ADVANCES IN INTEGRATED NUTRIENT MANAGEMENT OF COMMERCIAL CUT FLOWERS: A REVIEW

ABSTRACT

Integrated nutrient management means combined application of different sources of plant nutrients like organics, inorganics and biofertilizers for sustainable crop production without degrading the natural resources on long term basis. The sustainability in agriculture system is a global issue. After the industrial revolution widespread introduction of inorganic fertilizers, led to a decline in the use of organic materials in the cropping system and the indiscriminate use of fertilizers has adversely affected the soil fertility, crop productivity and particularly the environment. A pot culture experiment was conducted during 2018-19 and 2019-20 to study the effect of organic manures and biofertilizers on growth and floral attribute of chrysanthemum (Dendranthema grandiflora Tzelev) cv. Maa White. For the continuous development of floriculture sector, we need proper soil and nutrient management because proper plant nutrition supply is essential for successful production of floricultural crops in open and under protected conditions. Integrated nutrient management is a tool that can provide eco-friendly options and a cost-effective way to provide crop plants with adequate amounts of most macro and micronutrients. it can be concluded that by reducing the level of chemical fertilizer and optimizing the dose of different organic fertilizer can optimize the yield in ornamental crops and improve overall soil health without depleting the environment.

Keywords: Integrated nutrient management, crop production, ornamental crops, floricultural crops

# INTRODUCTION

Floriculture is a branch of horticulture concerning cultivation of flowering and ornamental plants for garden and floristry. It includes cut flowers, cut greens, bedding plant, houseplants, seeds, bulbs, tubers, rooted cuttings, dried flowers, potted plants etc (Wani et al., 2016). The rising in living standards and unabated urbanization in the present day has led the world to growing demand of flowers and their products thereby making the floriculture sector an important commercial trade (Wani et al., 2017). The area under floriculture production in India was 283 thousand hectares with production of 2295.07 thousand tonnes loose flowers and 833.16 thousand tonnes cut flowers (NHB, 2022). The country has exported 21024.41 MT of floriculture products to the world for the worth of Rs. 707.81 crores in 2022-23. The U.S.A, Netherlands, United Arab Emirates, U.K, Germany and Malayasia were major importing countries during the said period. In India, more than 50% of the floriculture products are produced in Karnataka, Andhra Pradesh, Tamil Nadu, Madhya Pradesh, and West Bengal (Ministry of Agriculture and Farmers Welfares, 3rd Advance estimates, 2022).

In India commercial floriculture has emerged as hi-tech activity-taking place under controlled climatic conditions inside greenhouse which is being viewed as a high growth industry. It has been found that, commercial floriculture has higher potential per unit area than most of the field crops and is therefore a lucrative business (Laishram et al., 2016). The floriculture industry of India has been shifting from traditional flowers to cut flowers for export purposes (Kumar & Chaudhary, 2018). The important floricultural crops in the international cut flower trade are rose, carnation, chrysanthemum, gerbera, gladiolus, gypsophila, orchids, anthurium, tulip and lilies (Tripathi et al., 2012).

The sustainability in agriculture system is a global issue. After the industrial revolution widespread introduction of inorganic fertilizers, led to a decline in the use of organic materials in the cropping system and the indiscriminate use of fertilizers has adversely affected the soil fertility, crop productivity and particularly the environment. Flower cultivation is no longer exception to this (Swaroop et al., 2017). The continuous use of chemical fertilizers has affected the soil health and ultimately the flower quality. In this regard, the use of organic fertilizers is an appropriate approach to boost the productivity of flower crops (Leoni et al., 2019). And since floriculture is energy and cost intensive type of farming, the input cost of fertilizers is very high, which can be avoided by going for alternative methods like INM for increasing crop yields and sustaining them at high level. Practice of INM is the better option for the improvement of physical, chemical and

biological properties of soils (Das *et al.,* 2015). Several investigations reported that integration of both organic and inorganic sources of nutrient increases growth and yield of crop than using inorganic fertilizer alone (Gangadharan and Gopinath, 2000). 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).

# What is INM?

**“**Integrated nutrient management means combined application of different sources of plant nutrients like organics, inorganics and biofertilizers for sustainable crop production without degrading the natural resources on long term basis.”

# Components of INM

* Manures

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.

**Table 1**: Nutrient status in organic manures.

|  |  |  |  |
| --- | --- | --- | --- |
| **Organic Manure** | **N %** | **P2O5 %** | **K2O %** |
| **Bulky organic manures** |
| Cattle dung | 0.50 | 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 |

**Source:** Borah *et al.,* 2019

* Green manures

Green manuring - Green Manuring is the practice of growing leguminous plants in the field and incorporating into the soil after sufficient growth. The most important green manure crops are sunhemp, 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. The important plant species useful for green leaf manure are Neem, Mahua, wild indigo, Glyricidia, Karanji (*Pongamia glabra*) calotropis, avise (*Sesbania grandiflora*) and subabul.

* Biofertilizers

Bio-fertilizers may be defined as preparations containing living 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.

**Table 2:** Different groups of bio-fertilizers based on their nature and function.

|  |  |  |
| --- | --- | --- |
| **Sl. No.** | **Groups** | **Examples** |
| **N2 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 Zincsolubilizers | *Bacillus sp.* |
| **Plant Growth Promoting Rhizobacteria** |
| 1. | Pseudomonas | *Pseudomonas fluorescens* |

Source**:** Borah *et al.,* 2019

# 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, etc.
4. Vesicular-Arbuscular Mycorrhizae (VAM): VAM is applied in flower crops such as Crossandra, China Aster, Marigold, Gladiolus, Chrysanthemum, Tuberose, etc.

# INM investigations in some commercial cut flowers:

Study by many researchers have revealed the beneficial influence of INM, and the following reviews are the information regarding the role of integrated nutrient management in flower crop production both under both greenhouse as well as open field conditions.

**Chrysanthemum (*Dendranthema grandiflora*)**

A pot culture experiment was conducted during 2018-19 and 2019-20 to study the effect of organic manures and biofertilizers on growth and floral attribute of chrysanthemum (*Dendranthema grandiflora* Tzelev) cv. Maa White. It was conducted at Horticulture nursery and Floriculture laboratory, Department of Floriculture and Landscape Architecture, College of Agriculture, IGKV, Raipur, Chhattisgarh. The experiment was laid out in completely randomized design with 3 replications and 9 treatments with combinations constituting various organic manures and inorganic manures as control. The treatments include: T1- 100 RDF, T2- Mushroom waste + 50% RDF, T3- FYM + 50% RDF, T4- Cocopeat + 50% RDF, T5- Vermicompost + 50% RDF, T6- Mushroom waste + *Azospirillum* + *Azotobacter* + PSB + 50% RDF, T7- FYM + *Azospirillum* + *Azotobacter* + PSB + 50% RDF, T8- Cocopeat + *Azospirillum* + *Azotobacter* + PSB + 50% RDF, T9- Vermicompost + *Azospirillum* + *Azotobacter* + PSB + 50% RDF.

**Results and discussion**

On comparing the organic treatments, it was observed that (Table 3) tallest plants (14.40, 28.80 and 32.60 cm in height) was recorded in treatment T9 at 20, 40 and 60 DAP. Results also revealed that the treatments of organic manures and biofertilizer showed significant influence on flower yield. Maximum plant spread (24.40 cm), Maximum flower diameter (6.90 cm), the highest number of flowers per plant (9.10) and maximum flower yield per plant (49.10 g) was also recorded with treatment T9 (vermicompost + *Azospirillum* + *Azotobacter* + PSB + 50% RDF).

**Table 3:** Effect of different nutrient mixture on the vegetative and floral attribute of chrysanthemum cv. Maa White

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Treatments** | **Plant height (cm)** | **Avg. plant spread (cm)** | **Avg. flower stalk length (cm)** | **Avg. no of flowers****/plant** | **Avg. flower diameter****(cm)** | **Avg. flower yield/plant****(g)** |
| **20****DAP** | **40****DAP** | **60****DAP** |
| **T1** | 12.30 | 23.20 | 26.20 | 20.00 | 8.30 | 5.90 | 5.30 | 28.00 |
| **T2** | 12.60 | 23.80 | 27.30 | 21.20 | 8.60 | 6.00 | 5.50 | 30.00 |
| **T3** | 13.07 | 23.80 | 27.80 | 23.60 | 8.80 | 6.80 | 6.10 | 29.90 |
| **T4** | 12.87 | 25.50 | 28.20 | 21.50 | 8.40 | 6.70 | 5.40 | 27.10 |
| **T5** | 13.87 | 24.40 | 28.50 | 23.70 | 9.00 | 7.07 | 6.60 | 30.40 |
| **T6** | 13.86 | 24.10 | 28.20 | 23.60 | 8.60 | 7.66 | 6.40 | 32.20 |
| **T7** | 14.20 | 28.60 | 31.90 | 21.90 | 9.00 | 8.70 | 6.80 | 38.50 |
| **T8** | 13.96 | 23.60 | 28.80 | 21.50 | 8.80 | 8.30 | 6.30 | 35.20 |
| **T9** | 14.40 | 28.80 | 32.60 | 24.40 | 9.20 | 9.10 | 6.90 | 49.10 |
| **SEm±** | 0.33 | 0.57 | 0.63 | 0.50 | 0.17 | 0.42 | 0.20 | 1.17 |
| **C.D.(5%)** | 1.00 | 1.71 | 1.89 | 1.49 | 0.52 | 1.25 | 0.60 | 3.49 |

Source: Sahu *et al.*, 2022

**Gladiolus (*Gladiolus grandiflorus* L.)**

An investigation was performed to assess the effect of integrated nutrient management on growth, flowering, and yield of gladiolus cv. PDKV Gold during the years 2018-19 and 2019-20 at College of Agriculture, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola (M.S.). The experiment was laid out in Randomized Block Design with 3 replications and 13 treatments.

Through the findings depicted in (Table 4), it was concluded that, growth parameters *viz.,* minimum days to 50 per cent sprouting of corms, maximum plant height and flowering parameters *viz.,* minimum days to first spike emergence, days to opening of first floret were recorded in treatment T7 (75% RDF + 8t/ha vermicompost + *Azotobacter* + PSB). Likewise, the flower yield in respect of number of spikes per plant and number of spikes per hectare were harvested maximum under the same treatment.

**Table 4.** Effect of integrated nutrient management on growth, flowering and yield parameters of gladiolus cv. PDKV Gold.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Treatments** | **Days to 50% sprouting of corms (days)** | **Plant height (cm)** | **Days to 1st spike emergence** | **Days to opening of 1st pair of florets** | **Spikes plant-1** | **Spikes ha-1 (Lakh)** |
| **T1-100% RDF****(500:200:200 kg NPK ha-1)** | 13.33 | 109.85 | 68.90 | 78.83 | 2.03 | 2.26 |
| **T2- 32 t Vermicompost** | 16.50 | 87.56 | 73.83 | 85.63 | 1.37 | 1.52 |
| **T3- 32 t Vermicompost +****Azotobacter + PSB** | 16.17 | 92.56 | 73.33 | 84.93 | 1.43 | 1.59 |
| **T4- 100 t FYM** | 16.83 | 82.20 | 75.60 | 87.90 | 1.27 | 1.41 |
| **T5-100 t FYM + Azotobacter + PSB** | 15.50 | 94.46 | 72.60 | 83.83 | 1.50 | 1.67 |
| **T6- 75% RDF + 8 t Vermicompost** | 14.83 | 96.98 | 71.30 | 82.47 | 1.63 | 1.81 |
| **T7- 75% RDF + 8 t Vermicompost + Azotobacter + PSB** | 12.50 | 116.44 | 66.90 | 76.43 | 2.57 | 2.85 |
| **T8- 50% RDF + 16 t Vermicompost** | 15.17 | 95.59 | 72.03 | 83.43 | 1.57 | 1.74 |
| **T9- 50% RDF + 16 t Vermicompost****+ Azotobacter + PSB** | 12.83 | 111.11 | 68.47 | 78.37 | 2.10 | 2.33 |
| **T10- 75% RDF + 25 t FYM** | 14.50 | 100.94 | 70.40 | 80.80 | 1.77 | 1.96 |
| **T11- 75% RDF + 25 t FYM +****Azotobacter + PSB** | 14.17 | 103.60 | 69.50 | 80.20 | 1.87 | 2.07 |
| **T12- 50% RDF + 50 t FYM** | 14.83 | 98.36 | 70.67 | 81.13 | 1.70 | 1.89 |
| **T13- 50% RDF + 50 t FYM +****Azotobacter + PSB** | 13.67 | 107.54 | 69.10 | 79.17 | 1.93 | 2.15 |
| **‘F’ Test** | Sig | Sig | Sig | Sig | Sig | Sig |
| **SE (m) +** | 0.40 | 1.16 | 0.25 | 0.47 | 0.10 | 0.12 |
| **CD at 5%** | 1.19 | 3.42 | 0.73 | 1.38 | 0.30 | 0.34 |

Source: Patokar *et al.,* 2022

**Carnation (*Dianthus caryophyllus*)**

A field experiment was laid out in CRD design to assess the effect of integrated nutrient management on growth and flowering of carnation (*Dianthus caryophyllus* L.) at Department of Horticulture, University of Agricultural Sciences, GKVK, Bangalore. The treatment combination consisted of use of inorganic fertilizers (250:80: 200 g NPK/m2), vermicompost (2.5 kg/m2/year), biofertilizers namely, *Azospirillum brasilense*, *Bacillus megaterium*, *Glomus fasciculatum* (VAM Fungi) @ 10 g/m2 and *Trichoderma harzianum* @ 10 g/m2 and biostimulants namely panchagavya (3%) and jeevamrutha (10 ml/m2). The recommended dose of fertilizers applied was 250:80:200 g NPK/m2.

Through the findings (Table 5), it was found that treatment T7 *viz.,* 75% RD of N, P and 100% K +*Azospirillum brasilense* + *Bacillus megaterium* + *Glomus fasciculatum* (VAM Fungi)+*Trichoderma harzianum* + vermicompost + panchagavya + jeevamrutha significantly performed the best in terms of floral attributes (Table 6) flower stalk length (75.45 cm), number of flowers/m2 (739.59) and vase life (10.17 days).

**Table 5.** Effect of integrated nutrient management on flower quality and yield of carnation (*Dianthus caryophyllus* L.).\*Significant at 5%.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Treatments** | **Flower stalk****length (cm)** | **No. of****flowers/plant** | **No. of flowers/ ha****(thousand)** | **Vase life****(days)** |
| **T1- 100% RDF** | 64.30 | 15.69 | 522.95 | 6.33 |
| **T2- T1 + Vermicompost** | 65.20 | 16.19 | 539.61 | 6.50 |
| **T3- 75% RD of N, P and 100% K +*****Azospirillum brasilense* + *Bacillus megaterium* + VAM + VC** | 71.35 | 19.56 | 651.94 | 8.33 |
| **T4- T3 + *Trichoderma harzianum*** | 72.21 | 20.06 | 668.59 | 8.83 |
| **T5- T3 + Jeevamrutha** | 74.33 | 21.50 | 716.60 | 9.67 |
| **T6- T3 + Panchagavya** | 73.56 | 21.06 | 701.93 | 9.33 |
| **T7- T3 + Panchagavya + Jeevamrutha +*****Trichoderma harzianum*** | 75.45 | 22.19 | 739.59 | 10.17 |
| **T8- 50% RD of N, Pand 100% K+*****Azospirillum brasilense* + *Bacillus megaterium* + VAM + Vermicompost** | 66.25 | 16.56 | 551.94 | 6.83 |
| **T9- T8 + *Trichoderma harzianum*** | 66.95 | 17.16 | 571.94 | 7.00 |
| **T10- T8+Jeevamrutha** | 69.70 | 18.59 | 619.60 | 7.83 |
| **T11- T8 + Panchagavya** | 68.80 | 18.16 | 605.27 | 7.50 |
| **T12- T8 + Panchagavya + Jeevamrutha****+ *Trichoderma harzianum*** | 71.61 | 19.63 | 654.27 | 8.50 |
| ***F*-test** | \* | \* | \* | \* |
| **SEm±** | 0.64 | 0.34 | 11.21 | 0.23 |
| **CD at 5%** | 1.89 | 0.98 | 32.72 | 0.67 |

Source: Harshavadhan *et al.,* 2016

**Gerbera (*Gerbera jamesonii*)**

A two-year experiment was conducted in the premises of Bio-technology cum Tissue Culture Centre, Odisha University of Agriculture Technology, Bhubaneswar from 2015-16 and 2016-17 to assess the impact of INM practices on growth and flowering of gerbera (*Gerbera jamesonii* B.) cv. Shimmer. The experiment was laid down in Completely Randomized Design (CRD) with eight treatment combinations and 3 replications. The treatment consisted of T1- RDF (15:10:30 g NPK/10 plants) in alternate month,T2- RDF @ 15:10:30 g NPK/10 plants in every month ,T3- 75 % RDF + Vermicompost @ 25 g/10 plants, T4- 75 % RDF + Vermicompost @ 25 g/10 plants + *Azospirillum* @ 20 g/10 plants + PSB @ 20 g/10 plants,T5- 75 % RDF + Vermicompost @ 25 g/10 plants+ *Azotobacter* @ 20 g/10 plants + PSB @ 20 g/10 plants,T6- 75 % RDF + vermicompost @ 25 g/10 plants + sprayable macro and micro elements @ 2 ml/l,T7- 75 % RDF + vermicompost @ 25 g/10 plants + *Azospirillum* @ 20 g/10 plants + PSB @ 20 g/10 plants + sprayable macro and microelements @ 2 ml/l and T8-75 % RDF + vermicompost @ 25 g/10 plants + *Azotobacter* @ 20 g/10 plants + PSB @ 20 g/10 plants + sprayable macro and micro elements @ 2 ml/l .

From their findings (Table 6), it was concluded that application of 75% RDF (15:10:30 g NPK/10 plants) + vermicompost (25g/10 plants) + *Azospirillum* / *Azotobacter* (20g/10 plants)

+ PSB (20g/10 plants) + macro and micro element spray increased all of flowering parameters of gerbera and can be concluded that reducing level of chemical fertilizer to 75 % RDF along with application of different organic source of nutrient can improve flower yield of gerbera.

**Table 6.** Effect of INM on number of flowers/plant/m2/month

|  |  |
| --- | --- |
| **Treatments** | **Number of flowers/m2/month** |
| **Winter** | **Summer** | **Rainy** |
| **T1- RDF (15:10:30g NPK/10 plants) in alternate****month** | 21.03 | 17.84 | 19.86 |
| **T2- RDF in every month** | 11.84 | 10.95 | 11.61 |
| **T3- 75 % RDF + VC** | 16.53 | 14.91 | 15.56 |
| **T4- 75 % RDF + VC + *Azospirillum* + PSB** | 24.05 | 21.20 | 23.06 |
| **T5- 75 % RDF + VC + *Azotobacter* + PSB** | 24.03 | 21.96 | 23.04 |
| **T6- 75 % RDF + VC + macro and micro****elements** | 22.53 | 18.57 | 20.43 |
| **T7- 75 % RDF + VC + *Azospirillum* + PSB +****macro and micro elements** | 29.28 | 25.14 | 25.43 |
| **T8- 75 % RDF + VC + *Azotobacter* + PSB +****macro and micro elements** | 29.48 | 25.53 | 26.42 |
| **SE (m) ±** | 0.729 | 0.43 | 0.943 |
| **CD (0.05)** | 2.44 | 1.22 | 3.15 |

Source: Bishnupada *et al.,* 2020

**Dahlia (*Dahlia variablis*)**

A field work was performed at the Horticulture Research Farm, Department of Horticulture, National post graduate college Barhalganj, Gorakhpur to evaluate the effect of integrated nutrient management on flowering and flower yield of dahlia (*Dahlia variabilis* L.) cv. Kenya Orange during 2019-2020. The experiment was laid out in a randomized block design with three replications. The treatments consisted of absolute control (T0) Control- RDF (NPK @ 100-120-100 Kg/ha), (T1)- FYM 50% + PSB 50%, (T2)- FYM 50% + PSB 50%

,(T3)- FYM 50% + *Azotobacter* 50%, (T4)- Vermicompost 75% + PSB 25%, (T5)-

Vermicompost 25% + *Azotobacter* 75%, (T6)- PSB 50% + *Azotobacter* 50%, (T7)-FYM 25%

+ Vermicompost 25% + PSB 50% , (T8)- FYM 25% + Vermicompost 25% + *Azotobacter* 50%

, (T9)-FYM 25% + Vermicompost 25% + *Azotobacter* 25% + PSB 25%, (T10)-Vermicompost

50% + *Azotobacter* 25% + PSB 25%, (T11)-Vermicompost 75% + Azotobacter 25%.

The results from the investigation (Table 7) revealed that treatment T6 (PSB 50% + *Azotobacter* 50%) recorded the best treatment for days to first flowering (66.63 days) and days to 50% flowering (76.53 days). However, it was noted that the treatment T10 (vermicompost 50% + *Azotobacter* 25% + PSB 25%) was observed as best treatment with respect to flower diameter (22.50 cm)and flower stalk length (25.30 cm). Whereas treatment T4 (vermicompost 75% + PSB 25%) recorded the best treatment in terms of flower yield.

**Table 7.** Effect of integrated nutrient management on flowering and flower yield of dahlia (*Dahlia variabilis* L.) cv. Kenya Orange

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Treatmen t No.** | **Days to 1st****flowering** | **Days to 50%****flowering** | **Flower diameter****(cm)** | **Stalk length****(cm)** | **No. of flowers/****plant** | **Avg. no of flower/plot** | **Avg. no of flower/ ha** | **Vase life of flowers** |
| **T0** | 74.27 | 84.23 | 15.67 | 12.43 | 12.43 | 86.40 | 320000.00 | 7.33 |
| **T1** | 70.2 | 81.30 | 16.98 | 13.93 | 13.93 | 117.88 | 436592.59 | 12.67 |
| **T2** | 68.4 | 79.77 | 21.33 | 23.00 | 23.00 | 103.20 | 382222.22 | 12.00 |
| **T3** | 70.2 | 81.03 | 18.38 | 16.73 | 16.73 | 109.20 | 404444.44 | 11.00 |
| **T4** | 69.6 | 81.00 | 17.47 | 17.27 | 17.27 | 133.60 | 494814.81 | 13.00 |
| **T5** | 69.97 | 81.67 | 17.28 | 15.60 | 15.60 | 97.20 | 360000.00 | 14.67 |
| **T6** | 66.64 | 76.53 | 21.32 | 21.33 | 21.33 | 89.20 | 330370.38 | 9.00 |
| **T7** | 67.74 | 79.50 | 19.43 | 20.33 | 20.33 | 97.60 | 361481.47 | 8.67 |
| **T8** | 67.1 | 77.87 | 18.82 | 18.97 | 18.97 | 113.60 | 420740.75 | 10.00 |
| **T9** | 70.01 | 80.20 | 18.50 | 19.50 | 19.50 | 109.60 | 405925.94 | 10.33 |
| **T10** | 69.5 | 81.73 | 22.50 | 25.30 | 25.30 | 102.40 | 379259.25 | 9.33 |
| **T11** | 71 | 81.77 | 20.05 | 17.83 | 17.83 | 107.20 | 397037.03 | 11.00 |
| **F-test** | S | S | S | S | S | S | S | S |
| **C.D(5%)** | 1.06 | 0.44 | 0.30 | 0.46 | 0.46 | 5.45 | 20106.57 | 0.58 |
| **SE (m) ±** | 3.12 | 1.29 | 0.533 | 1.36 | 1.36 | 15.92 | 58970.33 | 1.69 |

Source: Chaudhary *et al.,* 2020.

**China Aster (*Callistephus chinensis* L.)**

A field experiment on the effect of integrated nutrient management practices on yield of China aster (*Callistephus chinensis* L.) cv. Arka Archana was carried out at the college farm under College of Horticulture and Research Station, Rajnandgaon during 2021-22. The experiment was laid out in a Randomized Block Design with 13 treatment combinations with 3 replications. The treatments were designed by using different combinations of vermicompost (10t/ha), *Azospirillum* (2kg/ha) , PSB (2 kg/ha) and FYM (20t/ha) with 100% RDF as control.

Based on the study, it is indicative from the (Table 8) that yield parameters like flower yield per plant (45.93 gm), flower yield per plot (2.82 kg) and flower yield per hectare (104.42 q) were significantly superior in the treatment T9 (RDF 50%+VC 50%+ *Azospirillum* + PSB), and similar trend of result with treatment T5 (RDF 50% + FYM 50% + *Azospirillum* + PSB).

**Table 8.** Effect of integrated nutrient management on yield parameters of China aster.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Treatments** | **No. of****flowers/plant** | **Flower****weight (g)** | **Flower****yield/plant (g)** | **Flower****yield/plot (kg)** | **Flower****yield/ha (q)** |
| **T1- RDF 100% (Control)** | 42.40 | 2.60 | 92.46 | 2.68 | 99.31 |
| **T2- RDF 50% + FYM 50%** | 28.67 | 1.83 | 78.14 | 2.27 | 83.92 |
| **T3-RDF 50% + FYM 50% +*****Azospirillum*** | 33.60 | 2.12 | 82.95 | 2.41 | 89.09 |
| **T4- RDF 50% + FYM 50% +****PSB** | 33.27 | 2.05 | 81.12 | 2.35 | 87.13 |
| **T5- RDF 50% + FYM 50% +*****Azospirillum* + PSB** | 42.60 | 2.79 | 95.52 | 2.77 | 102.60 |
| **T6- RDF 50% + VC 50%** | 36.20 | 2.38 | 88.57 | 2.57 | 95.14 |
| **T7- RDF 50% + VC 50% +*****Azospirillum*** | 41.47 | 2.43 | 90.64 | 2.63 | 97.35 |
| **T8- RDF 50% + VC 50% +****PSB** | 38.67 | 2.41 | 90.20 | 2.62 | 96.88 |
| **T9- RDF 50% + VC 50% +*****Azospirillum* + PSB** | 45.93 | 2.93 | 97.22 | 2.82 | 104.42 |
| **T10- RDF 50% + FYM 25%****+VC 25%** | 31.67 | 2.00 | 80.22 | 2.33 | 86.17 |
| **T11- RDF 50% + FYM 25%****+VC 25% + *Azospirillum*** | 34.73 | 2.33 | 87.04 | 2.52 | 93.49 |
| **T12- RDF 50% + FYM 25%****+VC 25% + PSB** | 34.00 | 2.26 | 84.17 | 2.44 | 90.40 |
| **T13- RDF 50% + FYM 25%****+VC 25% + *Azospirillum* + PSB.** | 42.20 | 2.58 | 91.81 | 2.66 | 98.62 |
| **SEm (±)** | 1.29 | 0.12 | 3.93 | 0.11 | 4.22 |
| **CD (5%)** | 3.78 | 0.35 | 11.54 | 0.33 | 12.39 |
| **CV (%)** | 6.00 | 8.82 | 7.76 | 7.70 | 7.76 |

Source: Verma *et al.,* 2023.

**Tulip (*Tulipa gesneriana* L.)**

An investigation entitled, effect of integrated nutrient application on yield and bulb production characters in Tulip (*Tulipa gesneriana* L.) cv. Red Beauty was conducted at the Regional Research Station, Wadura, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir during 2015 and 2016. The experiment was laid out in Randomized Complete Block Design with 12 treatments replicated three times. The treatments comprised of T1- 100% NPK of recommended fertilizer dose (RFD),T2- 75% NPK(RFD),T3- 50% NPK(RFD), T4- 25% NPK(RFD), T5- Biofertilizers (PSB+KSB+VAM) +100% NPK, T6-

Biofertilizers (PSB+KSB+VAM) +75% NPK, T7- Biofertilizers (PSB+KSB+VAM) +50% NPK, T8- Biofertilizers (PSB+KSB+VAM) +25% NPK, T9- Vermicompost+100% NPK, T10-Vermicompost + 75% NPK, T11-Vermicompost+ 50% NPK and T12- Vermicompost + 25% NPK.

The results revealed that tulip responded well to the biofertilizers and significant improvement was observed in bulb characteristics. It is indicative from (Table 9) that treatment combination containing biofertilizers, T5- (PSB+KSB+VAM) + 100% NPK resulted in highest number of bulbs per plant (1.91) and m2 (56.85), maximum number of bulblets per plant (3.48), maximum weight of bulbs/m2 (779.33 g), maximum weight of bulblets per plant (4.59 g) and maximum size of bulb (12.85 cm).

**Table 9.** Effect of integrated nutrient application on yield and bulb production in Tulip (*Tulipa gesneriana* L.) cv. Red Beauty

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Treatments** | **No. of****bulbs/ plant** | **No. of bulbs/m2** | **No. of****bulblets/ plant** | **Bulb weight/ m2 (g)** | **Weight of****bulblets/ plant (g)** | **Bulb size (cm)** |
| **T1** | 1.72 | 51.34 | 2.77 | 766.80 | 6.63 | 11.82 |
| **T2** | 1.66 | 49.26 | 2.54 | 764.38 | 6.45 | 11.61 |
| **T3** | 1.53 | 45.35 | 2.12 | 760.25 | 5.24 | 10.72 |
| **T4** | 1.41 | 41.88 | 1.40 | 751.27 | 4.59 | 9.10 |
| **T5** | 1.91 | 56.85 | 3.48 | 779.33 | 7.57 | 12.85 |
| **T6** | 1.82 | 53.82 | 2.99 | 771.88 | 7.35 | 12.26 |
| **T7** | 1.61 | 47.93 | 2.27 | 762.54 | 6.27 | 11.42 |
| **T8** | 1.47 | 43.93 | 2.04 | 756.37 | 5.26 | 10.43 |
| **T9** | 1.88 | 55.91 | 3.15 | 777.87 | 7.14 | 12.25 |
| **T10** | 1.78 | 52.88 | 2.94 | 769.79 | 6.87 | 11.82 |
| **T11** | 1.59 | 47.18 | 2.18 | 761.38 | 6.04 | 11.18 |
| **T12** | 1.45 | 43.16 | 1.96 | 755.69 | 5.03 | 9.93 |
| **C.D(p≤0.05)** | 0.04 | 3.55 | 0.50 | 2.36 | 0.52 | 1.10 |

Source: Fayaz *et al.*, 2018

**Tuberose (*Polianthes tuberosa*)**

An investigation was carried to study the response of tuberose (*Polianthes tuberosa* Lin*.*) to organic amendments and recommended dose of NPK in terms of bulb production and it was performed in an experimental farm in the Department of Horticulture, North Eastern Hill University, Tura Campus, Meghalaya during 2020-2021. The experiment consisted of 11 treatments and was replicated 3 times in a randomized block design. The treatment combinations were T1 (Control), T2 (Recommended dose of NPK/60:30:45 kg/ha), T3 (FYM @25 tons/ha), T4 (FYM @50 tons/ha), T5 (FYM @75 tons/ha), T6 (Vermicompost @10 tons/ha), T7 (Vermicompost @20 tons/ha), T8 (Vermicompost @30 tons/ha), T9 (FYM + Vermicompost @25 tons/ha +10 tons/ha), T10 (FYM + Vermicompost @50 tons/ha+20 tons/ha) and T11 (FYM +Vermicompost @75 tons/ha +30 tons/ha).

An appraisal of data as shown in (Table 10) it is indicative that treatment T11 recorded the maximum average bulblet diameter (1.89 cm), mother bulb diameter (4.69 cm), weight of the mother bulb (69.02 g), weight of bulblets (7.34 g),number of bulbs per clump (29.18), highest weight of bulbs per clump (214.44 g) and maximum bulb yield (1.50 kg) and thereby, concluded that treatment T11 (FYM @ 75 tons/ha + vermicompost @ 30 tons/ha) outperformed all other treatments in all the parameters.

**Table 10 .** Effect of NPK, FYM and vermicompost on bulblet diameter, mother bulb diameter, mother bulb weight, bulblet weight, number of bulbs per clump, bulb yield per clump, and bulb yield per unit area of tuberose (*Polianthes tuberosa* L.) cv. Prajwal

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Treatments** | **BD****(cm)** | **LBS****(cm)** | **MBD****(cm)** | **MBW****(g)** | **BW(g)** | **BPC** | **BYPC****(g)** | **BY/A(kg/m2)** |
| **T1** | 1.51 | 2.85 | 3.19 | 31.58 | 2.28 | 20.47 | 57.33 | 0.55 |
| **T2** | 1.65 | 3.97 | 4.45 | 57.04 | 3.74 | 28.44 | 124.44 | 1.00 |
| **T3** | 1.70 | 3.83 | 3.98 | 36.10 | 3.58 | 24.06 | 134.44 | 0.91 |
| **T4** | 1.71 | 3.59 | 4.36 | 60.15 | 5.63 | 27.42 | 137.44 | 1.19 |
| **T5** | 1.58 | 3.86 | 4.52 | 63.03 | 5.61 | 28.49 | 154.16 | 1.41 |
| **T6** | 1.72 | 3.54 | 3.39 | 29.25 | 3.22 | 23.27 | 77.11 | 0.74 |
| **T7** | 1.77 | 3.52 | 3.64 | 34.38 | 3.39 | 25.93 | 122.77 | 0.74 |
| **T8** | 1.71 | 3.76 | 4.49 | 58.19 | 5.75 | 27.44 | 167.77 | 1.33 |
| **T9** | 1.79 | 3.73 | 4.38 | 57.97 | 5.95 | 26.70 | 164.16 | 1.18 |
| **T10** | 1.72 | 3.84 | 4.52 | 58.49 | 5.40 | 27.53 | 203.30 | 1.44 |
| **T11** | 1.89 | 4.36 | 4.69 | 69.02 | 7.34 | 29.18 | 214.44 | 1.50 |
| **Mean** | 1.36 | 3.76 | 4.1 | 50.47 | 4.72 | 26.27 | 141.58 | 1.09 |
| **C.D(5%)** | 0.23 | 0.34 | 0.35 | 8.31 | 0.84 | 2.40 | 27.56 | 0.56 |
| **Se(d)** | 0.11 | 0.16 | 0.16 | 3.96 | 0.40 | 1.14 | 13.12 | 0.27 |
| **C.V(%)** | 8.99 | 5.26 | 9.49 | 9.60 | 10.45 | 5.33 | 11.34 | 31.17 |

BD: Bulblet diameter; LBS: Largest bulblet size; MBD: Mother bulb diameter; MBW: Mother bulb weight; BW: Bulb weight; BPC: Bulb per clump; BYPC: Bulb yield per clump; BY/A: Bulb yield per area

Source: Jamja *et al.,* 2024

# CONCLUSION

To maintain productivity and reduce dependence on chemical fertilizers alone is increasingly becoming important to flower growers. For the continuous development of floriculture sector, we need proper soil and nutrient management because proper plant nutrition supply is essential for successful production of floricultural crops in open and under protected conditions. And as such 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.

Integrated nutrient management is a tool that can provide eco-friendly options and a cost-effective way to provide crop plants with adequate amounts of most macro and micronutrients. It can reduce the use of chemical fertilizers, create favourable soil physiochemical conditions and a healthy environment, remove constraints, protect soil nutrient balance in the long run, and generate an optimum level for sustaining desired crop productivity. Research should be carried out on the use of different sources of organic matter, their effectiveness and reclamation of soil nutrients. Government should assist the farmers on balanced use of inorganic and organic fertilizers for better production of healthy crop, maintenance of soil health, and sound environment. Finally, agriculture experts and farmers should focus their attention on a simple integrated nutrient management technique that is an acceptable option, a cost-effective practice that farmers can easily implement, and an environmentally friendly approach that reduces fertilizer use and can give higher yields with better quality traits while maintaining a satisfactory profit margin. Therefore, it can be concluded that by reducing the level of chemical fertilizer and optimizing the dose of different organic fertilizer can optimize the yield in ornamental crops and improve overall soil health without depleting the environment.

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