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Effect of Integrated Sources of Nutrients on Growth, Flowering, Yield and Soil Quality of Floricultural Crops: A Review

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A B S T R A C T

Now a days agriculture is getting more and more dependent upon the supply of synthetic inputs such as chemical fertilizers, pesticides etc. which are inevitable to meet food demand for growing population in the world. However, excessive, imprudent and imbalanced use of inputs may throw devastating impacts on the water, air and soil environments. Probably the soil environment is the most vulnerable to the direct effects of these practices in modern agriculture. They could destroy the fertility of the soil in a long run which compels the scientific community to look for the alternatives like organic farming and integrated use of organic and inorganic fertilizers. In the present review, we discuss the role of INM in resolving these concerns, which has been proposed as a promising strategy for addressing these 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. 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 any negative effect on crop yields. An available comparative literature research revealed that INM increases crop growth and yield of floricultural crops as compared with conventional methods. INM practices increases nutrients use efficiency and improving soil health and sustainability. Strong and convincing evidence indicates that INM practice could be an innovative and environment friendly practice for sustainable growth and yield of floricultural crops.

Keywords

Organic manure, Inorganic fertilizers, Bio-fertilizers, INM, Soil quality, Flowers

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Introduction

Floriculture is the segment of horticulture concerned with commercial production, marketing, and sale of bedding plants, cut flowers, potted flowering plants, foliage plants, flower arrangements, and non-commercial home gardening. Floriculture crops include bedding plants, flowering plants, foliage plants or house plants, cut cultivated greens, and cut flowers. As distinguished from nursery crops, floriculture crops are generally herbaceous. Bedding and garden plants consist of young flowering plants (annuals and perennials) and vegetable plants. They are grown in cell packs (in flats or trays), in pots, or in hanging baskets, usually inside a controlled environment, and sold largely for gardens and landscaping. Geraniums, impatiens, and petunias are the best-selling bedding plants. Floriculture is an ancient farm activity with immense potential for generating remunerative self-employment among small and marginal farmers. Flowers are being cultivated in India from time immemorial. Since ancient times ornamental plants have been an integral part of life with gardens, flowers, and ornamental horticulture being noted in most of our historical references.

According to The International Association of Horticultural Producers (AIPH, 2010), 702,383 ha area was under flower production in different countries of the world, of which the total area in Europe was 48,705 ha, 1,067 ha in North America, 523,829 ha in Asia, 4,026 ha in middle East, 7,604 ha in Africa, 21,067 ha in North America and and South America, it was the 97,152 ha. The total area under floriculture in India is 248.51 thousand hactare with production of 1685 thousand tonnes loose flowers and 472 thousand tonnes of cut flowers during 2014-15 (www.apeda.gov.in). Total export of floriculture products during the year 2015-16 was 22,518 MT with value of Rs. 479 crores (www.apeda.gov.in). To increasing the production and get more income by flower production in the country, 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 (Wani *et al.*, 2017). Integrated nutrient management (INM) programme 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). Integrated Nutrient Management in floricultural crops is very important to address the issues like poor quality of cut flowers and planting material, inappropriate planting methods and fertilization practices which result in low yield and production.

One of the factors affecting the productivity of most of the floricultural crops is improper use of nutrients. To improve the productivity, adequate amount of fertilizers in balanced proportion should be used which has been given less attention by the flower growers or floriculturists.

Why integrated nutrient management is needed in floricultural crops?

INM is very essential to address the following issues:

The decline in productivity can be attributed to the appearance of deficiency in secondary and micronutrients.

The physical condition of the soil is deteriorated as a result of long-term use of chemical fertilizers

The recent energy crisis, high fertilizer cost and low purchasing power of the farming community have made it necessary to rethink alternatives.

Unlike chemical fertilizer, organic manure and bio-fertilizer are available locally at cheaper rates

Principles of Integrated Nutrient Management (INM)

The main principle of INM is to maximize biological potential for improving crop productivity and resources use efficiency through root zone/rhizosphere management. Plant roots take up nutrients from soils via the rhizosphere, a narrow zone of the soil that is directly influenced by root growth, root secretions, and associated soil microorganisms (Zhang *et al.,* 2012). The rhizosphere is the important interface where interactions among plants, soils, and microorganisms occur and is a "bottleneck" controlling nutrient transformations, availability, and flow from soils to plants. Therefore, the chemical and biological processes occurring in the rhizosphere determine the mobilization and acquisition of soil nutrients together with microbial dynamics, and also control NUE by crops, and thus profoundly influence cropping system productivity and sustainability (Zhang *et al.*, 2004, 2010, 2011, 2012).

The principle of INM is to control the N losses and their harmful environmental effects, while achieving high crop productivity (Gruhn *et al.*, 2000). The fate of N in field is an integrated consequence of crop N uptake, immobilization and residues in the soil, and N losses to the environment, such as ammonia volatilization, NOX emissions, denitrification, N leaching and runoff (Witt *et al.*, 2004).

Advantages of INM

Enhances the availability of applied as well as native soil nutrients

Synchronizes the nutrient demand of the crop with nutrient supply from native and applied sources.

Provides balanced nutrition to crops and minimizes the antagonistic effects resulting from hidden deficiencies and nutrient imbalance.

Improves and sustains the physical, chemical and biological functioning of soil.

Minimizes the deterioration of soil, water and ecosystem by promoting carbon sequestration, reducing nutrient losses to ground and surface water bodies and to atmosphere

Disadvantages of INM

Organic sources used in INM are comparatively low in nutrient content, so larger volume is needed to provide enough nutrients for crop growth.

The nutrient composition of compost and FYM is highly variable; the cost is high as compared to chemical fertilizers.

Components of INM

Organic manures

Organic manures are valuable by-products of farming and allied industries, derived from plant and animal sources. These manures have the advantage of supplying secondary and micro nutrient along with NPK, which is important for sustained production

Farm Yard Manure (FYM)

FYM is a decomposed mixture of dung and urine of farm animals along with the litter (bedding material) and left-over material from roughages or fodder fed to the cattle. On an average, it contains 0.5% N, 0.2% P_2O_5 and 0.5% K_2O

Enriched organic manure

The enriched farmyard manure is prepared by using 10 kg of rock phosphate and 10 kg of each biofer- tilizers viz., *Azospirillum*, Azotobacter and Phosphobacteria is thoroughly mixed with 1000 kg of decom-posed and powdered farmyard manure on dry weight basis and made into a heap like structure. The heap is kept for 60 days for composting under the shade with 60% moisture. For enriched poultry manure compost, 20 kg of rock phosphate and 10 kg of each biofertilizers viz., *Azospirillum*, Azotobacter and Phosphobacteria are thoroughly mixed with 1000 kg of poultry manure on dry weight basis and made into a heap like structure. The heap is kept for 60 days for composting under the shade with 60% moisture (Sims *et al.*, 1992)

Vermicompost

Compost made from the biological activity of earthworms. It contains 1.9% N, 2.0% P and 0.8% K, 100 mg/Kg Cu and 500 mg/kg Mn. Earthworms effectively harness the beneficial soil micro flora, destroy soil pathogens and convert organic wastes into valuable products known as cast which contains biofertilizers, vitamins, enzymes, antibiotics, growth hormones and proteinaceous worm biomass. Hence, earthworms are called as 'artificial fertilizer factories'. The exotic species used for making vermicompost are *Eisenia foetida*, *Eudrillus euginiae* and *Perionyx excavatus*, while indeginous species include *Lampito mauriti*, and *Perionyx sansibaricus*

Poultry manure

It is rich organic manure, since liquid and solid excreta are excreted together resulting in no urine loss.

Green Manuring

Green manure crops are grown usually for restoring or enhancing soil organic matter content, properties of soil and nitrogen content in the soil and their use in cropping system is called green manuring. Legumes are generally used as green manure crops due to their ability to fix atmospheric nitrogen in the root nodules through symbiotic association with a bacterium

According to the Chandra (2005), there are different green leaf manure crops that can be cultivated and they are:

Cowpea

Cowpea is one of the important leguminous green leaf manure crops. As this plant is easily decomposable and very well suited for green manure purpose. June-July months are best suited for sowing of this manure. Even though it is being cultivated in summer months (March to April). Use of effective *Rhizobium* bacteria increase the fixation of nitrogen up to 40 kg/ha.

Dhaincha (*Sesbania aculeate*)

Dhaincha is suitable for loamy and clayey soils. It is fairly resistant to drought as well as stagnation of water. It grows well even in alkaline soils and corrects alkalinity if grown repeatedly for 4-5 years. The roots have plenty of nodules. It yields about 10-15 tonnes of green manure per ha and requires a seed rate of 30-40 kg/ha. Use of effective Rhizobium strain with seeds fixes the Nitrogen 1 kg/day.

Sesbania Speciosa

It is a valuable green manure for wetlands and can be grown in a wide range of soils. Seed production is prolific however, its pods are frequently attacked by insects. This green manure can be raised on the field borders. Sesbania seedling (21days) can be planted in a single line at 5-10 cm apart in the borders of the fields. In about 90 days it produces about 2-4 tonnes of green manure per ha. It does not affect the rice yield by shading or root effect. If second rice crop is planted immediately after the first crop, the manure can be incorporated into the field. About 300-400g of seeds are sufficient to raise nursery foe one ha area. To control insects *Verticillium lacanii* (Liquid) fungi is useful.

Sunnhemp (*Crotalaria juncea*)

It is a quick growing green manure crop and gets ready for incorporation in about 45 days after sowing. It does not withstand heavy irrigation leading to flooding. The crop is at times subject to complete damage by leaf eating caterpillars.

The crop can produce about 8-12 tonnes of green biomass per ha. The seed requirement is 30 kg/ha.

Sesbania rostrata

One of the important features of this green manure is to produces nodules in the stem in addition to root nodules. The stem nodulation is an adaptation for waterlogged situation since flooding limits growth of green manures and may reduce root nodulation. Under normal condition, both root and stem nodules are effective in N fixation. It has higher N content of 3.56% on dry weight basis. Biomass production is higher during summer (April – June) than in winter (Dec. – Jan.) season. This green manure can also be produced by raising seedlings (30 days old) and planted in the paddy field along the bunds or as intercrop with rice. Use of *Rhizobium* bacteria increase the nitrogen fixation (60-100 kg/ha/year).

Wild Indigo (*Tephrosia purpurea*)

This is a slow growing green manure crop and cattle do not prefer to graze it. The green manure is suitable for light textured soils, particularly in single crop wetlands. It establishes itself as a self-sown crop and the seeds remain viable till the harvest of rice. On an average about 3-4 tonnes of green manure is obtained in one ha. The seed rate is 30 kg/ha. The seeds have a waxy impermeable seed coat and hence scarification is required to induce germination. Soaking seeds in boiling water for 2-3 minutes is also equally effective in promoting germination.

Indigo (*Indigofera tinctoria*)

It resembles wild indigo and is a long duration crop with more leafy growth. It comes up well in clayey soils with one or two irrigations.

Pillipesara (*Pheseolus trilobus*)

This is a dual purpose crop yielding good fodder for the cattle and green manure. Pillipesara comes up well in hot season with sufficient soil moisture. Loamy or clayey soils are best suited.

After taking one or two cuttings for fodder or light grazing by animals, the crop can be incorporated into the soil. About 5-8 tonnes of manure can be obtained from one ha.

Glyricidia (*Glyricidia maculeata*)

This is a shrubby plant that comes up well in moist situations. Under favourable conditions, it grows well like a tree. It can be easily grown in waste lands, farm road sides, field bunds, etc.

The crop can be established by stem cuttings or seedlings. It is planted on the field borders. It can be pruned for its tender loppings and compound leaves for green leaf manuring at the time of puddling rice. On an average, a well-established plant yields 12-15 kg green matter. About 400 plants on the peripheral bunds yields 5-6 tonnes green manure/ha.

Karanj (*Pongamia glabra*)

It is a leguminous tree grown in wastelands. On an average, a tree can yield 100-120kg of green matter. The leaves contain about 3.7% N (on dry weight basis).

Calatropis (*Calotropis gigantca*)

On roadsides and fallow lands, the plant grows wild under different soil and climatic conditions. The leaves are more succulent and a plant can produce about 4-5 kg of green matter. Besides, it also helps in controlling soil born pests like termite

Oil cakes

Many kinds of oilcakes can be used in crops as a source of nutrients. Nutrients present in oil cakes, after mineralization, are made available to crops 7 to 10 days after application. Before application to the flowering crop, oilcakes should be well-powdered to facilitate their application and decomposition by soil microorganisms. Depending on crop, oilcakes are applied broadcast, drilled or placed near the root zone. The oil cakes are of two types.

Edible oil cakes which can be safely fed to livestock; e.g.: Groundnut cake, Coconut cake, Niger cake, Rape seed cake, Sesame cake etc.

Non edible oil cakes which are not fit for feeding livestock; e.g.: Castor cake, Neem cake, Mahua cake, Safflower cake etc

Biogas slurry

Biogas (Gobar gas) plant produces methane and biogas slurry, which could be used as a valuable manure in bulbous flower crops. Biogas slurry is quite rich in nitrogen than the original ingredients due to addition of living and dead micro-organisms. Biogas slurry also contains phosphates, potash, sulphur and a number of micro-nutrients like zinc and iron. Biogas slurry is extremely cheap and is made by locally available material. It can be directly used in rice after mixing with irrigation water.

Urine

Animal urine is a very good source of nitrogen, because 60% of the nitrogen excreted is found in urine and only 40% in manure. As few as two cattle can save the cash equivalent of purchasing about 100kg of urea per year. Urine can be applied directly as liquid fertiliser (WOCAT, 2008).

Liquid manures

These can be made using fresh plant material (plant tea), compost (compost tea) or fresh animal manure (manure tea). Manure tea and plant tea are both rapid sources of nitrogen, while compost tea is a more nutritionally balanced liquid fertiliser.

Plant tea

Fresh and green material is soaked in water for several days or weeks to undergo fermentation. Nutrient- or nitrogen-rich material should be used.

Ashes

The ashes of burnt organic material are often also used as organic fertiliser. Ash provides a rapid supply of phosphorous; however burning organic material also includes a loss of other nutrients and thus has severe long-term consequences.

Biofertilizers scenario

The biofertilizers market is projected to grow at a CAGR of 14.08% from 2016, to reach USD 2,305.5 million by 2022 (Biofertilizers

Market Analysis, Grand View Research, San Francisco, USA). The market is driven by factors such as: i) increase in demand for fertilizers due to the rise in global food production and ii) development of new biofertilizer manufacturing technologies. The high growth potential in emerging markets and untapped regions provide new growth opportunities for the players in the biofertilizers market.

On the other hand, some factors restraining the biofertilizers market are lack of awareness and low adoption of biofertilizers coupled with poor infrastructure. Although biofertilizers were first commercialized in North America and Europe, there is increasing preference towards their use in parts of Asia Pacific and South America. North America was the largest market for biofertilizers, followed by Europe. Together these markets accounted for over 50% of the global revenue.

Asia Pacific is the third largest market for biofertilizers, with increased demand from regional markets such as India, China and Taiwan. Asia Pacific is expected to witness double-digit growth over the period 2013 to 2020 due to the increased consumer preference towards organic food and growing agricultural activities. However, contrary to other regions, the key application of biofertilizers in Asia Pacific is soil treatment but not seed treatment.

In India, during the 2008-09, the production of bio-fertilizers was 25065.035 ton which increased to 20040.36 and 37997.61ton in 2009-10 and 2010-11 and reached 80696.46 ton in 2014-15 (NCOF, 2014 and 2015). It is estimated that the present requirement of biofertilizers is around 5,50,000 metric tonnes and there is an ample potential to increase it to 50,000-60,000 tons by 2020 (Pindi and Satyanarayana, 2012); however, the total production of biofertilizers in our country is much less than requirement which points out the inevitability of increase in biofertilizer production. Biofertilizers can be grouped in to five catagories (Barman *et al.,* 2017)

Nitrogen (N_2) fixing Biofertilizers: It can be sub group in three category

Free-living- Example, *Azotobacter*, *Clostridium*, *Anabaena*, Nostoc

Symbiotic - Example, *Rhizobium*, *Frankia*, *Anabaena azollae*

Associative Symbiotic- Example, *Azospirillum*

P-solubilizing biofertilizers

Bacteria- Example, *Bacillus megaterium* var. *phosphaticum*, *Bacillus circulans*, *Pseudomonas striata*

Fungi- Example, *Penicillium sp*., *Aspergillus awamori*

P-mobilizing biofertilizers

Arbuscular mycorrhiza- Example, *Glomus sp*., *Gigaspora sp*., *Acaulospora sp*., *Scutellospora sp*., *Sclerocystis sp*.

Ectomycorrhiza –Example, *Laccaria sp., Pisolithus sp., Boletus sp., Amanita sp.*

Orchid mycorrhiza – Example, *Rhizoctonia solani*

Biofertilizers for micro nutrients

Silicate and zinc solubilizers-Example, *Bacillus sp.*

Plant growth promoting *Rhizobacteria*

Pseudomonas- Example, *Pseudomonas fluorescens*

Application of biofertilizers

Seed treatment was the largest application of biofertilizers and accounted for over 70% of the market in 2012. Treating seeds with biofertilizers helps them sustain bacteria and virus attacks and also helps increasing the yield. In addition, biofertilizers help in harnessing atmospheric nitrogen and making it available to the plant. Seed treated with biofertilizers are capable of increasing phosphorous content of soil by solubilizing it and improving availability. Soil treatment is the other primary application of biofertilizers and it involves the spraying of biofertilizers over the agricultural land. It increases the fertility of the soil and improves the yields of the planted crop.

Biofertilizers

It is well known fact that some biofertilizers fixed the atmospheric N and can be increased by organisms such as *Rhizobium, Azotobacter,* blue green algae, *Azolla/Anabaena* (Gaur and Singh, 1995). The commonly used organic fertilizers/biofertilizers are as follows

Azotobacters and *Azospirillum*

These are free-living bacteria that fix atmospheric nitrogen in cereal crops without any symbiosis and they do not need a specific host plant. Azotobacters are abundant in well drained and neutral soil. They can fix 15-20 kg/ha N per year. *Azotobacter* sp. can also produce antifungal compounds to fight against many plant pathogens.

Rhizobia

Rhizobia are symbiotic bacteria that fix atmospheric N_2 gas in plant root nodules and have a mutually helpful relationship with their host plants. The plant roots supply essential minerals and newly synthesized substances to the bacteria. Rhizobium inoculation is a well-known agronomic practice to ensure adequate N supply for legumes in place of N fertilizer

Plant growth promoting rhizobacteria (PGPR)

PGPR represent a wide variety of soil bacteria which, when grown in association with a host plant, result in stimulation of host growth. PGPR modes include fixing N_2, increasing the availability of nutrients in the rhizosphere, positively influencing root growth and morphology and promoting other beneficial plant–microbe symbioses. Some researchers have indicated that PGPR will often have multiple modes of action. Ratti *et al.,* (2001) found that a combination of the arbuscular mycorrhizal fungi *Glomus aggregatum*, the PGPR *Bacillus polymyxa* and *Azospirillum brasilense* maximized biomass and P content of the aromatic grass palmarosa (*Cymbopogon martinii*) when grown with an insoluble inorganic phosphate.

Phosphate-solubilizing bacteria (PSB)

Under acidic or calcareous soil conditions, large amounts of phosphorus are fixed in the soil but are unavailable to the plants. Phosphobacterins, mainly bacteria and fungi, can make insoluble phosphorus available to the plant. The solubilization effect of phosphobacterins is generally due to the production of organic acids that lower the soil pH and bring about the dissolution of bound forms of phosphate. It is reported that PSB culture increased yield up to 200-500 kg/ha and thus 30 to 50 kg of superphosphate can be saved.

Vesicular arbuscular mycorrhiza (VAM)

Mycorrhizae are mutually beneficial (symbiotic) relationships between fungi and plant roots. VAM fungi infect and spread inside the root. They possess special structures known as vesicles and arbuscules. The plant roots transmit substances (some supplied by exudation) to the fungi, and the fungi aid in transmitting nutrients and water to the plant roots. Some VAM fungi form a kind of sheath around the root, sometimes giving it a hairy, cottony appearance. Because they provide a protective cover, mycorrhizae increase seedling tolerance to drought, to high temperatures, to infection by disease fungi and even to extreme soil acidity.

Inorganic fertilizer scenario

According to the Food and Agriculture report world demand for total fertilizer nutrients is estimated to grow at 1.8% per annum from 2014 to 2018. The demand for nitrogenous, phosphatic, and potash is forecasted to grow annually by 1.4%, 2.2%, and 2.6%, respectively, during the period. Over the next five years, the global capacity of fertilizer products, intermediates and raw materials will increase further. The global demand for nitrogenous fertilizers is expected to grow around 5.6% to 119.4 MT in four years through 2018, according to the Food and Agriculture Organization of the United Nations. Asian nations, led by China and India, are expected to account for 58% of this increase.

India is the 2nd largest consumer of fertilizers in the world, after China and USA. India also ranks second in the production of nitrogenous fertilizers and third in phosphatic fertilizers whereas the requirement of potash is met through imports since there are limited reserves of potash in the country. It accounts for 12.2% of the world's production of nitrogenous (N) and phosphatic (P) nutrients and 12.6% of the world's consumption of NPK. However, India's annual consumption of chemical fertilizers in nutrient terms (NPK), has increased from 0.7 lakh MT in 1951-52 to 277.39 lakh MT 2011-12 and it has been reached 413.24 lakh MT of fertilizers during the year 2016-17. Urea dominates the total fertilizer production in the country. While India is the world's second largest consumer of urea, the Government of India is working towards increasing the production of urea so as to end imports by 2022 and achieve self-sufficiency in urea production (Fig. 1 and 2). The Figure 3 clearly indicates that the maximum production of urea in the year 2015-16 was 244.8 LMT which was decreased to 241.9 LMT during the year 2016-2017. The data revealed in Figure 4 the maximum urea imported by the India was 87.49 LMT during 2014-15 and it was decreasing in 2015-16 and 2016-17 respectively. The data produced in the Figure 5 clearly demonstrates that the total DAP production was 36.5 LMT during 2012-13 and it was decreased in 2013-14. The data also showed that during the year 2015-16, the total production of DAP was 37.9 LMT and it was again increased upto 43.3 LMT during the year 2016-17. The data given in Figure 6 clearly demonstrates that during the year 2012-13, the total DAP imported from the other countries was 57.02 LMT which was decreased during the year 2013-14 and the total quantity was 32.61 LMT. The maximum DAP (60.80 LMT) was imported during the year 2016-17 and it was again decreased during the year 2016-17. Among the total fertilizers, MOP is totally imported from the other countries. The data pertaining in Figure 7 demonstrates that the maximum MOP (41.97 LMT) was imported during the year 2014-15 and the minimum MOP imported during the year 2012-13. In the year 2015-16 lesser MOP was imported as compared to the 2014-15 but the MOP quantity again increased during the year 2016-17 and its reached upto 37.36 LMT. Out of the total fertilizer production, India produces only 10%-12% of DAP but due to recent fall of raw material prices in the international markets, phosphates have become cheaper and its economical to produce the fertilizer rather than importing the end product. Hence, the government is encouraging sprucing up the production of DAP, which is the second most widely used fertilizer after urea. Production of Complex Fertilizers includes the various grades of NPK Fertilizers (Nitrogenous- Phosphorus-Potassic). The Government is encouraging SSP production as SSP is also considered as a substitute to diammonium phosphate (DAP), which is largely import based and costlier vis-a-vis to SSP.

Types of fertilizers

A fertilizer is a chemical product either mined or manufactured material containing one or more essential plant nutrients that are immediately or potentially available in sufficiently good amounts.

Chemicals fertilizers are classified on the basis of quantum required by the soil as Primary, Secondary and Micronutrients. Primary nutrients are further categorized on the type of nutrients they are supplied to the soil which are as nitrogenous, phosphatic and potassic fertilizers.

Secondary nutrients include calcium, magnesium and Sulphur while micronutrients, include iron, zinc, copper, boron and chlorine. India is dependent on imports for raw materials for production of Nitrogenous & Phosphatic fertilizers. Product wise Chemical Fertilizers are classified into Urea, Diammonium Phosphate (DAP), Single Super Phosphate (SSP), Muriate of Potash (MOP) and other Complex fertilizers like Calcium Ammonium Nitrate (CAN) and various grades of NPK Fertilizers (Fertilizers having different grades of Nitrogen (N), Phosphorus (P), and Potassium (K)). In India the most widely used fertilizers in the Nitrogenous category are Urea, DAP and MOP for Phosphorus and Potassium respectively.

Different methods of Integrated Nutrient Management (INM) in crops

Combined use of chemical and organic fertilizers

The integrated nutrient management system is an alternative and is characterized by reduced input of chemical fertilizers and combined use of chemical fertilizers with organic materials such as animal manures, crop residues, green manure and composts.

Management systems that rely on organic inputs as plant nutrient sources have different dynamics of nutrient availability from those involving the use of chemical fertilizers. For sustainable crop production, integrated use of chemical and organic fertilizer has proved to be highly beneficial.

Combined use of biofertilizers with chemical or organic fertilizers

In this system, the nutrients provided to the crops by combined use of i.e. biofertilizers, chemical fertilizers and organic materials such as animal manures, crop residues, green manure and composts.

Impact of Integrated Nutrient Management (INM) on soil quality of harvested flowers field

An experiment was conducted by Sharma *et al.,* (2017) at Indian Agricultural Research Institute, New Delhi to study the effect of efficient micro-organism compost on plant growth and soil health in calendula and marigold.

The results showed that the application of EM compost improves the humus content, organic carbon and available nitrogen status of soil which in turn increased the soil fertility over the control receiving chemical fertilizer only.

soil enzyme activities, e.g., dehydrogenase, *β*-glucosidase and acid phosphatase activity, are enhanced with the increase in the rate of application of EM composts along with half dose chemical fertilizer. Highest dehydrogenase activity (10.46 g TPF·g^{-1}·d^{-1}), acid phosphatase activity (82.63 g *p*NP·g^{-1}·h^{-1}) and *β*-glucosidase activity (0.30 IU·g^{-1}) were observed in treatment receiving 20 000 kg·hm^{-2} EM compost with half of the recommended dose of NPK and lowest dehydrogenase activity was observed in the plots received full dose of NPK by chemical fertilizers.

Khanam *et al.,* (2017) found the improvement in the available N, P and K nutrients by the integrating use of 50% recommended dose of fertilizers (RDF) with 2.5 ton/ha of vermicompost in harvested soil of gladiolus.

Sathyanarayana *et al.,* (2017) studied the effect of integrated nutrient management on Gladiolus (*Gladiolus grandiflorus* L.) cv. American Beauty who recorded the minimum soil electrical conductivity (0.67 dSm-1) and highest available nitrogen (178.73 kg/ha), available phosphorus (19.48 kg/ha), available potash (314.13 kg/ha), soil organic carbon (0.80%) and microbial population (90.67 x 10-7 CFU/g soil) with 100% RDF + FYM @ 7.5 t/ha + *Azotobacter* + PSB + KMB + 1% foliar spray of *Nauroji* Novel Organic Liquid Fertilizer while Dikr and Belete (2017) concluded that organic manure has a role in improving the soil chemical as well as physical properties of soil.

They further reported that the role of bio-fertilizers containing symbiotic or non-symbiotic nitrogen-fixing bacteria in augmenting vegetative growth characters, yield and yield components, essential oil productivity and/or chemical composition (including chlorophyll a, b and carotenoids and/or N, P and K leaf percent and content

Application of Integrated Nutrient Management (INM) in some floricultural crops

China aster (*Callistephus chinensis* (L) Nees)

Kulkarni, (1994) recorded increased growth and dry weight of China aster with the application of vermicompost at 2.5 to 5.0 tonnes per ha alone or in combination with organic fertilizer. Srinivas (1994) stated that the application of NPK and 15 tonnes of FYM per hectare or phosphor-compost 8 tonnes /ha produced optimum flower yield. In addition, Nethra (1996) found more plant height, number of leaves, number of flowers per plant and flower yield per hectare due to the application of vermicompost at 10 tonnes per hectare and recommended dose of NPK. In China aster, while working on integrated effects on crop. Haripriya and Sriramachandrasekharan (2002) found that application of FYM + mine soil at 1:2 ratio resulted in the better growth and yield of marigold as compared to leaf mould and pressmud, while Kumar *et al.,* (2003) observed that application of half N,P + full K + VAM + phosphobectrium gave maximum plant growth and flower yield in China aster. Nandre *et al.,* (2005) recorded maximum flower yield by the soil application trated with *Azotobacter* along with 75 per cent nitrogen. An experiment conducted by Mogal *et al.,* (2006) who observed the best growth in China aster (*Callistephus chinensis* L.) while plants received FYM at 20 tonnes per hectare, *Azotobacter* and PSB at 3 kg per hectare and 100% N through urea. Smitha *et al.,* (2006) also reported that FYM + *Azotobacter* + Phosphorus solubilizing bacteria +100 percent nitrogen produced maximum yield of flowers, with improved quality of flowers and vase life (11.23 days) in China aster. Another study carried out by Chaitra and Patil, (2007) on biofertilizers which were used in combination with VC and inorganic fertilizers. Findings revealed that application of *Azospirillum.* PSB, vermicompost and 50 per cent recommended NPK gave highest flower yield of (11.71 t/ha) with the maximum net returns per rupee invested (1:4.1). The results strongly endorses the integrative approaches for over all optimum growth and yield inoculation of *Azospirillum* and PSB, enhanced the cell division and enlargement and also produced growth hormones, which is possible reason for increased growth. The cultivar Kamini of China aster performed better even when recommended dose of fertilizer was reduced to 50 per cent and integrated with application of *Azospirillum* + PSB + Vermicompost as compared to 100 per cent of RDF (Patil *et al.,* 2007). More ever, Kirar *et al.,* (2009) found that application of 75% NPK + Vermi-compost + Azotobactor + PSB gave better results followed by, under treatment 50% NPK + Vermi-compost + Azotobactor + PSB in china aster. Masaye and Rangwala (2009) reported that application of 200 kg N+100 kg P_2O+50 kg K_2O and FYM at 5 t/ha as a basal dose improved flower quality of china aster var. Poornima Swathi (2009) revealed that growth parameters *viz*., plant height, number of branches per plant, plant spread, leaf area and total dry matter production were highest with the combined application of 5 t ha-1 vermicompost, PSB and *Azospirillum* each at 5kg ha^{-1} along with 75 per cent recommended dose of fertilizers. Similarly, Sonawane *et al.,* (2008) concluded that the application of nitrogen at 200 kg ha^{-1}, phosphorus at 75 kg ha-1 and FYM at 10 t ha^{-1} was found efficient to achieve significantly maximum flower yield over other levels. The application of N at 200 kg/ha through urea, P at 75 kg/ha through single superphosphate and FYM at 10 t/ha with basal 50 kg K_2O kg/ha through MOP was found beneficial in increasing the growth parameters, flower yield and N, P and K uptake by China aster. However, Laishram *et al.,* (2010) found that the treatment of 22.5g per m^2 each of NPK + vermicompost (1 kg per m^2) + biofertilizes (*Azotobacter* + PSB+ VAM) produced the maximum flower yield in China aster. Ravindra *et al.,* (2013) reported that the application of one ton/acre vermicompost and PSB and *Azospirillum* each of 2 kg/acre in China aster gave better results. Munikrishnappa and Chandrashekar (2014) concluded that the growth, flowering and quality of China aster is significantly influenced by application of major nutrients along with organic manures. Khanna *et al.,* (2016) concluded that application of Farmyard manure + Forest Litter + PSB can be recommended for commercial cultivation of China aster cv. Kamini.

Gladiolus

While studying the effect of vermicompost and sewage sludge applications combined with NPK, Gangadharan and Gopinath (2000), reported that the combination of 10 tonnes vermicompost per hectare + 80 per cent NPK in gladiolus cv. White Prosperity resulted in the maximum number of cormels per plant, whereas 5 tonnes sewage sludge per hectare + 80 per cent NPK and 10 tonnes vermicompost per hectare + 60 per cent NPK gave more number of spikes per hectare. In another study carried out by Gangadharan and Gopinath (2000) who observed that in gladiolus cv. White Prosperity, the combination of vermicompost @ 10 tonnes per hectare + 80 per cent recommended NPK increased the plant height, number of leaves, leaf area, leaf area index, fresh weight of whole plant, length of spike, width of spike, length of rachis, number of florets per spike and diameter of corms, while Asrey *et al.,* (2002) reported that organic amendments like vermicompost, FYM and cotton cake were effective in increasing the vase life of gladiolus cv. Traderhom as compared to the inorganic NPK fertilizers. More ever, Pimpini and Zanin (2002) also studied the effect of type of soil and fertilizers on gladiolus. They observed better spike length, number of florets per spike and corm production with the application of 50 tonnes/ha manure, 250 kg/ha nitrogen, 125 kg/ha phosphorus and 250 kg/ha potassium. However, the best results were obtained in peat soil and the poorest in sandy soil. Another experiment was conducted by Godes (2005) on integrated effects of inorganic and organic nutrients in gladiolus. The findings revealed that days required for flowering, number of florets per spike, spikes ha-1 were found maximum with application of 80% RDF with Vermicompost + Azotobacter + PSB. Similar results were reported by Godse *et al.,* (2006) who observed that plants receiving vermicompost 8 t ha^{-1} + Azotobacter and PSB @ 25 kg ha^{-1} each + 80% RDF significantly increased yield and quality attributes of gladiolus viz., number of spikes ha^{-1}, length of spike and number of florets $spike^{-1}$ when compared with RDF and other treatments. Sharma *et al.,* (2008) observed that the application of recommended doses of NPK along with vermicompost and dual inoculation of Azotobacter and PSB in gladiolus gave minimum days to sprouting, maximum spike length and number of florets per spike. The maximum corms and cormels were also recorded from the same treatment, Dubey *et al.,* (2009) reported that combined application of *Azotobacter* + PSB was found best for all growth and flowering characters in gladiolus. Ali *et al.,* (2013) stated that the treatment containing *Azospirillum* had recorded maximum plant height, florets spike-1, Spike length, Florets fresh weight and earliest sprouting than other treatments in gladiolus. An experiment conducted on gladiolus cv. Pusa Srijana to study the economic fisibility of gladiolus under different treatments. The results revealed that the maximum vase life of spikes (10.3 day) was recorded with the application of pendimethalin 0.75 kg/ha + metribuzin 0.3 kg/ha pre-emergence as compared to control (7.3 day). The maximum yield of corms 89.48 q/ha and cormels and marketable spikes (1.43 lakh per ha), net profit (Rs. 3.48 lakh/ha) and benefit: cost ratio (1.99) was received with the application of metribuzin 0.4 kg/ha pre-emergence + residue (dry grass 5.0 tonnes/ha) over control (Dhakar *et al.,* 2013). Kumari *et al.,* (2013) conducted an experiment to study the effect of integrated nutrient management on growth and floral parameters in gladiolus (*Gladiolus hybridus* L) cv. American Beauty. The results of the experiment revealed that among the different treatments, application of 75 per cent RDF + VC (3 t/ha) + VAM (10 kg/ha) + *Azospirillum* (10 kg/ha) + *Trichoderma harzianum* (5 kg/ha) resulted in maximum plant height, number of leaves per plant, minimum number of days taken for spike emergence, number of days taken for first flower bud opening on a spike, maximum number of florets per spikes, spike length, and spike girth. However, Kumar *et al.,* (2013) had conducted an experiment on integrated nutrient management in gladiolus. The findings revealed that the treatment 80% R.D. of NPK (96 kg N, 80 kg P and 80 kg K/ha) + vermicompost (128 q/ha) + *Azotobacter* (5.28 kg/ha) showed better response to plant height, number of leaves and other growth parameters. Singh *et al.,* (2013) reported that the application of 75% RDF+ 2 Tonnes of Vermicompost + PSB, (2.5kg/ha) + *Azatobactor*, (2.5kg/ha)] significantly increased the maximum plant height, number of leaves per plant, length of longest leaf per plant, number of sprouts per plant. This treatment was also found better in respect of early flowering, days required for visibility of first spike, days required for opening of the first flower. Basoli *et al.,* (2014) investigated the impact of integrated nutrient management on gladiolus cv. Novalux. The results revealed that application of 3/4th recommended dose of N, P and K+ *Azotobacter* + PSB + KSB was found most effective in increased the weight of corm /plant, size of corm, available N and K content in soil. The number of florets opened per spike and available P content in soil were also recorded maximum with application of ½ recommended dose of N, P and K+ *Azotobacter* + PSB + KSB. Whereas, 3/4th recommended dose of N, P and K+ *Azotobacter* + PSB resulted maximum number of corms and cormels /plant. Kumar, (2014) reported that application of 75% RDF+ 25% VC + 2.0 g/plant *Azospirillum* + 2.0 g/ plant PSB, significantly induced earlier sprouting and increased the height of plant, number of leaves per plant and length of longest leaf per plant. However, plant recieved 50% RDF+ 50% VC + 2.0 g/plant *Azospirillum* + 2.0 g/plant PSB had significantly maximum diameter of leaf. Plants received 50% RDF+ 50% VC + 2.0 g/plant *Azospirillum* + 2.0 g/plant PSB had emerged earlier spike while minimum days required for opening of first flower on spike and maximum longevity of spike was observed in treatment when plants received 75% RDF + 25% Leaf Mould + 2.0 g/plant *Azospirillum*.+ 2.0 g/plant PSB.

In terms of vase life of cut flowers at room temperature, treatment 75% RDF+ 25% VC + 2.0 g/plant *Azospirillum* + 2.0 g/ plant PSB shown maximum vase life. Singh *et al.,* (2014) also further reported that the application of 75% RDF+ 2 Tonnes of Vermicompost + PSB, (2.5kg/ha) + *Azatobactor*, (2.5kg/ha flower and corm characters during the study. Chaudhary *et al.,* (2016) studied the combined effect of integrated nutrient management on vegetative growth and flowering characters of gladiolus cv. Snow Princess with the application of *Azospirillum*, PSB, vermicompost and FYM with and without 100, 75 and 50% recommended dose of NPK. The results showed that the application of integrated nutrients, i.e. 50% RDF (60:40:40 kg/ha NPK) + 10 tonnes/ha each of FYM and vermicompost + 2 g/plant each of *Azospirillum* and PSB produced significantly increased maximum length of spike, number of florets per spike, duration of flowering and yield of corms. The dry weight of plant was also found maximum with the application of 75% RDF + 10 tonnes/ha each of FYM and vermicompost + 2 g/plant each of *Azospirillum* and PSB**.** Akter *et al.,* (2017) observed significant variation in most of the parameters when organic manure, chemical fertilizer and bio-control agents were applied. The treatment containing poultry manure (5 t/ha) + Trichocompost (3 t/ha) + ¼ RDF had taken the minimum period (68 days) for 80% spike initiation while the maximum length of spike (80.0 cm) and rachis (34.0 cm), number of florets/spike (16), number of spikes/ha (200000) was registered with the plant recieving Vermicompost (5 t/ha) + Trichocompost (3t/ha) + ¼ RDF. Khanam *et al.,* (2017) obtained the maximum growth and quality parameters with integration of 50% recommended dose of chemical fertilizers (RDF) with vermicompost @ 2.5 ton/ha.

Singh *et al.,* (2014) inoculated the gladiolus corms with *Azospirillum* and VAM alone and in combination of nitrogen, phosphorus and potash including application of 10 tonnes FYM ha-1 in each treatment. Soil pH, electrical conductivity, organic carbon, available nitrogen, phosphorus and potash were estimated. Results revealed that lowest soil pH observed with *Azospirillum* + 50% N + 200 kg P_2O_5 + 200 kg K_2O while lowest EC was recorded with *Azospirillum* + 75% N + 200 kg P_2O_5 + 200 kg K_2O being 0.57 dSm-1 and 0.51 dSm-1 respectively. The treatment combination i.e. (*Azospirillum* + 75% N + 200 kg P_2O_5 + 200 kg K_2O) when applied in gladiolus also showed highest available Nitrogen, phosphorus and potash in soil of field. The build-up of available N, P and K in soil and consequent higher plant leaf nutrients was also detected with 50% RDF + vermicompost @ 2.5 ton/ha. Sathyanarayana *et al.,* (2017) stated that the application of 100% RDF + FYM @ 7.5 t/ha + *Azotobacter* + PSB + KMB + 1% foliar spray of *Nauroji*

Novel Organic Liquid Fertilizer significantly increased maximum growth, flowering and corm production in gladiolus.

Tuberose

In tuberose Cv. Single, increased flower yield was obtained by inoculating *Azotobacter* and *Azospirillum* alone or in combination (Wange *et al.,* 1995) while, Munikrishnappa *et al.,* (2004) stated that the application of 50 per cent of recommended dose of fertilizer (RDF) along with vermicompost at 5 tonnes per hectare had improved the flower characters viz., spike length, rachis length, florets diameter, number of florets per spike and flower yield of tuberose. Padanagur *et al.,* (2005) observed that plants which received vermicompost either alone or in combination with ½ RDF had earlier flowering, while higher flower spike yield (1.12 and 1.16 lakh per hectare was obtained with the application of 3 kg vermicompost per square metre along with 50% recommended dose of fertilizers. Tripathi *et al.,* (2012) found maximum spike yield, shoots per clump and number of leaves in tuberose when 75% recommended 100 kg NPK ha–1)+ 500q ha–1 FYM + 250q ha–1 VC were applied in tuberose. Hadwani *et al.,* (2013) observed that application of FYM @ 30 t/ha + PSB @ 2 g/m2 + Azotobacter @ 2 g/m^2 increased maximum length of spike, number of florets per spike, number of spike per plant, longest vase life and *in situ* longevity of spike were recorded in treatment ½ RDF + NC @ 1 t/ha + PSB @ 1g/m2 + Azotobacter @ 1 g/m^2. Kashyap *et al.,* (2013) evaluated the effect of boifertilizers (*Azotobacter*, PSB) along with the chemical fertilizers (N, P and K) and a basal dose of FYM @ 5 kg/m^2on growth and flowering in tuberose. The growth parameters (plant height, number of leaves per plant, days taken for emergence of bulbs) were increased significantly with the increasing levels of chemical fertilizers along with the boifertilizers applications while, Kumar, (2014) concluded that 75% RDF + 25% VC + 2.0 g/plant *Azospirillum* + 2g/plant PSB, significantly induced earlier sprouting and also increased the height of plant, number of leaves per plant, length of longest leaf per plant and width of longest leaf. Results also showed significant variation among the treatments in terms of days required for visibility of first spike and opening of first flower on the spike. Kumar *et al.,* (2015) concluded that 50% RDF+ 50% vermicompost +2g/plant *Azospirillum* + 2g/plant PSB produced maximum diameter of flower, number of flowers/spike, diameter of spikes/ bulb, while 75% RDF+ 25% VC + 2g each *Azospirillum* and PSB gave longer spike and maximum bulbs. Shirsat *et al.,* (2015) recorded maximum number of spikes $plant^{-1}$, $plot^{-1}$ and $hectare^{-1}$, number of florets $spike^{-1}$ and total nutrient content (N, P and K) in flower and plant with the application of 50% N through vermicompost+50% N through urea+P and K (RDF) followed by application of 50% N through FYM+50% N through urea + P and K (RDF) and application of recommended dose of fertilizer.

Marigold

Gupta *et al.,* (1999) observed that growth and flower yields were highest with *Azotobacter* + Phosphorus Solubilizing Bacteria (AZB + PSB) in combination of 75% to100% nitrogen in marigold (*Tagetes erecta* L.). Various yield parameters of plant such as size of flowers, average weight of flowers, fresh weight of flowers per plant (flower yield), dry weight of flowers per plant and dry matter yield of plant were recorded. Application of vermicompost (15 tonnes per hectare) + 100 per cent recommended NPK in marigold produced maximum number of flowers per plant with greater flower diameter and flower yield than plants received no vermicompost and fertilizer application (Mashaldi, 2000).

Fig.1 The nutrient budgets between inputs and outputs, and the principles of INM method (Jat *et al.*, 2015)

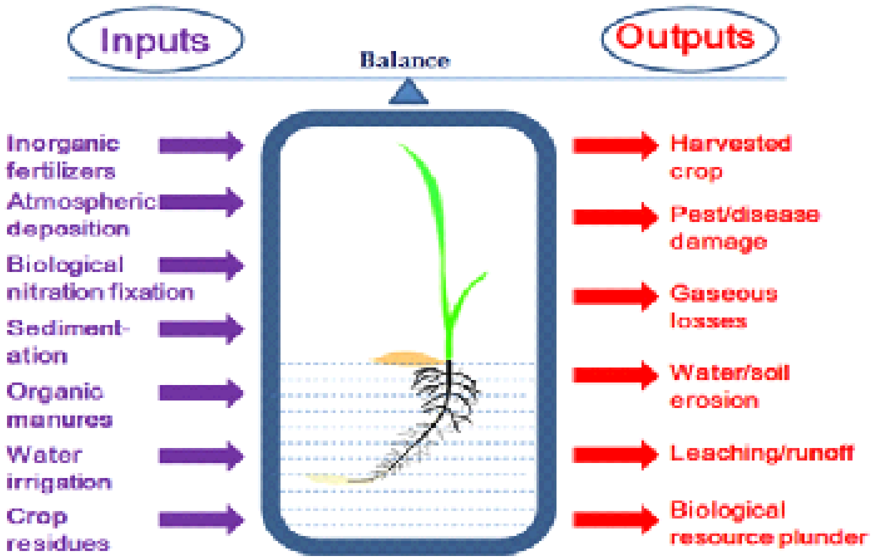


Fig.2 Global biofertilizers market revenue, 2012 – 2022 (USD Million)

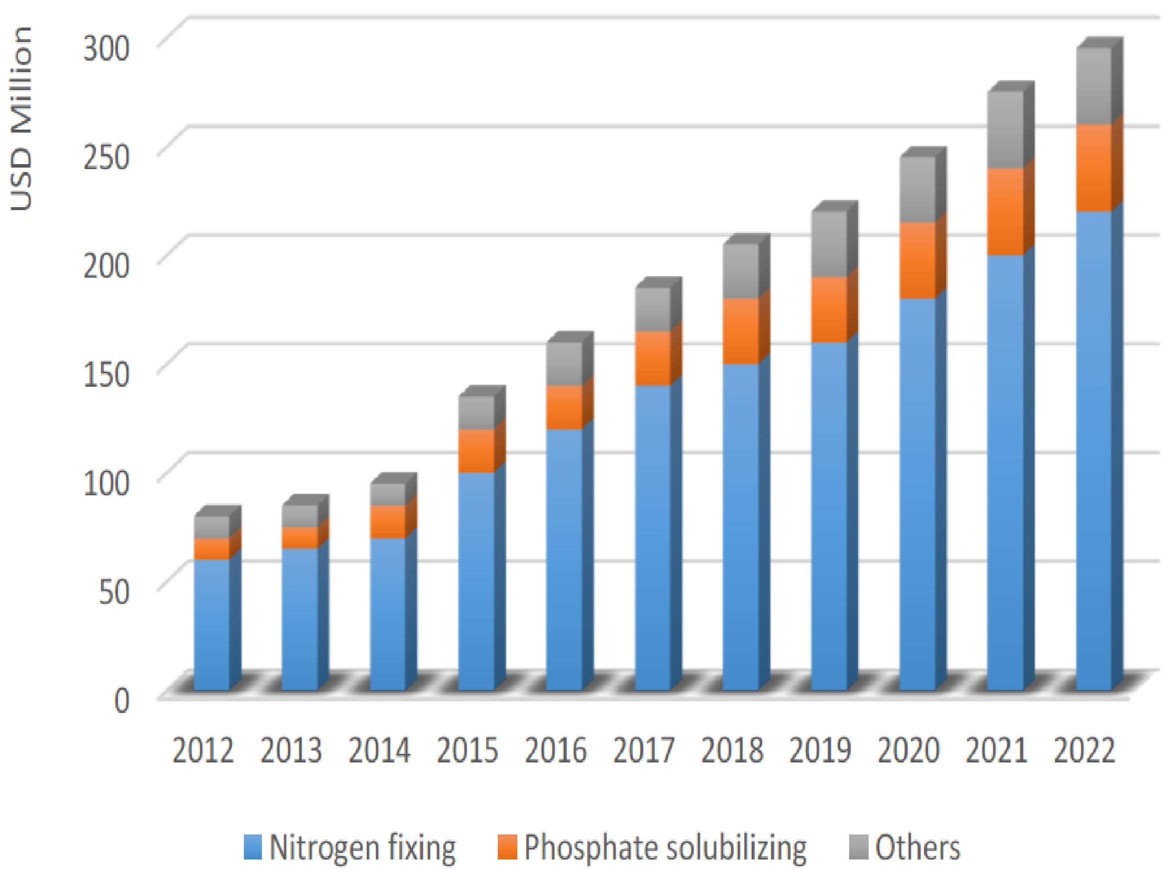


Fig.3 Production of Urea in India (in units of LMT)

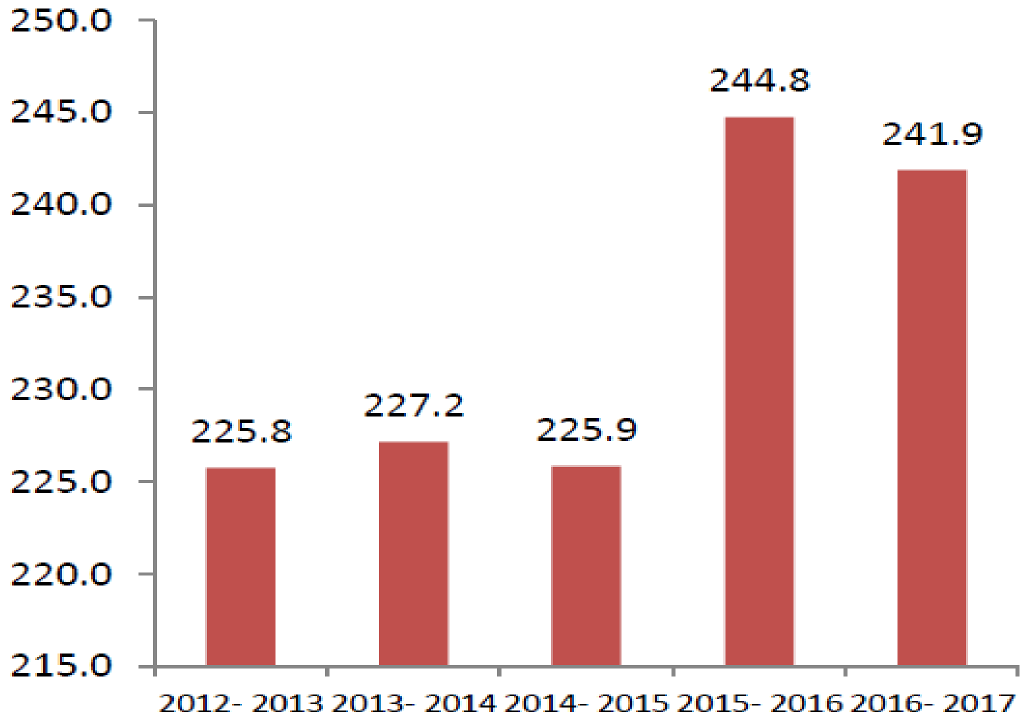


Fig.4 Urea Imports by India (in units of LMT)

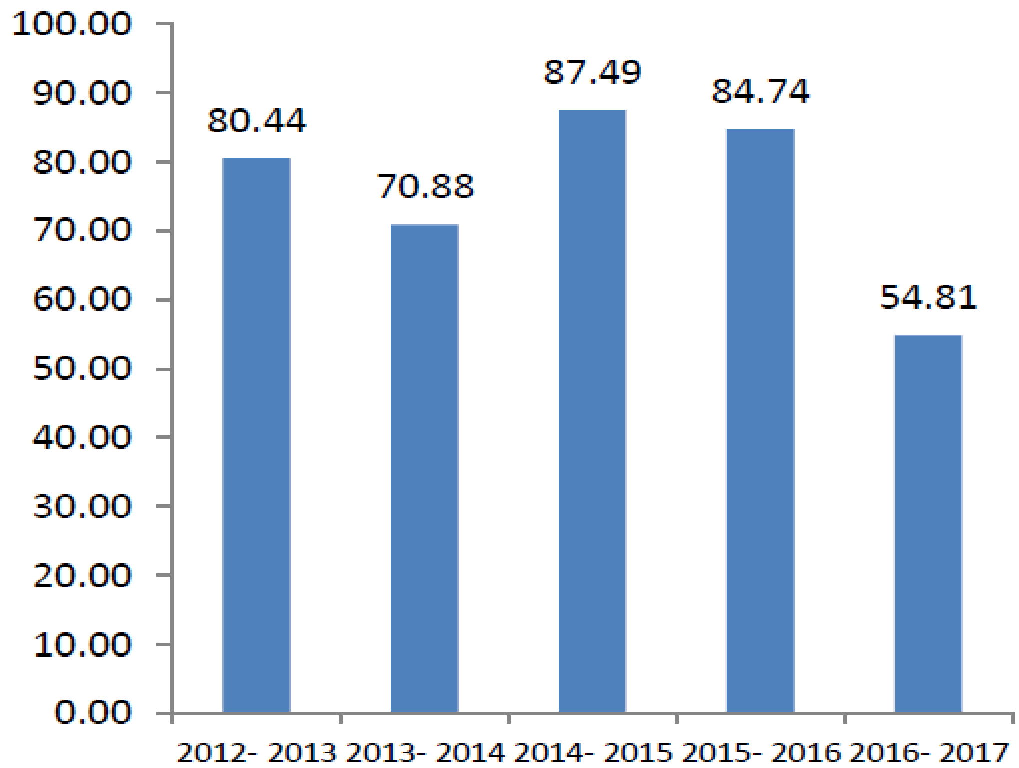


Fig.5 Production of DAP in India (in units of LMT)

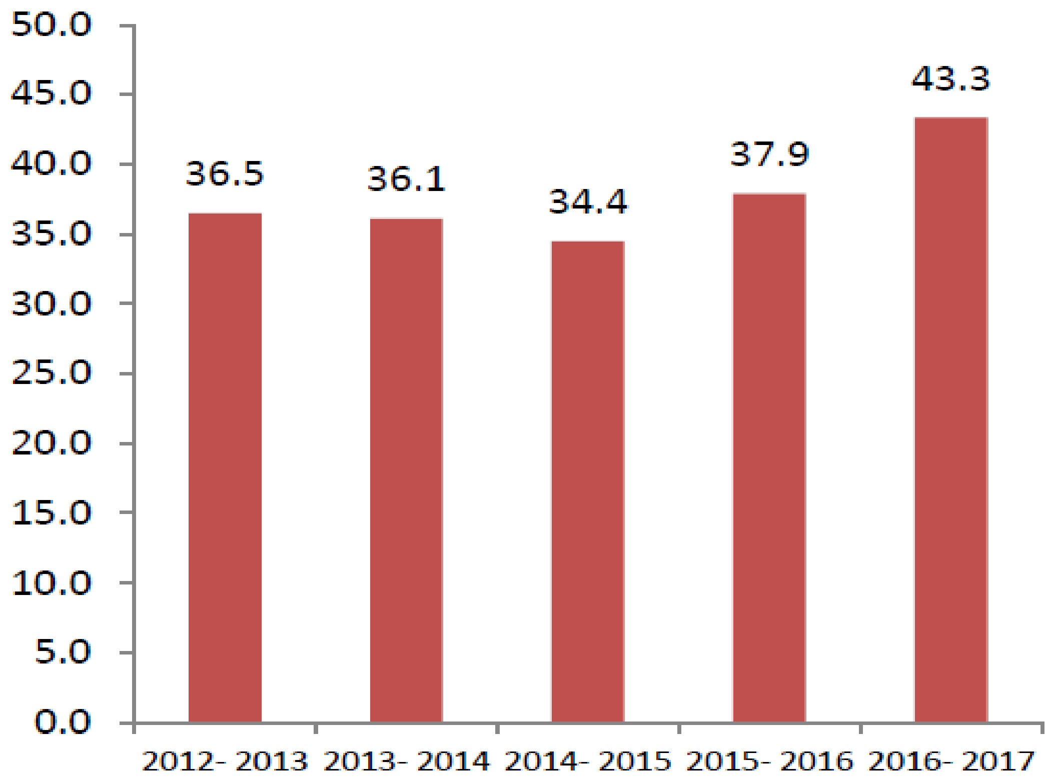


Fig.6 DAP imports by India (in units of LMT)

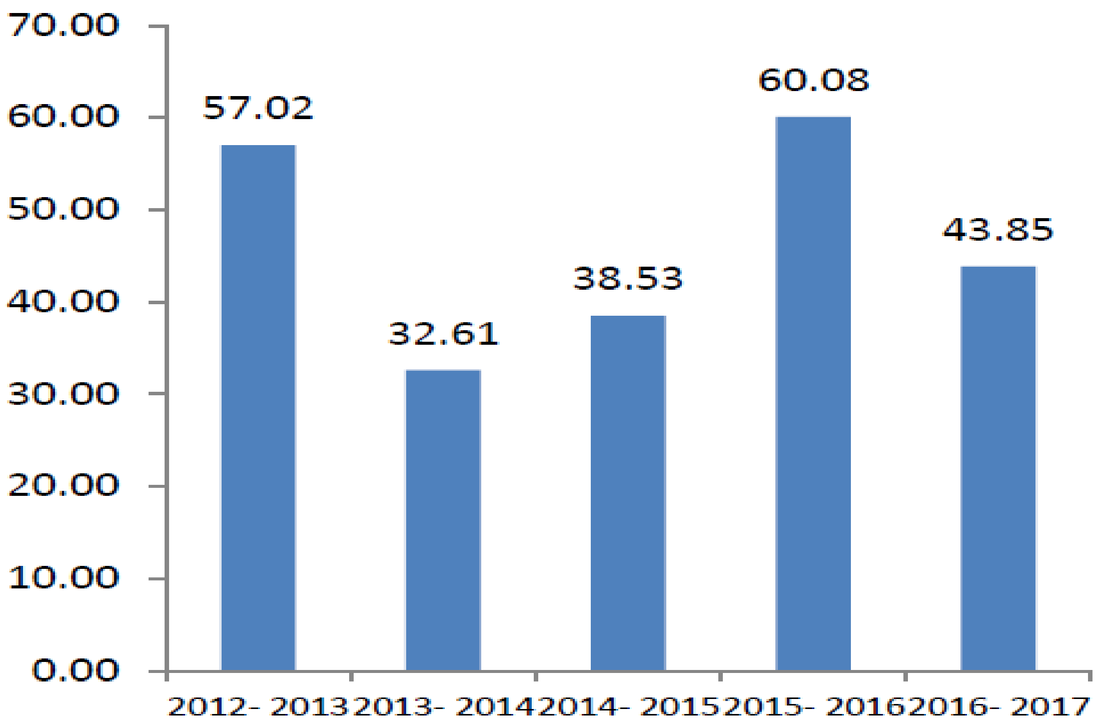
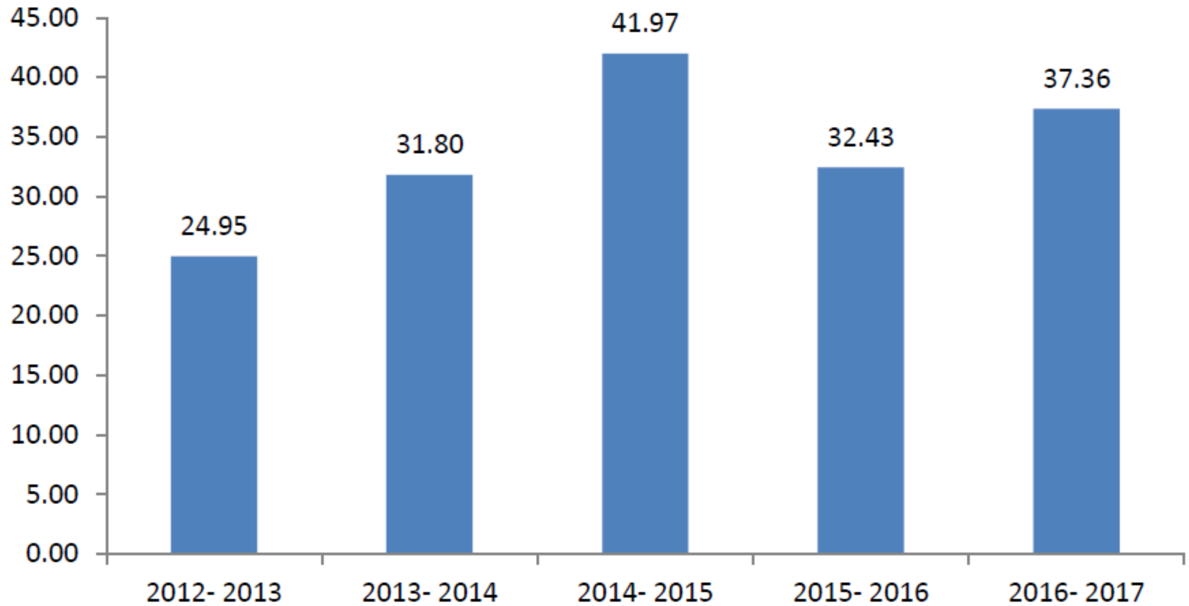


Fig.7 MOP imports by India (in units of LMT)



Atiyeh *et al.*, (2000) found that relatively low concentration of vermicompost could promote plant growth in marigold. Rajadurai *et al.*, (2000) reported that application of NPK @ 45:45:37.5/kg along with combined inoculation of *Azospirillum* and VAM exhibited increased growth in respect of plant height (144.50 cm) number of leaves (156.20) and laterals per plant (28.30) in marigold. Yadav *et al.*, (2000) observed the reduction in flower size, number of flowers per plant and flower yield) in African marigold at higher dose of N (>180ppm. The application of FYM improved the flower characters. Chauhan *et al.*, (2005) studied the effect on application of vermicompost in marigold cv. Pusa Narangi Gainda. The findings revealed that application of vermicompost @ 1000 g/m2 recorded higher yield of flowers (1757.76 g/m2) compared to vermicompost @ 500 g/m2 (1429.00 g/m2). Shubha (2006) reported that in days to flower bud initiation and 50 per cent flowering in marigold cv. Orange Double with vermicompost + Poultry manure + *Azospirillum* + 75 per cent recommended dose of nitrogen. Another study carried out to examine the effect of integrated nutrient management on carotenoid yield in African marigold. It was inferred that yield components like number of flowers per plant, flower yield and petal meal yield were maximum with treatment combination of vermicompost (12.5%N) + poultry manure (12.5%N) + *Azospirillum* along with 75 %RDN per hectare (Naik *et al.*, 2008). Pushkar *et al.*, (2008) found that soil application of VAM fungi @ 10 kg per hectare was most effective for floral characters and flower yield of African marigold. Similar results were observed by Kumar *et al.*, (2009) when used the application of *Azotobacter* + PSB +FYM @ 30 tonnes per hectare + N @100 kg per hectare and P @ 50 kg per hectare and found to be the best for growth, flowering behaviour and yield of cv. African Giant double orange. Application of 50% NPK + FYM + vermicompost in African marigold cv. Pusa Narangi, recorded significantly higher plant height (75 cm), maximum number of branches (12.45), number of flower/plant (60), flower diameter (9.40 cm), flower weight (7.85 g) and flower yield per plant (471 g) compared to treatment when plants received 100% NPK + FYM + vermicompost (Bhat *et al.*, 2010). However, Sangwan *et al.*, (2010) worked on the effect of vermicompost with potting media on growth and flower yield in marigold. They observed that addition of vermicompost in appropriate quantities, to potting media has synergistic effects on flowering of plants including number of buds, number of flowers, and diameter of flowers. Maximum numbers of flowers was produced in the potting media containing 30% of vermicompost (common dose). The diameter of the biggest flower in marigold was reported in the potting media containing 40% of sugar mill waste water treatment plant sludge vermicompost. Singh *et al.*, (2015) stated that plants gown in sand + soil + vermicompost (1:1:2) + 5% biodynamic amendment significantly gave maximum plant height (27.750 cm), plant spread (23.175 cm), number of branches per plant (25.454),stem diameter (1.549 cm), number of leaves per plant (140.714), leaf length (9.308 cm) and leaf width (4.896 cm). The same treatment was also found superior in terms of days to first flower bud initiation (24.22), flower bud diameter (1.94 cm), bud length (3.49 cm), number of flower per plant (16.27), and flower diameter (7.98 cm) over control. Singh *et al.*, (2015) reported that the application 75 % recommended dose of NPK (75 Kg N, 75 Kg P2O5 and 75 Kg K2O ha-1)+ vermicompost 80 q ha-1 + Azatobacter 3.3 Kg ha-1), gave maximum high of the plant (94.84 cm), plant spread (49.41 cm), leaf area (49.46 cm) number of branches (15.92), total dry matter (39.03 g/plant), flower diameter (6.7 cm), weight of flower plant-1 (45.97 g), number of flower (58.32), per cent weight (3.99g) and yield of flower plant-1 (368.29g), yield of flower (26.48 tonne ha-1). The treatment was also found significantly most effective in inducing earliest flowering and duration of flowering. However, Sharma *et al.*, (2017) worked on the effect of integrated nutrient management on marigold and concluded that the application of *Azospirillum* + Phosphate-Solubilizing Bacteria + 5% Cow Urine + 50% recommended dose of "N" through Vermicompost + 50% recommended dose of NPK fertilizer was most effective in increasing vegetative growth parameters, such as plant height, number of branches, plant spread, as well as flower yield parameters like number of flowers, flower diameter, fresh and dry weight of flowers, flower yield, flowering duration, shelf life, and it also had the maximum benefit:cost ratio was also calculated with the treatments. Another study carried out by Kumawat *et al.*, (2017) who reported that the application of 75% RDF + FYM @ 20 t ha per ha along with inoculation of seedlings with Azotobacter + PSB produced higher plant height, number of primary branches on plant, weight of flower, number of flowers plant, yield of flowers plot as well as ha. These parameters were statistically at par with the application of 50% RDF + FYM @ 20 t ha1 along with inoculation of seedlings with Azotobacter + PSB.

Gerbera

Narayanagowda, (2003) recorded maximum flower yield, flower diameter and stalk length with treatment combination of vermicompost 15 tonnes per hectare and 75 per cent recommended NPK. Thane *et al.*, (2007) reported that the application of 70% RFR + *Azotobacter* + PSB resulted in the greatest flower stalk length (52.96 cm), flower stalk diameter (0.70 cm), flower diameter (9.20 cm) and number of flowers per plant (7.22) in *Gerbera jamesonii*. Gurav *et al.*, (2008) reported that the plants treated with CBD + vermicompost @ 500g per m^2 twice a year) + 3% panchagavya +3% Manchurian tea had significantly maximum number of flowers per plant (35.4), lower stalk length (50.8), flower stalk diameter (6.78) and vase life (5.5days). However, Sindhu *et al.,* (2009) worked on the effect of nutrient management on soil quality and productivity in gerbera. The findings revealed that the highest bulk density (0.58 g/cm3) and electric conductivity (0.85 dS/m) were recorded in media when amended with soil + farmyard manure + vermicompost + samridhi + sawdust. The maximum leaf magnesium content (0.55%) was recorded in the plants grown in media amended with vermicompost.

Carnation

Carnation cv. Raggio-desole produced maximum plant height number of flowers, length of stalk, flower size, earliness in flowering, highest vase life when grown in a culture having soil + sand + Vermicompost (1:1:1) (v/v + inorganic fertilizer + Bio fertilizer (*Azospirillum* and PSB) compared to treatments having FYM and municipal compost in the place of vermicompost (Bhalla *et al.,* 2007). Swamy (2010) observed that carnation cv. Dona recorded maximum plant growth, flower quality and yield when plants are supplied with 50 per cent RDF + Vermicompost + 3 per cent Manchurian tea + 3 per cent Panchagavya. Least number of flowers per plant and flowers per square meter were recorded in plants receiving common basal dose (8.00 and 160.00 respectively). Sharma *et al.,* (2010) stated that carnation plants supplied with common basal dose along with biofertilizers (*Azospirillum*, PSB, VAM and Trichoderma @ 2g/plant) + 6% Panchagavya and 6% Manchurian mushroom tea showed highest plant height (71.03 cm), stem length (64.77 cm), flower size (4.99 cm) and Number of flowers (6.60/plant). Singh *et al.,* (2010) observed that the treatment 75% RDF + FYM 1 kg per m2 per year + vermicompost 300g per plant per year + *Azospirillum* + PSB 2 g produced the maximum number of flowers per plant (6.3), flower stem length (67.40 cm) and flower per square meter (125.67) in carnation.

Chrysanthemum

Chrysanthemum flower yield increased from 10.79 to 16.85 tonnes per hectare, when the plots received N, P_2O_5 and K_2O at the rate of 20:20:20 g + 5 kg FYM per sq. m (Chezhiyan *et al.,* 1986) while, Verma *et al.,* (2011) reported that the use of *Azospirillum*, PSB, vermicompost equivalent 50% RD‘N’, 50 per cent FYM along with 50 per cent recommended nitrogen, phosphorus and potassium helped in realizing better plant growth, flower yield and better quality of flowers and higher benefit cost ratio under field condition in chrysanthemum (*Chrysanthemum morifolium* Ramat.) Cv. Raja. Pandey *et al.,* (2010) studied the influence of bio-inoculant (*Azotobacter* and VAM) and vermicompost with different levels of nitrogen, phosphorus and potassium (100%, 75% and 50%) on growth and flowering of chrysanthemum cultivars 'Prof. Harris' and 'Sunil'. Application of 75% recommended dose of fertilizer and vermicompost coupled with dual inoculation of Azotobacter and VAM produced significantly maximum plant, higher number of lateral shoots, plant spread, advancement in visible bud formation, bud showing colour and flowering respectively. Extension of flowering duration was recorded with 100% recommended dose of fertilizer. Maximum number of leaves were recorded with 75% dose of N + *Azotobacter*+ VAM + full P and K while, higher leaf area was observed when crop was fertilized with 75 % dose of N and P+ *Azotobacter* + VAM + full K as compared with 100% recommended dose of fertilize. However, Kumar, (2015) studied the effect of integrated nutrient management on growth and flowering in chrysanthemum. The results revealed that the application of 75% RDF+ 25% VC + 2.0 g/plant *Azospirillum* + 2.0 g/

plant PSB significantly induced the days taken to sprouting and produced maximum plant height, number of leaves per plant and length of longest leaf. However, treatment received 50% RDF +50% Leaf Manure + 2g/plant *Azospirillum* + 2g/plant PSB had maximum diameter of leaf. The treatment receiving 50% RDF+ 50% VC + 2.0 g/plant *Azospirillum* + 2.0 g/plant PSB emerged earlier spike while minimum days required for opening of first flower on spike and maximum longevity of spike was observed in treatment where plants recieved 75% RDF+ 25% VC +2g/plant *Azospirillum* +2g/plant PSB. In terms of vase life of cut flowers at room temperature, the treatment receiving 75% RDF +25% Leaf Manure shown maximum vase life. Mahadik *et al.,* (2017) recorded the maximum plant height, number of branches per plant, minimum days to first flower bud initiation, opening of flower and 50% flowering, maximum flower heads plant1, flower yield per plant, diameter and shelf life of the flower when plants were received biofertilizers and 50% RDF (15:100:100 kg per ha of NPK) + 10 t per ha VC (50% N through VC).

Dahlia

Ahmed *et al.,* (2004) reported that application of Urea, P_20_5 and FYM in different combinations significant reduced early flowering and increased number of flowers per plant and vase life as compared to other doses of fertilizers. Size of flowers were increased by the application of urea with combination of potash and FYM and also by using single P_20_5 while single FYM and urea did not affect size of flowers in dahlia. While, Pandey *et al.,* (2017) worked on the effect vermicompost and biofertilizers on growth and flowering on dahlia. The findings revealed the maximum plant height (65.07 cm), number of primary branches (9.67), number of leaves (33.67), plant spread (43.73cm), number of flowers (8.13), duration of flowering (10.53), flower yield ha 1(33.65), weight of tuber (56.67 g), number of tubers (4.87) and tuber yield (13.80 t ha^{-1}) when plants received the Vermicompost@ 2.5 t per ha + Azotobacter @ 2.0 kg per ha + Phosphorous Solubilizing Bacteria @ 2.0 kg per ha.

Rose

Choudhury *et al.,* (2009) observed that the application of 50 g N per plant + *Azotobacter* and *Azospirillum* each @ 1ml per plant produced maximum diameter of flower, number of petals, weight of individual flower, shelf life and yield of flowers as compared to control. Application of 25 g N per plant *Azotobacter* and *Azospirillum* each @ 1ml per plant produced maximum initiation of first flower in rose (*Rosa damascena* L.) than control.

Other floricultural crops

Reduction in the fertilizer levels were made up with the vermicompost application without any loss of yield owing to higher P mineralization due to symbiotic mycorrhizal association in salvia and ornamental plants Kale *et al.,* (1987). The significant increase in the leaf area index and flowering was also observed due to vermicompost application. Ravichandran (1991) reported improved flower yield, flower diameter and weight in *Crossandra infundibuliformis,* with *Azospirillum* + recommended dose of nitrogen. However, Bhavanisanker and Vangamudi, (1999) reported that combined application of 100 per cent nitrogen as urea and *Azospirillum* showed maximum length of spike (3.53cm) and number of flowers per spike (5.66) in Crossandra. Another experiment conducted by Bhavanishankar and Vanangamudi, (1999) who reported that the combined application of 75 per cent recommended N as neem cake blended urea + *Azospirillum* recorded the highest flower yield in *Jasminum sambac* (1.560, 1.739 and 1.779 kg per plant, respectively after 1, 2 and 3 years fertilizer application and 1 and 2 years of fertilizer application (1.445 and 1.607 kg per plant, respectively). The golden rod plants supplied with vermicompost (10 tonnes per hectare) and 100 per cent recommended NPK (100:50:50 kg/ha) produced greater plant height, maximum number of leaves and highest flower yield (Kusuma, 2001). Narasimha Raju and Haripriya, (2001) noticed maximum plant height, higher number of branches, dry matter and increased flower yield in crossandra by the application of *Azospirillum* and phosphobacteria in combination with 100 per cent of NPK (75:50:125 kg ha^{-1}). Padmadevi *et al.,* (2001) observed highest vase life in Anthurium when plants were treated with *Azospirillum*, phosphobacteria, VAM along with inorganic nutrients and growth regulators. Gayithri *et al.,* (2004) conducted an experiment on statice and observed that flower components were significantly increased by application of 75% recommended dose of N and P + 100% K + Vermicompost + Azotobacter + PSB and was at par with 50% N and P + 100% K + Vermicompost + Azotobacter + PSB in respect of spike emergence, initiation of flowers, flower harvesting, spike length, spread and number of branches per spike. Prakash *et al.,* (2002) stated that phosphorous and potassium content in the leaves increased with addition of 5 and 10 per cent FYM whereas, N content was increased in the leaves only with addition of 5 per cent FYM. Addition of FYM to the soil also increased the yield parameters in their study. Jawaharlal and Padmadevi (2003) noticed that the application of biofertilizers along with inorganic nutrients and growth regulators had significant effect on growth and flowering in anthurium. While, Gayathri *et al.,* (2004) when working with combined use of inorganic, biofertilizers and organic manures and observed that the application of 75 per cent NP + 100 per cent K + VC + *Azotobacter* +PSB significantly increased plant height, number of leaves, number of branches and highest flower yield per plant in statice. Singh and Rathore (2004) recorded highest number of spikes and flower yield per hectare with NPK (120 + 60 + 40 kg per hectare) + FYM 10 tonnes per hectare + $ZnSO_4$ 25 kg per hectare. While working with organic sources of nutrients i.e. panchagavya in combined with traditional organic and inorganic sources, Mohd *et al.*, (2006) reported that the combination of panchagavya 4% + 50% recommended dose of fertilizers (RDF) increased the spathe length (32.10cm) while the combination of vermicompost 100g per plant + 50% RDF recorded the highest value of inflorescence longevity (88.30 days), number of days for exhibiting flowers loss, spathe blueing and spadic necrosis. An experiment was carried out by Jhon *et al.*, (2007) to assessed the interaction impact of organic manure and inorganic fertiliser (M x F) on growth and bulb production in tulip cv. Apeldoorn. The results revealed that the interaction of organic manure and mineral fertility levels showed significant effect on plant height, wrapper leaf area, number of bulbs and their weight, large sized bulbs, number of bulblets and their weight $m\text{-}^{2}$,. The findings also demonstrated that organic manure (60 tonnes ha-1) in conjugation with inorganic fertilizers (N 75 P 30 K 30 kg/ha) improved plant height, wrapper leaf area, total number of bulbs/m, large sized bulbs and number of bulblets/m^2. However, Chamani *et al.*, (2008) observed that increasing the vermicompost content in the base media decreased flower numbers in petunia. Jayamma *et al.,* (2008) observed that the biofertilizes application could substitute the recommended NPK fertilizers to the extent of 50% without affecting various floral characteristics and flower yield in jasmine

(*Jasminum sambac*). Anburani *et al.,* (2008) studied the influence of various organic manures (FYM @ 25 tonnes per hectare and neem cake @ 5 tonnes per hectare) combined with graded levels of inorganic fertilizers (75,100 and 125% of RDF) and with two levels of vermiwash on growth attributes of jasmine. Application of neem cake @ 5 tonnes hectare combined with 125% of RDF (150:300:300g per plant) and vermiwash application increased the plant height, number of leaves per primary shoot and leaf area per plant. the application of 75 per cent NP + 100 per cent K + VC + *Azotobacter* +PSB while Naik *et al.,* (2009) reported that application of NPK with *Azospirillum*, phosphobacteria each at 2 g/plant significantly increased the number of leaves, flowers, leaf area and early flowering in anthurium. Sowmyamala *et al.,* (2009) working on the effect of different sources of nutrient on growth and yield of gaillardia who observed that the application of 100% recommended doses of NPK + pressmud at 10 tonnes per hectare produced maximum diameter of flowers (6.7cm), duration of flowering in plants and plots (131.66 and 140 days respectively) and also increased maximum flower yield per plant, per plot and per hectare 236 g and 4720 g and 29.13 tonnes respectively in gaillardia. Use of sand and FYM (1:1) produced maximum plant height, number of sprouts per plant, number of leaves per plant, diameter of shoot and number of flowers plant in wax Begonia (Anil *et al.*, 2009). In Anthurium cv. Verdun Red, produced maximum leaf length (38.00 cm), leaf width (17.2 cm), petiole length (49.4 cm), petiole girth (2.11 cm), number of suckers (5) and all the economic traits *i.e.*, floral parameters *viz.*, early flowering (152.3 days) and number of spikes (9.4), spathe length (12.1 cm), spathe width (8.7 cm), spadix length (7.5 cm), stalk length (53.5 cm), girth of stalk (1.9 cm), longevity of spike on plant (21.0 days), days to loss of lustre (16 days), days to spathe blueing (18 days) and days to spadix necrosis (19 days) with applying common basal dose + 3% vermiwash. The plants received a common basal dose (CBD) with FYM 200 g/pot + decomposed coir compost 100 g/pot + vermicompost 25 g/pot + Biofertilizers (VAM + *Azospirillum* + PSB) @2 g each/pot and *Trichoderma viridae* 20 g/pot at an interval of two months (Nagalakshmi, 2010). Parya *et al.,* (2010) observed maximum plant height, number of leaf, suckers and number of flower stalk per plant in golden rod (*Soildago canadensis*) when plants treated with reduced level of chemical fertilizer (75% of RDF) along with 3t/ha of vermicompost, which was at par with treatment receiving 75% of RDF in conjunction with 3 t/ha of FYM. The findings also revealed that in presence of organic manure even at lower level 1.5 t/ha along with 75% RDF showed statistically similar response that to of 100% RDF. However, Gayathiri and Anburani, (2011) observed the combination of FYM @ 25 t ha-1, consortium biofertilizer (2 kg ha-1) along with the recommended dose of inorganic fertilizers @ 112.5:37.5: 56.25 kg NPK ha-1 gave good results as compared to the other treatments in glory lilly. Deivasigamani and Thanunathan, (2011) worked on the effect of enriched FYM on growth and flowering on lily. The results demonstrated that the application of Enriched FYM at 750 kg ha^{-1} had highest yield attributes like number of capsules $plant^{-1}$, number of seeds $capsule^{-1}$, test weight (g), seed yield and tuber yield in glory lilly. Moghadam *et al.,* (2012) observed that the plants of cv. Novona treated with 30% vermicompost had maximum number number of leaves, stem height and diameter and increased GA_3 content in roots of lilium. Mousavi and Ordebili (2014) observed increased proline, soluble carbohydrate, K, and Ca contents in leaf and root tissues of lilium plants when plants received vermicompost + sugarcane bagasse sewage-sludge based compost. The combination of organic fertilizer along with inorganic fertilizer had beneficial for the photosynthetic activity and productivity of tea. Bioinoculants (BF) and/or inorganic fertilisers (IOF) were applied to assess the growth and development of nursery grown BSS (biclonal seed stocks) seedling. The findings revealed that during the first six months period, the recommended dosage of inorganic fertilizers with bio inoculants provided significantly higher values of biometric characteristics in terms of stem diameter, number of leaves, biomass production followed by the 100 % recommended practice of IOF and 50% IOF + BF. After 12 months, it was noticed that 100 % IOF had an edge over the other treatments followed by 50 % IOF + BF in most of the biometric parameters (Balamurugan *et al.*, 2013).

Kumar *et al.*, (2015) observed the highest photosynthetic rate (PN) with 45: 22.5: 45 kg-ha basal through Urea, RP, MOP + vermicompost 50%, followed by, 90: 45: 90 kg-ha basal through Urea, RP and MOP but the lowest values of these characters with the application of FYM @ 15 tones-ha. The application of 75% of NPK 90:38:56 kg ha-1 along with FYM @ 12.5 t ha-1 and vermicompost @ 5 t ha-1 was found to be superior in improving the growth and yield characters like plant height, number of branches, number of leaves, number of flowers, number of pods, pod yield per plant, pod yield per plot, seed yield per plant and estimated seed yield per hectare in glory lily (Sivasankar and Manivannan, 2015). Anand, *et al.*, (2016) revealed that that application of common basal dose (N:P:K 30:10:10) + FYM 1.0 Kg per pot + Decomposed Coir Compost 100g per pot + Biofertilizers (VAM + *Azospirillum* + Trichoderma viride 20g per pot) + 3% Panchakavya + 3% Manchurian tea produced maximum plant height, number of leaves per plant in *Cymbidium giganteum*. One-year-old Bird-of-Paradise plants were supplied with different combinations of organic and inorganic nutrient sources. The findings revealed that maximum height of the plant, maximum leaf length, leaf width, number of leaves, number of suckers and plant spread were recorded when plants received 80 per cent RDF through fertigation plus organic source of nutrients like Vermicompost (300g) along with different biofertilizers such as Azotobacter, PSB and KMB as compared in plants received 100 per cent RDF as normal fertilizers through soil application Yathindra *et al.*, (2016). Petunia plants produced the maximum plant height (25.20 cm), plant spread (43.43 cm), number of branches per plant (17.66), number of leaves per plant (300.30), yield of flower per plant (81.30 gm), yield of flower per plot (731.76 gm), flower yield per hectare (4.32 t/ha) and the maximum benefit - cost ratio (1:2.46) when plants were treated with Azotobactor + PSB +PMB + N120:P90:K60 (Kumari and Prasad, 2017).

In summery the growth, flowering and yield attributing characters of floricultural crops was significantly increased with the combined use of inorganic, organic and biofertilizers than the control and recommended doses of inorganic fertilizers. This increase was appear due to proper and judious uses of inorganic and organic sources of nutrients which resulted in supply of NPK and essential micronutrients on larger quantity to plants. So a judicial combination of inorganics and bio-fertilizers will give the best result on yields and its attributing characters in floricultural crops.

The above results showed that the pure chemical or pure organic treatments could not result in highest yield and quality. The integration of organic, biofertilizers along with chemical fertilizers has a positive effect on the growth, flowering and yield of floricultural crops and gives highest net returns and also increasing soil fertility status in harvested flower crops.

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