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Effect of integrated nutrient management (INM) with special reference to floricultural crops: A review

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Abstract
Sustainable agriculture has become a burning issue due to “energy crisis” and “environmental protection”. One aspect of sustainable agriculture is Integrated Nutrient Management (INM) (Wani *et al.*, 2017). Integrated Nutrient Management (INM) involves conjugative use of inorganic fertilizers, organic manure and biological source of nutrients. The productivity and quality of flowers is greatly influenced by the quantity and source of nutrients. At present, these nutrients are primarily supplied through chemical fertilizers. The indiscriminate use and complete reliance on the use of chemical fertilizers has also led to deterioration of soil health, thereby affecting sustainable flower production. INM holds great promise in exhibiting the growing nutrient demands of intensive farming like Floriculture and maintaining productivity at its optimum with holistic improvement in the quality of resource base, which is very much important in-case of cut and bulbous flowers. Investigations by many researchers have revealed the beneficial influence of INM, on vegetative (plant height, leaf area, leaf number), floral (first bud appearance, floral diameter, weight of flower) and yield attributes (seed weight, seed production) of many flower crops, reduced the cost of fertilizer inputs and increased the B/C ratio, despite maintaining a good soil physico-chemical environment (Wani *et al.*, 2017). Use of different sources of nutrients in an integrated manner helps to produce sustainable yields with good quality flowers and also maintains soil health (Angadi, 2014). Therefore, by reducing the level of chemical fertilizer and optimizing the dose of different organic fertilizer can improve the yield in ornamental crops and improve soil health as well (Jayoti *et al*., 2014).

Keywords: INM, flower, sustainable, quality, organic, fertilizer

Introduction

Floriculture is a branch of horticulture concerning cultivation of flowering and ornamental plants for gardens and floristry. It includes cut flowers, cut greens, bedding plant, houseplants, flowering garden and potted plants etc. The rising living standards and unabated urbanization in the present day the world has led to growing demand of flowers and their products thereby making the floriculture an important commercial trade. Commercial floriculture has higher potential per unit area than the field crops and is therefore evolving as a lucrative business all over the world (Misra and Sudip, 2016). The area and under floriculture in India are about 253.65 thousand hectare with production of 1.652 million tonnes loose flowers and 76.73 million tonnes cut flowers (NHB, 2012). Indian floriculture industry stands 2nd in world production (Shilpa and Narpat, 2016) and occupies 51Ist in terms of exports and contributes rupees 455 crores which is 0.06 percent of global trade (De and Singh, 2016). There is as such an urgent need of scientific approach and wise use to promote the relevant management practices, improvement of flower germplasm, balanced nutrient management, modern production technology, quality planting material, precision farming etc., for conservation and commercialization of the floriculture industry and diversification from the traditional field crops due to higher returns per unit area. The overall strategy for increasing crop yields and sustaining them at high level must include integrated approach to the management of nutrients. The sustainability in agriculture system is a global issue. Integrated nutrient management program is a critical component of the type of integrated farming systems (Edwards *et al.*, 1990). The program involves maximize biological inputs to crop production and minimize the use of inorganic amendments so as to create a much more sustainable pattern of crop production, not only ecologically but also environmentally (National Research Council, 1991). Since the nutrient turnover in soil plant system is considerably high in intensive farming, integrated approach of chemical, organic and biological sources can achieve sustainable production. Practice of INM is the better option for the improvement of physical, chemical and biological properties of soils (Das *et al.,* 2015). To maintain productivity and reduce dependence on chemical fertilizers alone is increasingly becoming important to flower growers. It is important to exploit the potential of organic manures, composts, crop residues, biofertilizers and their synergistic effect with chemical fertilizers for increasing balanced nutrient supply (Wani *et al.,* 2016). This kind of intervention is of paramount importance in horticulture in general and ornamentals in particular. The use of biofertilizers reduces per unit consumption of inorganic fertilizers and increase the quality and quantity of flower (Syamal *et al.,* 2006). The growth and quality of flower are greatly influenced by numerous environmental factors like soil type and nutrient availability being the most essential factors for appropriate growth (Tariq *et al.,* 2012). The quality and production of cut flowers is primarily a varietal trait, it is greatly influenced by climatic, geographical and nutritional factors. The quality and quantity of applied fertilizer are the key factor affecting the growth, yield and quality of the cut flower (Dufour and Gue¡rin, 2005). The quality of flowers is influenced both by quantity and source of nutrients as well.

In India, there is a profitable production system for standard crops like gladiolus, mums, carnations, tuberose and roses. The domestic flower consumption as well as market, though not nearly as demanding as the international market, has incredible potential for expansion. (1) The quality and quantity of applied fertilizer are the key factor affecting the growth, yield and quality of the cut flower. (2) Use of high yielding varieties and other management practices aimed at higher production from unit area involves a high application rate of nutrients and excess amount of fertilizer that leaches from the soil affects quality for both the environment and human health. (3) The sustainability in agriculture system is a global issue. Practice of INM is the better option for the improvement of physical (structure and water retention capacity), chemical (nutrients and cation exchange capacity) and biological (microflora and microfauna) properties. (4) Further, it has been proved time and again under a limited range of soil organic matter contents, the crops yield for a given soil increases with the increase in soil organic matter. (5) To maintain productivity and reduce the application of chemical fertilizers is increasingly becoming important to flower growers. However, little information is available concerning flower production using organic fertilizer, even now when the concern is being raised more often (Jayoti *et al.*, 2014).

What is INM?

"Integrated nutrient management means combined application of different sources of plant nutrients like organics, inorganic and bio fertilizers for sustainable crop production without degrading the natural resources on long term basis."

The basic concept underlying the integrated nutrient management system (INMS), nevertheless, remains the maintenance and possible improvement of soil fertility for sustained crop productivity on long term-basis and also to reduce inorganic (fertilizer) input cost. The three main components of INMS as defined by FAO, 1998 are:

1. Maintain or enhance soil productivity through a balanced use of fertilizers combined with organic and biological sources of plant nutrients.
2. Improve the stock of plant nutrients in the soils.
3. Improve the efficiency of plant nutrients, thus, limiting losses to the environment.

Thus, integrated nutrient supply/management (INS) aims at maintenance or adjustment of soil fertility and of plant nutrient supply to an optimum level for sustaining the desired crop productivity through optimization of benefit from all possible sources of plant nutrients in an integrated manner (Roy and Ange, 1991).

Requirement of a crop for a nutrient is decided by the rooting behaviour and its mining ability, the native soil status, the potential yields as decided by the soil-agro climatic situations, the targeted yields and nutrient management.

While fertilizer misuse can contribute to environmental contamination, it is often an indispensable source of the nutrients required for plant growth and food production. Unless all the soil nutrients removed with the harvested crops are replaced in proper amounts from both organic and sustained; soil fertility will decline. If in the past, the emphasis was on increased use of fertilizer; the current approach should aim on educating farmers to optimize use of organic, inorganic and biological fertilizer in an integrated way. Plant nutrition in the present day requires judicious and integrated management of all sources of nutrients for sustainable agriculture.

Therefore, an INMS is the most efficient and practical way to mobilize all the available, accessible and affordable plant nutrient sources in order to optimize the productivity of the crops/cropping systems and economic return to the farmer. Three years data collected from 267 sites in India under different crops convincingly show a 22% increase in yield by following INM rather than farmer's practice (Govil and Kaore, 1997).

Importance of INM

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, 1995a). Rather than focusing nutrition management practices on one crop, INM aims at optimal use of nutrient sources on a cropping-system or crop-rotation basis. This encourages farmers to focus on long-term planning and make greater consideration for environmental impacts.

INM relies on a number of factors, including appropriate nutrient application and conservation and the transfer of knowledge about INM practices to farmers and researchers. Boosting plant nutrients can be achieved by a range of practices covered in this guide such as terracing, alley cropping, conservation tillage, intercropping, and crop rotation. Given that these technologies are covered elsewhere in this guidebook, this section will focus on INM as it relates to appropriate fertilizer use. In addition to the standard selection and application of fertilizers, INM practices include new techniques such as deep placement of fertilizers and the use of inhibitors or urea coatings (use of area coating agent helps to reduce the activity and growth of the bacteria responsible for de nitrification) that have been developed to improve nutrient uptake.

Key components of the INM approach include

1) Testing procedures to determine nutrient availability and deficiencies in plants and soils. These are:
   - Plant symptom analysis – visual clues can provide indications of specific nutrient deficiencies. For

example, nitrogen deficient plants appear stunted and pale compared to healthy plants
- Tissue analysis and soil testing – where symptoms are not visible, post-harvest tissue and soil samples can be analysed in a laboratory and compared with a reference sample from a healthy plant

2) Systematic appraisal of constraints and opportunities in the current soil fertility management practices and how these relate to the nutrient diagnosis, for example insufficient or excessive use of fertilisers.
3) Assessment of productivity and sustainability of farming systems. Different climates, soil types, crops, farming practices, and technologies dictate the correct balance of nutrients necessary. Once these factors are understood, appropriate INM technologies can be selected
4) Participatory farmer-led INM technology experimentation and development. The need for locally appropriate technologies means that farmer involvement in the testing and analysis of any INM technology is essential.

Components of INM

Manure

Manures are the organic materials which improve soil fertility when incorporate into the soil. They are made up of animal remains and dead plants and contain more than one nutrient element. Concentration of nutrient in organic manure is low.

Advantages of manure

- They improve soil physical properties like structure, water holding capacity.
- To increase availability of nutrients.
- They prevent the loss of nutrients by leaching or erosion.
- Manures supply, plant nutrients including micro-organisms.

a. Bulky organic manure

Bulky organic manures contain small percentage of nutrients and they are applied in large quantities. Farmyard manure (FYM), compost and green-manure are the most important and widely used bulky organic manures.

b. Concentrated organic manure

Concentrated organic manures have higher nutrient content than bulky organic manure. The important concentrated organic manures are oilcakes, blood meal, fish manure etc. These are also known as organic nitrogen fertilizer. Before their organic nitrogen is used by the crops, it is converted through bacterial action into readily usable ammoniacal nitrogen and nitrate nitrogen. These organic fertilizers are, therefore, relatively slow acting, but they supply available nitrogen for a longer period.

Table 1: Nutrient Contents of Organic Manures

Organic Manure	N %	P2O5 %	K2O %
Bulky organic manures			
Cattle dung	0.40	0.20	0.17
Poultry manure	3.03	0.63	1.40
Farmyard manure	0.50	0.25	0.50
Rural compost	0.75	0.20	0.50
Urban compost	1.75	1.00	1.50
Vermicompost	3.00	1.00	1.50
Concentrated organic manure			
Castor cake	4.37	1.85	1.39
Coconut cake	3.00	1.80	1.90
Neem cake	5.22	1.08	1.48
Blood meal	12.00	2.00	1.00
Groundnut cake	7.30	1.50	1.30
Pressmud	2.10	4.40	0.80

Green Manure

Green undecomposed material used as manure is called green manure. It is obtained in two ways: by growing green manure crops or by collecting green leaf (along with twigs) from plants grown in wastelands, field bunds and forest.

Green Manuring

Green Manuring is the practice of growing in the field, plants usually belonging to leguminous family and incorporating into the soil after sufficient growth. The plants which are grown for green manure are known as green manure crops. The most important green manure crops are Sunnhemp, dhaincha, *Pillipesara,* Clusterbeans and *Sesbania rostrata.*

Green leaf Manuring

Application of green leaves and twigs of trees, shrubs and herbs collected from elsewhere is known as green leaf Manuring. Forest tree leaves are the main sources for green leaf manure. Plants growing in wastelands, field bunds etc., are another source of green leaf manure. The important plant species useful for green leaf manure are Neem, Mahua, wild indigo, Glyricidia, Karanji (*Pongamia glabra*) calotropis, avise (*Sesbania grandiflora*), subabul and other shrubs.

Advantages of green manure

- Green Manuring improves soil structure, increases water holding capacity and decreases soil loss by erosion.
- Growing of green manure crops in the off season reduces weed proliferation and weed growth.
- Green Manuring helps in reclamation of alkaline soils. Root knot nematodes can be controlled by green Manuring.

Bio-fertilizers

Bio-fertilizers may be defined as preparations containing living cells or latent cells of efficient strains of microorganisms that help crop plants' uptake of nutrients by their interactions in the rhizosphere when applied through seed or soil. They accelerate certain microbial processes in the soil which augment the extent of availability of nutrients in a form easily assimilated by plants. Very often microorganisms are not as efficient in natural surroundings as one would expect them to be and therefore artificially multiplied cultures of efficient selected microorganisms play a vital role in accelerating the microbial processes in soil. Use of bio-fertilizers is one of the important components of integrated nutrient management, 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. They can be grouped in different ways based on their nature and function.

Table 2: Different groups of Bio-fertilizers based on their nature and function

Sl. No.	Groups	Examples
N_2 fixing Bio-fertilizers		
1.	Free-living	*Azotobacter, Beijerinkia, Clostridium, Klebsiella, Anabaena, Nostoc,*
2.	Symbiotic	*Rhizobium, Frankia, Anabaena azollae*
3.	Associative Symbiotic	*Azospirillum*
P Solubilizing Bio-fertilizers		
1.	Bacteria	*Bacillus megaterium* var. *phosphaticum, Bacillus subtilis, Bacillus circulans, Pseudomonas striata*
2.	Fungi	*Penicillium sp, Aspergillus awamori*
P Mobilizing Bio-fertilizers		
1.	Arbuscular mycorrhiza	*Glomus sp., Gigaspora sp., Acaulospora sp., Scutellospora sp.* & *Sclerocystis sp.*
2.	Ectomycorrhiza	*Laccaria sp., Pisolithus sp., Boletus sp., Amanita sp.*
3.	Ericoid mycorrhizae	*Pezizella ericae*
4.	Orchid mycorrhiza	*Rhizoctonia solani*
Biofertilizers for Micro nutrients		
1.	Silicate and Zinc solubilizers	*Bacillus* sp.
Plant Growth Promoting Rhizobacteria		
1.	Pseudomonas	*Pseudomonas fluorescens*

Advantages of bio-fertilizers
1. They are biodegradable.
2. They do not Pollute soil and water resources.
3. They are less expensive.
4. Increase the grain yields by 10-40%.
5. Improve texture, structure and water holding capacity of soil.
6. No adverse effect on plant growth and soil fertility.
7. Replace 25-30% chemical fertilizers.

Bio-fertilizers used in floriculture
1. *Azospirillum*: *Azospirillum* is applied in several crops such as Marigold, Rose, Tuberose, Gladiolus, Chrysanthemum, Dahlia, etc.
2. *Azotobacter*: *Azotobacter* is being applied in flower crops including Marigold, Rose, Gladiolus, Chrysanthemum, Dahlia, etc.
3. Phosphate Solubilising Bacteria: PSB is applied in Rose, China Aster, Gladiolus, Tuberose, etc.
4. Vesicular-arbuscular Mycorrhizae (VAM): VAM is applied in flower crops such as Crossandra, China Aster, Marigold, Gladiolus, Chrysanthemum, Tuberose, etc.

Chemical Fertilizers
A fertilizer is any material of natural or synthetic origin that is applied to soils or to plant tissues (usually leaves) to supply one or more plant nutrients essential to the growth of plants.
Fertilizer is a rich source of nutrient and applied in order to supply a particular nutrient in which the soil is deficient.

Table 3: Chemical composition of major fertilizers

Fertilizer	N (%)	P (%)	K (%)	S (%)	Others
Urea	46	-	-	-	-
Ammonium sulphate	20.6	-	-	24	-
DAP	18	46	-	-	-
SSP	-	16	-	12	18(Ca)
MOP	-	-	60	-	-
Zinc sulphate	-	-	-	17	36(Zn)

Steps of integrated nutrient management
According to Singh and Biswas (2000), there are certain steps which are being followed in INM, which includes:
- To assess on farm and off farm resources
- Fixing yield target
- Estimation of nutrient requirement
- Integration of nutrient resources available with farmers to finalize probable best combination to meet nutrient requirement
- To determine time, method, mode of application considering type of crop
- To adopt efficient soil and water conservation measures to check soil erosion, soil organic carbon and nutrient losses and to facilitate in situ moisture availability
- Monitoring of soil fertility in terms of soil physical, chemical & biological properties & process

Advantages of integrated nutrient management
- Provides balance nutrition to the plants.
- Helps in the improvement of soil physical properties.
- Acts as reservoir of soil nutrients.
- Minimizes soil deterioration.
- Availability of soil nutrients to the plants.

Effect of INM on some flowers
- Singh (2007) [5] reported application of FYM + remaining required dose of NPK by chemical fertilizers with Azotobacter gave better growth, flowering & yield.
- Waheeduzzama *et al.* (2007) [7] proved Panchagavya at 4% foliar spray + RDF is optimum for growth & yield of Anthurium.
- Shankar *et al.* (2010) [6] revealed Single Tuberose when grown with vermicompost & PSB @ 1kg/m^2 & 2g/bulb, respectively produced highest spike length, maximum number of spikes/plant, weight of bulbs/plant & longevity of spikes.

Future line of work
- More emphasis on INM research with flower crops.

- Benefits of INM to be quantified.
- Awareness and popularising about various INM practices.
- Development of various INM models for flower production.

Conclusion
INM is an integrated process of combining various sources of nutrients for providing a balanced nutrition to the plants. As a result of adoption of INM

- Helps in both enhanced and sustainable production.
- Integration protects and improves soil health & crop productivity.
- More and more intensive research on varied INM components needed.

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