined application of chemical fertilizers and vermicompost or FYM. Wani *et al.* (2011) [13] assessed twelve treatment combinations involving organic and inorganic on cauliflower cv. Snowball-16. Among the organic manures, poultry manure in combination with chemical fertilizers proved superior to sheep manure, FYM, pea straw and mixture of organic manures. Combined application of organic manures and

inorganic fertilizers gave early crop as compared to their sole application. The maximum gross income of Rs 2, 27,570/- and net income Rs 1, 78,096/- per hectare with highest benefit cost ratio (3.59) was obtained by the treatment combination of 50% PM+50% RDF.

Conclusion

There is an urgent need to adopt an integrated nutrient supply and management system for promoting efficient and balanced use of nutrients. While the main emphasis was given on increasing the proper and balanced use of mineral fertilizers, the role of organic manures, biofertilizers, green manuring, and recycling o organic wastes should be considered supplementary.

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