

**Effect of Integrated Nutrient Management on Growth and  
Flowering of French Marigold (*Tagetes patula*)  
cv. Pusa Arpita**

**THESIS**



*submitted to the*

**Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya**

**In partial fulfilment of the requirements for the degree of**

**MASTER OF SCIENCE**

*In*

**HORTICULTURE**

(Floriculture and landscape architecture)

*By*

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**2019**

## CERTIFICATE- I

This is to certify that the thesis entitled “**Effect of Integrated Nutrient Management on Growth and Flowering of French Marigold (*Tagetes patula*) cv. Pusa Arpita**” submitted in partial fulfilment of the requirements for the degree of **MASTER OF SCIENCE (AGRICULTURE) in HORTICULTURE (Floriculture and Landscape Architecture)** of Rajmata Vijayaraje Scindia KrishiVishwa Vidyalaya Gwalior (M.P.) is a record of the bonafide research work carried out by **Mr. MANOHAR GV** under my guidance and supervision. The subject of the thesis has been approved by the Student’s Advisory Committee and Director of Instruction.

No part the thesis has been submitted for any other degree or diploma or has been published. All the assistance and help received during the course of this investigation has been acknowledged by the scholar.

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This is to certify that the thesis entitled “**Effect of Integrated Nutrient Management on Growth and Flowering of French Marigold (*Tagetes patula*) cv. Pusa Arpita**” submitted by **Mr. MANOHAR GV** to the Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior, in partial fulfilment of the requirements for the degree of **Master of Science (Agriculture)** in **Horticulture** in the **Department of Floriculture and Landscape Architecture**, has been, after evaluation by the External Examiner and approved by the Student“ s Advisory Committee after an oral examination on the same.

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## Acknowledgement

First of all I express my deep sense of adoration towards the Omniscient and Almighty god for giving me the opportunity of doing M.Sc. (Hort.) Floriculture and Landscape Architecture.

I express my profound sense of gratitude and indebtedness from the core of my heart towards my most respected guide and chairman of my advisory committee (Smt) Dr. Vidhya Sankar. M Assistant Professor and Dr. Anuj Kumar., Deptt. of Floriculture and Landscape Architecture, K.N.K. College of Horticulture, (Mandsaur), R.V.S.K.V.V. Gwalior for their praiseworthy guidance, valuable suggestions, overwhelming help, inspiration and encouragement during the course of investigation without which it would have not been possible to accomplish this stupendous task.

I owe whole hearted gratitude to all venerable members of my Advisory Committee, Dr. S.N. Mishra, Principal Scientist (Dept. of Soil Sciences and Agricultural Chemistry), Dr. G.P.S. Rathore, Principal Scientist (Department of Statistics and Computer Science) for their relevant guidance, inspiring suggestions, ever available generous help during the tenure of work.

Words fail to express my heartfelt thanks to Dr. H. Patidar Dean College of Horticulture, Mandsaur (M.P.) who provided all the necessary facilities during the course of present investigation.

I express my deep sense of gratitude to Dr. S. K. Rao Honourable Vice Chancellor, R.V.S.K.V.V. Gwalior, Dr. A.K. Singh, Director of Instruction, Dr. Mridula Billore, Dean Faculty of Agriculture, R.V.S.K.V.V., Gwalior (M.P.)

Words cannot express the heartfelt gratitude for my most revered family members; my father Venkatarreddy M, my mother Bharathi H M, and my Sister Manasa G V who gave me sincere affection, love, blessings and constant inspiration which enabled me to achieve this seemingly invincible goal, made my education possible and brought me to the present level.

Words can hardly register the sincere and heartfelt feeling, which I have for my batch mates and friends Birendra Pandey, Jayant Patel, Subham Khatri, Reena Parmar, Shakthi Prasad, Nithin Reddy, Nagendra Prasad, Chandramouli, Sharanappa, Madivalappa, Shwetha and Kaveri.

Place: Mandsaur

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Date: .../.../.....

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## List of Abbreviations used in text

|                |   |   |
|----------------|---|---|
| %              | : | Percentage  |
| &              | : | And   |
| /              | : | Per   |
| @              | : | At the rate of                                      |
| °C             | : | Degree Celsius                                      |
| ANOVA          | : | Analysis of Variance                                |
| C.D.           | : | Critical Difference                                 |
| cm             | : | Centimeter  |
| cv             | : | Cultivar  |
| d. f.          | : | Degree of Freedom                                   |
| DAP            | : | Days After Planting                                 |
| DAT.           | : | Days After Transplanting                            |
| EC             | : | Emulsifiable Concentrate                            |
| <i>et al.</i>  | : | et-alai   |
| Fig.           | : | Figure  |
| G              | : | Gram (s)  |
| ha             | : | Hectare   |
| <i>i.e.</i>    | : | That is   |
| Kg             | : | Kilogram (s)  |
| m              | : | Meter   |
| M. S. S.       | : | Mean Sum of Square                                  |
| m <sup>2</sup> | : | Meter square  |
| Max.           | : | Maximum   |
| Mg             | : | Milli Gram  |
| MH             | : | Million Hectare                                     |
| Min.           | : | Minimum   |
| ml             | : | Milliliter  |
| Mm             | : | Millimeter  |
| MT             | : | Million Tonne                                       |
| No.            | : | Number  |
| NS             | : | Non Significant                                     |
| MOP            | : | Murat of potash                                     |
| K              | : | Potassium   |
| N              | : | Nitrogen  |
| P              | : | Phosphorus  |
| q/ha           | : | Quintal per Hectare                                 |
| Qt             | : | Quintal   |
| RH             | : | Relative Humidity                                   |
| RVSKVV         | : | Rajmata Vijayaraje Scindia Krishi Vishwa Vidhyalaya |
| S.Em           | : | Standard error of mean                              |
| Sig.           | : | Significant   |
| spp.           | : | Species   |
| TSS            | : | Total Soluble Solids                                |
| Viz.           | : | (Videlicet) Namely                                  |



**CHAPTER - I**  
**INTRODUCTION**

## CHAPTER – I

### INTRODUCTION

---

Marigold is an important flower crop and constitutes one of the five most commonly cultivated and used flowers in urban and rural India. They are extensively used for making garlands, beautification and other purposes i.e. pigment and oil extraction and therapeutic uses. Apart from these uses, marigold is widely grown in gardens and pots. It is highly suitable as a bedding plant, in a herbaceous border and is also ideal for newly planted shrubberies to provide colour and fill the space. French marigold is most ideal for newly planted rockery, edging, hanging basket and window boxes. Flowers remain fresh for 4-5 days at room temperature and are used for religious offerings and social functions. Recently marigolds are grown commercially for extraction of carotene pigments mainly xanthophylls. The carotenoids extracted from the petals are added to poultry feed for intensification of yellow colour of egg yolk. Lutein which is the major constituent of xanthophylls is used for colouring of food stuffs. Purified extract of marigold petals containing lutein dipalmitate is marketed as an ophthalmologic agent under name adaptinol. Dietary carotenoids can be used to treat cancer and photosensitivity disease. Marigold leaves contain a distinct odoriferous oil. Wild marigold (*Tagetes minuta*) oil has valuable and precious essential oil which is used in high grade perfumes and cosmetics. The floral extracts of marigold are used for treating eye diseases and ulcers. (A.K. Singh., 2006)

Marigold (*Tagetes erecta* L.), which occupies a prominent place in ornamental horticulture, is one of the commercially exploited flower crops belonging to the family Asteraceae. Marigold is broadly divided into two groups, viz., African marigold (*Tagetes erecta* Linn.) and French marigold (*Tagetes patula* Linn). The former generally grows tall and is known as tall marigold and latter is short called as dwarf marigold. *Tagetes erecta* and *Tagetes patula* L. owe their origin to Mexico and South Africa, respectively. There are several other important species viz., *Tagetes tenuifolia* L (striped marigold), *Tagetes lucida* L. (sweet scented marigold) and *Tagetes minuta* L (perfume marigold). Though it is an introduction, considering its

acceptability under Indian conditions, it is presumed that marigold is of Indian origin (Desai, 1967)

*Tagetes patula* (French marigold) is an annual dwarf plant (0.3m. to 0.5m. in height) with reddish stem and dark green leaves adopted by various farmers for commercial production. Flowers are small, single or double, borne on proportionately long peduncles. The flower colour varies from yellow to mahogany-red. French marigold is most ideal for rockery, edging, hanging baskets and window boxes. French marigold is commercially grown all over India including Madhya Pradesh.

The area under flower production in India is around 255 thousand ha with a production of 2297 thousand MT of loose flowers and 543 lakh numbers of cut flowers. In MP, flowers are grown in an area of 17.1 thousand ha with an annual production of 200.4 thousand MT. Marigold is grown on small farms all over the country under open field conditions for centuries. Very few varieties have been developed for this crop and location specific package of practices is still not available. Marigold is grown in many districts of Madhya Pradesh. During Ganesh utsav, Durga pooja, Deepawali and other similar religious functions the price of marigold is usually high ranging from Rs. 8-15 per kilogram.

A large number of varieties is available in French marigold which is used by the farmers for successful cultivation of marigold. However a variety released from IARI viz, Pusa Arpita is a very good variety and quickly adopted by growers. There is a lack of technical information regarding its cultivation in M.P. and other states and so its cultivation is not yet popular. Nutrient status of the plants can be a pointer to the response of plant to the fertilization and internal content of the nutrients determine the fertilizer requirements. Nitrogen and potash being the major elements having immense importance in flowering crops and play a key role in the production of higher flower and seed yield of ornamentals. (Agrawal *et al.*, 2002).

The increasing use of chemical fertilizers to increase the production of flower is causing concern for the following reasons:

Soils which receive plant nutrients only through chemical fertilizers are showing declining productivity despite being supplied with sufficient nutrients. 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, especially the nitrogenous ones. Therefore, emphasis is now focused on the use of organic manures such as compost, vermicompost, farm yard manures, poultry manure and biofertilizers like *Azotobacter*, *Azospirillum*, phosphate solubilizing bacteria (PSB), etc., in addition to chemical fertilizers. (Mohanty *et al.* 2018)

Biofertilizers are microbial inoculants of selective microorganisms which help in improving soil fertility by way of accelerating biological nitrogen fixation, solubilization of the insoluble nutrients, decomposition of plant residues, stimulating plant growth and development ultimately.

*Azotobacter* is one of the most important non-symbiotic nitrogen fixing micro-organisms. The biofertilizers can save 25 to 35 per cent of the requirement of inorganic nitrogen per hectare (Vyas *et al.*, 1998). The beneficial effect of *Azotobacter* is attributed to its N fixing capacity (15-30kg ha<sup>-1</sup>) and also ability to produce growth promoting substances and antifungal antibiotics, which inhibit the growth of root pathogens.

Phosphate solubilizing bacteria particularly those belonging to genera *Pseudomonas* and *Bacillus* possess the ability to bring insoluble phosphate in soil into soluble form by secreting organic acids which lower the pH and bring about dissolution of bound phosphate.

Among manures, Farmyard manure (FYM) and Vermicompost appear to give better results. FYM is by far, the most popular and abundantly used organic source of plant nutrients, which consists of 0.5% N, 0.25% P<sub>2</sub>O<sub>5</sub> and 0.5% K<sub>2</sub>O. Vermicompost provides the vital macro elements such as N (2.3%), P<sub>2</sub>O<sub>5</sub> (1.6%) and K<sub>2</sub>O (1.5%). Organic manure also supplies the secondary and microelements such as Ca, Mg, Fe, Mo, Zn, Cu, etc.

Vermicompost is an excellent base for establishment of free living and symbiotic microbes. Application of vermicompost increases the total microbial population of the nitrogen fixation bacteria. It gives a quick response compared to ordinary compost or farmyard manure. It also increases the availability of phosphorus and nitrogen and improves microbial action in the soil. The use of

vermicompost in place of other organic fertilizer helps to overcome the problem of scarcity of organic fertilizer like FYM.

However, complete organic farming is possible only in subsistence farming and is not possible in commercial floriculture, where the yield of produce is as important as the quality of produce. Also, it is difficult to meet the requirement of nutrients for the crops exclusively through organic sources. In addition, the unavailability of organic matter in such huge quantities is also a constraint. Thus, the necessity to get sustainable flower production calls for an integrated approach of nutrient management.

An Integrated Nutrient Management System (INMS) may play a vital role in sustaining both soil health and crop production on long term basis, which may be achieved through combined use of all possible sources of nutrition. This practice not only reduces burden on chemical fertilizers but also balances use of natural resources coupled with chemical fertilizers to supply micro-nutrients and quality assurance besides maintaining soil fertility.

Keeping in view the above cited aspects, the present investigation was carried out entitled “Integrated Nutrient Management Studies in French marigold (*Tagetes patula* L.) under Malwa Conditions” to develop suitable INM practices in French Marigold cv. Pusa Arpita with following objectives:

1. To study the effect of INM on vegetative growth of French Marigold.
2. To study the effect of INM on flowering and flower quality.
3. To study the effect of INM on biochemical parameters associated with growth and flowering of French Marigold.



**CHAPTER - II**  
**REVIEW OF LITERATURE**

## CHAPTER – II

### REVIEW OF LITERATURE

---

The present investigation was carried out to study the “**Effect of Integrated Nutrient Management on Growth and Flowering of French Marigold (*Tagetes patula*) cv. Pusa Arpita**” It has been established that nutrition plays an important role in the improvement of growth and yield of African marigold crop (Patel, 1998; Chauhan *et al.*, 2005 and Gaur *et al.*, 2008). Continuous attempts are being made to ascertain the proper scheduling of inorganic and organic fertilizer management of floricultural crops. In the overall context of sustainable agriculture, the concept of integrated nutrient management involving the use of inorganic fertilizers, biofertilizers, FYM and vermicompost to augment fertilizer use through cheap nutrient sources is gaining attention. Such practices control pollution in part at least caused due to use of high dose of fertilizers.

Efforts have therefore been made to present in this chapter a brief summary of studies carried out at various places, related to the present investigation, with special reference to floriculture crops. The review has been highlighted under following heads:

#### Effect of integrated nutrient management on marigold and other crops

- A. Vegetative parameters
- B. Flowering parameters
- C. Post harvest parameters
- D. Biochemical parameters

#### A. Vegetative parameters

##### Marigold

**Suthar *et al.* (2005)** reported that an application of 100 kg N ha<sup>-1</sup> + 50 kg P<sub>2</sub>O<sub>5</sub> + 50 kg K<sub>2</sub>O along with *Azospirillum* and *Azotobacter* applied as seedling dip method gave the highest plant height (113.03 cm), number of branches per plant (27.66) and

plant spread (40.30 cm N-S and 38.30 cm E-W) as compared to control (150:50:50 kg NPK ha<sup>-1</sup>) in African marigold cv. 'Local' at Anand (Gujarat) conditions.

**Kumar et al. (2006)** reported that PSB applied through seed treatment in combination with FYM increased the plant height (44.3 cm) and plant spread (18.5 cm<sup>2</sup>) as compared to control (FYM) in marigold cv. 'Pusa Narangi' in Hisar (Haryana) conditions.

**Syamal et al. (2006)** reported that application of *Azotobacter* @ 1.5 kg ha<sup>-1</sup> along with 75% recommended dose of NPK (100:100:100 kg ha<sup>-1</sup>) gave optimum plant height (61.77 cm) as compared to recommended fertilizer dose without biofertilizers applications in marigold cv. 'Rusty Red'.

**Gaur et al. (2008)** observed that growth parameters i.e. plant height, plant spread and number of branches per plant were recorded maximum with 5 t ha<sup>-1</sup> vermicompost + 75% RDF 150:60:60) NPK kg ha<sup>-1</sup> as compared to control (unfertilized) in marigold cv. 'Pusa Narangi Gainda' under Agra conditions.

**Kumar et al. (2009)** carried out an experiment to study the effect of integrated nutrient management on growth, flowering behavior and yield of marigold (*Tagetes erecta* L.) during 2004 and 2005 in Randomized Block Design. There were thirteen treatments involving two biofertilizers, viz., *Azotobacter* and phosphorus solubilizing bacteria (PSB) and two levels of nitrogen and phosphorus, viz., (50% and 100%), farm yard manure (FYM) and control (recommended dose of NPK., i.e., 200:100:100 kg/ha). Results revealed that combined application of *Azotobacter* and PSB with FYM and 50% recommended dose of nitrogen and phosphorus significantly improved growth, during both years (2004 and 2005).

**Kumar et al. (2013)** conducted a field experiment at Horticultural Research Farm of Gochar Mahavidyalaya Rampur Maniharan. Saharanpur, U.P. The experimental findings revealed that the treatment T<sub>7</sub> (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 in terms of plant growth.

**Hassan et al. (2014)** conducted a study to determine the response of marigold to organic fertilizers and their extracts. The results showed that the type of organic fertilizer and the application method significantly affected vegetative growth (leaf

number/plant, shoot dry weight, leaf chlorophyll content, and carbohydrate leaf content), This study showed that compared to the other fifteen treatment conditions, the application of extract of sheep manure applied at 40% concentration and as a foliar spray produced superior results on vegetative growth.

**Jadhav et al. (2014)** studied the effect of organic and inorganic fertilizers on growth and yield of African marigold (*Tagetes erecta* L.) cv. Pusa Basanti Gaiinda. Studies showed significant effect on plant height (58.94 cm), number of branches per plant (7.20), in treatment with 75% RDN + 60kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup> + 60 kg K<sub>2</sub>O ha<sup>-1</sup> + Azotobacter + Enriched banana pseudo stem Sap (T<sub>8</sub>).

**Kumar et al. (2016)** carried out an investigation entitled “Effect of Integrated nutrient management (INM) on Plant growth, Flower yield and Shelf life of African Marigold (*Tagetes erecta* L.) c.v. Pusa Bsasanti”, during the year 2013-14. The results revealed that application of 75% RDF + 25% vermicompost (T<sub>2</sub>) produced significantly maximum plant height (76.77 cm), number of primary and secondary branches per plant (19.40, 33.47 respectively), number of leaves per plant (209.6) as compared to control.

**Singh et al. (2016)** concluded that the use of *Azotobacter*, PSB, along with 50 percent recommended nitrogen, phosphorous and 100 percent potassium and FYM helped in realizing better plant growth, higher quality flower, yield and above all for taking the economic production of African marigold (*Tagetes. erecta* L.) cv. ‘Pusa Narangi Gaiinda’ under field condition.

**Swathi et al. (2017)** reported that application of organic sources at optimum dosage showed increased and improved results in terms of growth and flowering as compared to control. Among all the treatments poultry manure at 15 t/ha significantly improved the plant height, plant spread and branch production of African marigold followed by mustard oil cake application as foliar application.

**Parmar et al. (2017)** conducted an investigation entitled Integrated Nutrient Management in African marigold (*Tagetes erecta* L.) The results revealed that maximum plant height (80.16 cm), during 4th month after transplanting, number of primary branches (16.25) and number of secondary branches (25.50) were observed during 2<sup>nd</sup> month after transplanting were recorded in treatment T<sub>10</sub> (FYM @ 5 t/ha +

100% RDF (150:100:100 kg NPK/ ha) + Azotobacter + PSB + KMB + 1% foliar spray of NAUROJI Novel organic liquid fertilizer).

An investigation was undertaken during the year 2013-14. The experiment was laid out in randomized block design. The results revealed that application of 75% RDF + 25% vermicompost (T<sub>2</sub>) produced significant maximum plant height (76.77cm), number of primary branches and secondary branches per plant (19.40 and 33.47, respectively) and number of leaves per plant(209.6) compared to control in marigold ( **Vishnu et al., 2015**)

**Rolaniya et al. (2017)** studied the effect of NPK, biofertilizers and plant spacing on growth and yield of African marigold. Application of 100% RDF of NPK + *Azotobacter* + PSB gave significantly higher values of plant height (82.75 cm), number of primary branches per plant (16.18 cm), plant spread, duration of flowering (68.01 days), chlorophyll content in leaves (2.56 mg/g), flower yield (184.13 q/ha) .

**Sharma et al. (2017)** revealed that 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 and plant spread Thus, use of inorganic fertilizers conjointly with bio-fertilizers and organic manures resulted in excellent vegetative growth in African marigold.

**Yadav et al. (2017)** carried out a field experiment find out the influence of different bio-fertilizers and its consortium on growth, flowering and seed yield of marigold and pooled data of both the years of experiments were taken. The treatments comprised of N<sub>2</sub> fixer (*Azotobacter*), PSB (*Pseudomonas* + *Bacillus polymyxa*), RDFYM and three levels of NPK. On the basis of data, fresh weight of leaf (4.50 g) was highest in T<sub>15</sub> albeit, T<sub>14</sub> resulted in maximum dry weight of leaf (1.75 g) and leaf biomass/plant (1773.57 g). The maximum stem diameter (1.84 cm) and plant height (136.44 cm) were recorded in T<sub>15</sub>-75% NPK + N<sub>2</sub> fixer (*Azotobacter*) + PSB (*Pseudomonas* + *Bacillus polymyxa*) + RDFYM and T<sub>14</sub>-75% NPK + N<sub>2</sub> fixer (*Azotobacter*) + PSB (*Pseudomonas* + *Bacillus polymyxa*), respectively. The maximum length of peduncle (5.08 cm) was recorded in T<sub>14</sub>.

**Kishore et al. (2018)** carried out an investigation to study the efficacy of *Azotobacter* and Phosphate Solubilizing Bacteria on vegetative and floral attributes of African marigold (*Tagetes erecta* L.) cv. Pusa Narangi Gainda under hilly regions of Uttarakhand. The results revealed that application of *Azotobacter* + PSB + RDF (T<sub>8</sub>) significantly recorded maximum vegetative attributes like plant spread (63.12 cm), number of primary branches per plant (15.70), number of secondary branches per plant (28.13), number of leaves per plant (442.00) and fresh weight of 30 leaves (33.33g).

**Yadav et al. (2018)** carried out an investigation to study effect of different bio-fertilizers on growth and flowering of marigold. Results revealed that growth parameters like number of primary branches/plant (13.42), secondary branches/plant (26.00), length of primary branches (58.83 cm), number of leaves/plant (408.79), leaf area (22.86 cm<sup>2</sup>), leaf area index (4.61) and spread of plant (39.14 cm) were recorded highest when plants treated with 75% NPK + N<sub>2</sub> fixer (*Azotobacter*) + PSB (*Pseudomonas* + *Bacillus polymyxa*) + RDFYM.

#### **Other flower crops - Calendula**

**Sakr et al. (2013)** observed that ½ NPK + compost tea + sheep manure tea was the best treatment examined for improving vegetative, flowering and yield parameters of pot marigold (*Calendula officinalis*).

#### **China aster**

**Chaitra and Patil (2007)** observed significant increase in plant height, number of leaves, number of branches, total dry matter production and also flower yield in China aster cv. Kamini with the application of vermicompost @ 2.5 t ha<sup>-1</sup> with 50 per cent RDF.

**Khanna et al. (2016)** carried out an investigation during 2015 to study the influence of organic manures and PSB on vegetative and flowering parameters of China aster cv. Kamini. The treatments consisted of Farmyard manure, Forest litter (each @ 1.5 kg/m<sup>2</sup>), PSB (@ 50 ml/15 L) and their combinations along with control. The results of the study revealed that tallest plant height (43.09 cm) with maximum plant spread

(20.06 cm), number of primary branches per plant (12.60), number of leaves (43.49), leaf area (54.63 cm), were recorded in Farmyard manure + Forest Litter + PSB. Thus, it can be concluded that application of Farmyard manure + Forest Litter + PSB can be recommended for commercial cultivation of China aster cv. Kamini.

### **Chrysanthemum**

**Rebecca et al. (2008)** studied the effect of N, P and K on growth and flowering of a *Dendrobium nobile* Lindl. hybrid, *Dendrobium* cv Red Emperor 'Prince'. Nitrogen, P, and K were tested in separate experiments as a factorial combination of five rates and three termination dates (1 Sept., 1 Oct., and 1 Nov. 2005). he came out of result that 100 mg L<sup>-1</sup> N, 25 mg L<sup>-1</sup> P, and 100 mg L<sup>-1</sup> K are recommended for optimal vegetative growth and reproductive development of *Dendrobium* cv Red Emperor 'Prince'.

**Panchal (2009)** reported that an application of 175 kg N ha<sup>-1</sup> + 100 kg ha<sup>-1</sup> P<sub>2</sub>O<sub>5</sub> + 100 kg ha<sup>-1</sup> K<sub>2</sub>O along with *Azospirillum* and *Azotobacter* applied as seedling dip method gave the highest plant height (96.23 cm), number of branches per plant (50.59) and plant spread (79.08 cm N-S and 78.79 cm E-W) as compared to control (200:100:100 kg NPK ha<sup>-1</sup>) in annual white chrysanthemum at Anand (Gujarat) conditions.

**Bohra et al. (2014)** conducted an investigation during 2010-2011, to study the effect of organic manures and bioinoculants on vegetative and floral attributes of chrysanthemum cv. Little Darling. among the treatments applied maximum plant height (30.17 cm), number of primary and secondary branches (3.78 and 19.78, respectively), plant spread (28.53 cm) and number of leaves per plant (184.33) were recorded in VAM (20 g/plant) + vermicompost (300 g/m<sup>2</sup>) at all stages of plant growth.

### **Gladiolus**

Application of 75% RDF + 25% vermicompost produced significantly tallest plant (105.60cm) with more number of leaves per plant (8.07), maximum number of shoots per plant (2.47), as compared to control (T<sub>0</sub>), and in economic point of view treatment T<sub>11</sub> (75% RDF + 25% vermicompost) was found to be most economically

viable in terms of gross return (6,94,236), net return (3,87,710) and benefit cost ratio (2.26 :1) of Gladiolus (**Kumar et al. 2014**).

In gladiolus the growth characters viz., plant height, at 30 and 45 DAP, number of leaves, leaf length, leaf width and days taken for sixth leaf stage were significantly influenced by the application of organic fertilizers T<sub>9</sub> [Vermicompost @ 2.5 t ha<sup>-1</sup> + VAM + humic acid @ 0.2 % (FS)] registered the maximum plant height (73.66 cm and 104.84 cm) at 30 and 45 DAP, respectively, number of leaves (5.60), leaf length (50.03 cm), leaf width (8.62 cm) and minimum days taken for sixth leaf stage (37.10) were recorded (**Keisam et al. 2014**)

### **Golden rod**

**Parmar et al. (2017)** studied the effect of chemical and bio-fertilizers on growth and flowering of golden rod (*Solidago canadensis* L.) cv. "Local". They reported that bio-fertilizers, application of *Azotobacter* + PSB + KMB to golden rod significantly increased growth with better quality flowers as well as maximum microbial population in soil with highest nitrogen and phosphorus content. In case of interaction, the application of RDF @ 100 % along with *Azotobacter* + PSB + KMB was found superior with respect to vegetative growth, flowering and yield parameter of golden rod.

### **Jasmine**

**Chamakumari et al. (2017)** studied effect of NPK and organic manures on plant growth, flower yield and flower quality of Jasmine (*Jasminum sambac*) var. Double mogra." They reported that treatment T<sub>6</sub> (60:120:120 g NPK + 10.5 kg FYM plant<sup>-1</sup>) was found to be statistically significant compared to other treatment combinations, which recorded maximum plant height (71.25 cm), plant spread (24.12 cm), number of leaves (85.16), Number of branches (15.08cm).

## **B. Flowering parameters**

### **Marigold**

**Rathi et al. (2005)** reported that an application of 75% recommended dose of N (150 kg ha<sup>-1</sup>), full dose of P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O (50 kg ha<sup>-1</sup> each) along with *Azotobacter* and *Phosphobacterin* (PSB) as seedling dip method gave the earliest first flower bud initiation (52.60) and 50% flowering (65.70) whereas maximum single flower weight (8.53 g), number of flowers per plant (40.54) and flower yield (72.22 q ha<sup>-1</sup>) obtained with the same treatment as compared to recommended fertilizer dose (200:50:50 kg NPK ha<sup>-1</sup>) under Navsari (Gujarat) conditions in African marigold cv. 'Local'.

**Balaji et al. (2006)** reported that the application of vermicompost (2.5-5 t/ha) helped to reduce the inorganic fertilizer requirement of China aster crop to the tune of 25-50 per cent without affecting the yield. Similarly, *in situ* vermiculture (2 lakhs earthworms/ha) without any fertilizer also showed similar results as those of recommended practices (180: 120:60 kg NPK/ha + 15 t/ha FYM).

**Gaur et al. (2008)** observed that flower yield (276.59 q ha<sup>-1</sup>) was obtained to be maximum with 5 t ha<sup>-1</sup> vermicompost + 75% RDF (150:60:60) NPK kg ha<sup>-1</sup> as compared to control (unfertilized) in marigold cv. 'Pusa Narangi Gainda' under Agra conditions.

An experiment was conducted at College Horticulture Nursery, Department of Horticulture, B.A. College of Agriculture, Anand Agricultural University. The results revealed that application of 70% RDF + 3 t/ha vermicompost + *Azotobacter*+ *Azospirillum*+ PSB (T<sub>7</sub>) produced significantly maximum flower diameter, number of pickings, average flower weight (g), number of flowers per plant, flower yield per plant (g) and per hectare (t) as compared to control, whereas the treatment of 60% RDF + 4 t/ha vermicompost + *Azotobacter*+ *Azospirillum*+ PSB (T<sub>4</sub>) recorded early flower initiation and 50% flowering as compared to other treatments in the crop African marigold (**Mittal et al., 2010**).

**Patel et al. (2011)** studied the effect of various levels of nitrogen (0, 120, 160, 200, 240 kg/ ha) and vermicompost (0, 5, 10, 15 t/ha) under FRBD with three replications. Application of 160 kg N per ha with 10 t/ha vermicompost minimized days to 50 per cent flowering (64.25), increased the number of flowers (58.38), flower yield (203.42 g/plant and 8793.60 kg/ha), flower diameter (7.60 cm), and keeping quality (9.28 days) of African marigold cv. Sierra yellow.

**Hassan et al. (2014)** conducted a study to determine the response of marigold to organic fertilizers and their extracts. The results showed that the type of organic fertilizer and the application method significantly affected flowering parameters (length of the flower stem, flower number/plant, and flower diameter). This study showed that compared to the other fifteen treatment conditions, the application of extract of sheep manure applied at 40% concentration and as a foliar spray produced superior results on both vegetative growth and flower parameters.

**Jadhav et al. (2014)** studied the effect of organic and inorganic fertilizers on growth and yield of African marigold (*Tagetes erecta* L.) cv. Pusa Basanti Gainda. Total number of flowers per plant (38.80), flower yield per plant (348.93), flower yield per plot (16.75kg), flower yield per m<sup>2</sup> (2.58kg) and hectare (25.85t.) were observed in treatment with 75% RDN + 60kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup> + 60 kg K<sub>2</sub>O ha<sup>-1</sup> + *Azotobacter* + Enriched banana pseudo stem sap (T<sub>8</sub>). The maximum gross return (516930.4 per ha), net return (435810.4 per ha) and benefit cost ratio (5.37:1) was recorded with the same treatment i.e. T<sub>8</sub> (75% RDN + 60kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup> + 60 kg K<sub>2</sub>O ha<sup>-1</sup> + *Azotobacter* + Enriched banana pseudo stem Sap) under Tansa farm (MH) area.

**Idan et al. (2014)** carried out an investigation entitled 'Effect of Organic manures on flower Yield of African Marigold (*Tagetes erecta* L.) cv. Pusa Narangi Gainda'. The maximum fresh weight of flower (9.20 gm), number of flowers per plant (39.75), flower yield per plant (366.02 g), flower yield per plot (3.29 kg), flower yield per hectare (32.94 t/ha), maximum gross return (Rs. 329,418 ha<sup>-1</sup>), net return (Rs 238,549 ha<sup>-1</sup>) and cost benefit ratio (3.63) were recorded maximum in treatment with T<sub>7</sub> (poultry manure) under Allahabad agro climatic conditions.

An investigation was taken under during the year 2013-14. The experiment was laid out in randomized block design. The results revealed that application of 75% RDF + 25% vermicompost (T<sub>2</sub>) produced the earliest first flowering (58.07), 50% of flowering (62.87), number of flowers per plant (44.07), flower yield per plant (375.42g) and flower yield per hectare (16.65t) as compared to control. In economic point of view treatment T<sub>2</sub> was found most economically viewable in turns of gross returns, net return and benefit cost ratio (2.52:1) in marigold (**Vishnu et al. 2015**).

**Kumar et al. (2016)** carried out an investigation entitled "Effect of Integrated nutrient management (INM) on Plant growth, Flower yield and Shelf life of African Marigold (*Tagetes erecta* L.) c.v. Pusa Basanti" during the year 2013-14. The results revealed that application of 75% RDF + 25% vermicompost (T<sub>2</sub>) produced significantly

maximum earliest first flower bud initiation (50.07), first flowering (58.07) and 50% flowering (62.87), the maximum number of flowers per plant (44.07), flower diameter (6.96 cm), flowering duration (54 days), average flower weight (8.52 g), flower yield per plant (375.42 g) and flower yield per plot (3.51 kg) and flower yield per hectare (16.65 t) as compared to control.

**Singh et al. (2016)** carried out an investigation during Kharif season of 2009-2010 with 16 treatments in RBD replicated 2 times. The results showed that 50% RDF and rest through poultry Manure gave a significant increase in flowering characters i.e. the earliest flower bud initiation (41.17days), the earliest 50% flowering (66.60days), the longest duration of flowering (60.59days), the maximum number of flower/plant (9.97) and ultimately produced a significantly higher flower yield/plot (26.86 kg) and per hectare (370.69 q/ha).

**Ahmed et al. (2017)** conducted an experiment to evaluate the yield and yield attributes of marigold (var. BARI Marigold) to different doses of N, P and K fertilizers and to find out the optimum and economic doses of NPK for maximizing flower yield. Flower yield and yield attributes of marigold significantly increased with NPK fertilizer for all three years. From the quadratic regression equation averaging three years data, the optimum and economic doses 103.75 and 102.44 kg N; 36.67 and 36.31 kg P and 90.10 and 88.43 kg K, respectively were found which could be recommended for marigold production in Grey Terrace Soil of Joydebpur under AEZ 28.

**Dikr et al. (2017)** reported that the physiological parameters of marigold were greatly increased by the use of NPK fertilizer and Application of bio-fertilizer significantly improved quality and quantity features in marigold, both NPK and bio fertilizers have a significant effect on morphological traits, the yield and economics of marigold as influenced by various treatments of organic fertilizers. *Azotobacter* is the free living nitrogen fixing bacteria which fix the nitrogen equivalent to 30-40 kg ha<sup>-1</sup>. Organic manure has a role in improving the soil chemical as well as physical properties of soil.

**Idan et al. (2014)** carried out an investigation entitled Effect of Organic manures on flower Yield of African Marigold (*Tagetes erecta L.*) cv. Pusa Narangi Gainda. Studies showed had fresh weight of flower (9.20gm), number of flowers per plant (39.75), flower yield per plant (366.02g), flower yield per plot (3.29kg), flower yield per hectare (32.94 t ha<sup>-1</sup>), maximum gross return (Rs. 329,418 t ha<sup>-1</sup>), net return (Rs

238,549) and cost of benefit ratio (3.63) was recorded maximum in treatment with T<sub>7</sub> (poultry manure) under Allahabad agro climatic conditions.

**Patel et al. (2017)** conducted an investigation entitled Integrated Nutrient Management in African marigold (*Tagetes erecta* L.) The results revealed that maximum total duration of flowering (77.37 days), flower diameter (6.86 cm), number of flowers per plant (87.23), flower yield (396.42 g/plant and 11.36 t/ha), with flower longevity (7.27 days) were recorded in treatment T<sub>10</sub> (FYM @ 5 t/ha + 100% RDF (150:100:100 kg NPK/ha) + Azotobacter + PSB + KMB + 1% foliar spray of NAUROJI Novel organic liquid fertilizer).

**Rolaniya et al. (2017)** concluded that application of 100 % RDF of NPK + Azotobacter+ PSB and plant spacing (60×45 cm) increased the growth and flower yield parameters of marigold.

**Sharma et al. (2017)** conducted an experiment in the experimental area of the Department of Horticulture, College of Agriculture, RVSKVV Gwalior (M.P.) with a view in to find out the optimum requirement of NPK, FYM and Biofertilizers (PSB and Azotobacter) for African marigold. The results revealed that application of the treatment of T<sub>8</sub> (50% NPK+FYM+AZB+PSB) recorded maximum duration of flowering and flower diameter (19.77 days, 7.20 cm).

**Sharma et al. (2017)** conducted an experiment in the experimental area of the Department of Horticulture, College of Agriculture, RVSKVV Gwalior (M.P.) with a view in to find out the optimum requirement of NPK, FYM and Biofertilizers (PSB and Azotobacter) for African marigold. The results revealed that application of the treatment of T<sub>5</sub> (75% NPK+FYM+AZB+PSB) produced significantly maximum branches, plant spread, fresh weight and dry weight of plant and flower (29.82 per plant, 0.357 cm, 413.28 gm and 85.20 gm per plant and 500.42 gm and 99.00 gm flower per plant respectively).

**Sharma et al. (2017)** conducted an experiment to study the effect of bio-organic and inorganic nutrient on African marigold cv. Orange Calcuttia. 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, flower yield parameters and the maximum B:C ratio. Thus, use of inorganic fertilizers

conjointly with bio-fertilizers and organic manures resulted in excellent vegetative growth and flower yield attributes in African marigold.

**Sharma et al. (2017)** revealed that 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 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 B:C ratio. Thus, use of inorganic fertilizers conjointly with bio-fertilizers and organic manures resulted in excellent vegetative growth and flower yield attributes in African marigold.

**Yadav et al. (2017)** carried out a field experiment find out the influence of different bio-fertilizers and its consortium on growth, flowering and seed yield of marigold and pooled data of both the years of experiments are taken. The treatments comprised of N<sub>2</sub> fixer (*Azotobacter*), PSB (*Pseudomonas* + *Bacillus polymyxa*), RDFYM and three levels of NPK. On the basis of data, maximum number of flowers/plant (44.04) and number of petals/flower (75.81) were noticed in T<sub>15</sub> and T<sub>14</sub>, respectively. The maximum fresh weight of flower (7.35 g) and dry weight of flower (1.81 g) were recorded with T<sub>15</sub>. the minimum number of days to seed ripening (60.61 days) was taken by T<sub>14</sub>.

**Kishore et al. (2018)** carried out an investigation to study the efficacy of *Azotobacter* and Phosphate Solubilizing Bacteria on vegetative and floral attributes of African marigold (*Tagetes erecta* L.) cv. Pusa Narangi Gaiinda under hilly regions of Uttarakhand. The results revealed that application of *Azotobacter* + PSB + RDF (T<sub>8</sub>) recorded the maximum values of floral attributes viz., the earliest first flower bud initiation (50.13 days), the earliest first flower opening (68.52 days), the earliest 50% flowering (78.39 days), flowering duration, (70.89 days), flower diameter (9.30 cm), number of flowers per plant (52.39 kg) and number of flowers per plot (628.72 kg).

**Singanjude et al. (2018)** studied the response of biofertilizers and nitrogen levels on yield and quality in African marigold during Kharif season of the year 2017-18. The experiment comprised of two factors i.e. factor A and factor B. Factor A consist of 3 levels of biofertilizers (N<sub>0</sub> - Control, N<sub>1</sub> - *Azotobacter* and N<sub>2</sub> - *Azospirillum*) and factor B consist of 5 levels of nitrogen (N<sub>0</sub> - Control, N<sub>1</sub> - 50 kg N ha<sup>-1</sup>, N<sub>2</sub> - 75 kg N ha<sup>-1</sup>, N<sub>3</sub> - 100 kg N ha<sup>-1</sup> and N<sub>4</sub> - 125 kg N ha<sup>-1</sup>) with fifteen treatment combinations replicated thrice in a Factorial Randomized Block Design. Significantly maximum

weight of flower and flower diameter were observed in the treatment combination of  $B_1N_3$  (*Azotobacter* and 100 kg N ha<sup>-1</sup>). The interaction effect of biofertilizers and nitrogen levels with respect to quality parameters i.e. flower disc diameter and number of petals per flower were found non-significant in the treatment combination of  $B_1N_3$  (*Azotobacter* and 100 kg N ha<sup>-1</sup>).

**Yadav et al. (2018)** carried out an investigation to study the effect of different biofertilizers on growth and flowering of marigold. Results revealed that the minimum number of days to bud initiation (35.16 days), the minimum days to flowering (48.68 days) and maximum bud diameter (2.00 cm) were recorded with the application of 75% NPK + N<sub>2</sub> fixer (*Azotobacter*) + PSB (*Pseudomonas* + *Bacillus polymyxa*) + RDFYM, whereas maximum bud length (2.41 cm) was measured with application of 75% NPK + N<sub>2</sub> fixer (*Azotobacter*) + PSB (*Pseudomonas* + *Bacillus polymyxa*). The greater diameter of flower (6.39 cm) was measured with 75% NPK + N<sub>2</sub> fixer (*Azotobacter*) + PSB (*Pseudomonas* + *Bacillus polymyxa*) + RDFYM and maximum duration of flowering (55.36 days) was noticed in with 75% NPK + N<sub>2</sub> fixer (*Azotobacter*) + PSB (*Pseudomonas* + *Bacillus polymyxa*) whereas, maximum flower longevity (42.74 days) was recorded with 75% NPK + N<sub>2</sub> fixer (*Azotobacter*) + PSB (*Pseudomonas* + *Bacillus polymyxa*) + RDFYM. The lowest values for growth and flowering traits were recorded in control.

### **Other flower crops**

#### **China aster**

**Nandre et al. (2005)** reported that an application of *Azotobacter* as soil application and 75% recommended dose of nitrogen (112.5 kg ha<sup>-1</sup>) with 50 kg ha<sup>-1</sup> (P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O each) resulted maximum number of flowers per plant (39.60) and flower yield (107.20 g/plant and 11.62 t ha<sup>-1</sup>) as compared to recommended fertilizer dose (150:50:50 kg NPK ha<sup>-1</sup>) in China aster under Akola (Maharashtra) conditions.

**Chaitra and Patil (2007)** found that the application of vermicompost (2.5 t ha<sup>-1</sup>), *Azospirillum* and PSB along with 50% RD of NPK gave early flowering (74.93 days), maximum number of flowers per plant (46.60) and flower yield (11.71 t/ha) in China aster cv. 'Kamini' as compared to recommended fertilizer dose (180:120:60 kg NPK/ha) in China aster cv. 'Kamini' under Dharwad (Karnataka) conditions.

**Khanna et al. (2016)** carried out an investigation during 2015 to study the influence of organic manures and PSB on vegetative and flowering parameters of China aster cv. Kamini. The treatments consisted of Farmyard manure, Forest litter (each @ 1.5 kg/m<sup>2</sup>), PSB (@ 50 ml/15 L) and their combinations along with control. The maximum duration of flowering (19.59 days), flower diameter (6.36 cm), stalk length (33.46 cm), average weight of flowers (2.61 g), number of flowers per plant (35.02), number of flowers per bed (315.18) and vase life (9.66 days) were recorded in Farmyard manure + Forest Litter + PSB. Similar, treatments showed minimum days taken to bud initiation and flowering (65.51 and 81.63, respectively). Thus, it can be concluded that application of Farmyard manure + Forest Litter + PSB can be recommended for commercial cultivation of China aster cv. Kamini.

### **Chrysanthemum**

Combined application of 175 kg N ha<sup>-1</sup> + *Azotobacter* + *Azospirillum* resulted in minimum days for first flower bud appearance (87.47 days), maximum number of flowers per plant (44.51), flower diameter (7.18 cm), weight of individual flower (3.11 g) and flower yield (110.33 g/plant and 11.76 t ha<sup>-1</sup>) as compared to control (200:100:100 NPK kg ha<sup>-1</sup>) in chrysanthemum cv. 'IIHR-6' (**Chauhan, 2005**).

**Bohra et al. (2014)** conducted an investigation during 2010-2011, to study the effect of organic manures and bioinoculants on vegetative and floral attributes of chrysanthemum cv. Little Darling. Among the treatments applied application of VAM (20 g/plant) + vermicompost (300 g/m<sup>2</sup>) was found the best as it resulted in the earliest bud initiation (55.78 days), the earliest first flowering (73.33 days), maximum flowering duration (28.33 days), maximum flower longevity (16.33 days), number of flowers per plant (70.56), flower stalk length (7.80 cm) and weight of flower (1.67 g). Maximum days taken to half of leaves (13.67) and flower wilting (17.17) were recorded in vermicompost (300 g/m<sup>2</sup>).

**Pandey et al. (2018)** conducted a field experiment to investigate the effect of bio-fertilizers and inorganic manures on plant growth and flowering of chrysanthemum (*Chrysanthemum grandiflora*) cv. Haldighati, The maximum plant height (28.80 cm) in 2014 and (30.30 cm) in 2015 the longest duration of flowering (11.73 days) first year and (12.03 days) second year, (79.13) and (76.73) days taken to flowering, the earliest flower bud appearance (61.93 days) in 2014 and (59.87 days) in 2015, the

earliest 50 percent flowering (72.40 days) in first year and (69.70 days) in second year observed in the treatment T<sub>15</sub> (*Azospirillum* + PSB + N175:P125:K125).

### **German chamomile**

**Mohammadreza et al. (2012)** studied the effect of various levels of nitrogen, phosphorus and potassium fertilizers on some agro morphological and biochemical traits of German chamomile in the years 2009 to 2010. Results showed that all fertilizers had significant effects on flower number per plant, wet weight of plant, plant dried weight, dried flowers yield, essence percent and chamazulene percent. The highest yield of dried flowers (1368.4 kg/ha) was obtained using 100 kg/ha nitrogen plus 50 kg/ha phosphorus fertilizer. Mean while, the highest amount of chamazulene (28.5%) was recorded in 50, 25, and 0 kg/ha levels of nitrogen, phosphorus and potassium, respectively.

### **Gladiolus**

**Keisam et al. (2014)** observed that flowering characters in gladiolus were significantly influenced by the application of organic fertilizers. T<sub>9</sub> [Vermicompost @ 2.5 t ha<sup>-1</sup> + VAM + humic acid @ 0.2 % (FS)] registered minimum days taken for first spike emergence (44.10), days taken for first flower to open (51.35) and maximum spike length (110.60 cm), rachis length (44.20 cm), number of florets per spike (11.40), flower weight (4.99 g) and the number of marketable spikes per plot (50.45) and also recorded longer vase life (12.66 days). From the above experiment, it may be judged that, the application of vermicompost @ 2.5 t ha<sup>-1</sup> + VAM + humic acid @ 0.2 percent (FS) enhanced the growth, flowering and yield.

Gladiolus (*Gladiolus grandiflorus* L.) cv. Eurovision was studied in respect of N, P, Zn nutrition for spike growth and development and florets number. Single application of N, P, Zn, N<sub>2</sub>, P<sub>2</sub>, Zn<sub>2</sub> produced 36.85, 32.86, 32.17 cm and 35.73, 32.84, 32.36 cm spike length during 2006-07 and 2007-08, respectively. Combined treatments of N<sub>2</sub>xP<sub>2</sub>, N<sub>2</sub>xZn<sub>2</sub> revealed considerable effects for spike length. Application of N<sub>2</sub>xP<sub>2</sub>xZn<sub>2</sub> treatment showed best effect with maximum spike length 47.16 and 48.26 cm in 2006-07 and 2007-08, respectively. Application of N, P, Zn treatments were found to have favorable response to number of florets/spike in gladiolus. (**Arya et al. 2017**)

## Jasmine

**Jayamma et al. (2014)** conducted field experiments to study the effect of biofertilizers on growth, yield, quality and nutrient content in Jasmine. Biofertilizers application improved chlorophyll content by 4.7 per cent, shelf-life of the loose flowers by over 33 per cent when compared to 100 per cent NPK treatment. Flower diameter, stalk length and petal length were increased by 8.6 percent, 11.2 percent and 13.4 percent respectively due to T<sub>6</sub> treatment (50% RDF+ biofertilizers).

**Chamakumari et al. (2017)** studied effect of NPK and organic manures on plant growth, flower yield and flower quality of Jasmine (*Jasminum sambac*) var. Double Mogra. They reported that treatment T<sub>6</sub> (60:120:120 g NPK + 10.5 kg FYM plant<sup>-1</sup>) was found to be statistically significant compared to other treatment combinations, which recorded. the earliest first flower bud initiation (123.22 days), the earliest flower bud development (15.08 days), the longest duration of flowering (85.25 days), the maximum flower bud length (2.25 cm), the maximum flower bud diameter (2.50 cm) and the longest shelf life of loose flower (47.08 hours). The lowest yield was obtained from T<sub>0</sub> (control)

## Tuberose

**Seema et al. (2006)** studied the effect of organic manures and bio-fertilizers on growth, flowering and yield of tuberose cv. Single. The results revealed that the tuberose bulbs treated with Azotobacter and PSB at 2.5 g/kg bulb gave maximum vegetative growth, early opening of first pair of florets, better flower quality parameters, maximum yield of flowers per ha and also fresh weight of bulb per plant followed by application of vermicompost @ 10 t/ha.

**Dhanumjaya et al. (2015)** studied the influence of INM practices to improve the growth and flower yield of tuberose cv. Hyderabad Double. The treatments consisted of combinations of organic fertilizers and bio inoculants along with different levels of NPK (100%, 75% and 50% RDF). Compared to 100% RDF with FYM alone, application of 75% RDF in integration with farm yard manure (FYM), vermicompost (VC), *Azospirillum* (AZO) and phosphate solubilizing bacteria(PSB) (T<sub>4</sub>) yielded maximum number of spikes per plant (2.33) with increased spike length, rachis length, number of florets per spike and also maximum number of bulbs per plant (32.60).

## C. Post harvest parameters

### Marigold

**Suthar (2005)** reported that the application of *Azotobacter* applied as seedling dip method with each of 50 kg P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O gave maximum vase life (5.33 days) as compared to control (150:50:50 kg NPK ha<sup>-1</sup>) in African marigold cv. 'Local'.

**Kishore et al. (2018)** carried out an investigation to study the efficacy of *Azotobacter* and Phosphate Solubilizing Bacteria on vegetative and floral attributes of African marigold (*Tagetes erecta* L.) cv. Pusa Narangi Gainda under hilly regions of Uttarakhand. The results revealed that application of *Azotobacter* + PSB + RDF (T<sub>8</sub>) significantly recorded maximum quality attributes viz. shelf life (7.73 days), whereas, *Azotobacter*+ RDF (T<sub>4</sub>) showed maximum plant height (94.97 cm), dry weight of 30 leaves (6.07± 0.89) and flower weight (14.10 ±1.25).

**Mittal et al. (2010)** reported that 60% RDF + 4 t/ha vermicompost + *Azotobacter*+ *Azospirillum*+ PSB (T<sub>4</sub>) recorded the maximum shelf life and vase life of flower as compared to control in the crop African marigold.

**Kumar et al. (2016)** carried out an investigation entitled "Effect of Integrated nutrient management (INM) on plant growth, flower yield and shelf life of African Marigold (*Tagetes erecta* L.) c.v. Pusa Basanti", during the year 2013-14. They reported that application of 50% RDF + 50% vermicompost (T<sub>6</sub>) showed maximum shelf life (6.70 days) of flowers at room temperature.

**Sharma et al. (2017)** conducted an experiment to find out the optimum requirement of NPK, FYM and Biofertilizers (PSB and *Azotobacter*) for African marigold. The results revealed that application of the treatments of T<sub>5</sub> (75% NPK+FYM+AZB+PSB) and T<sub>8</sub> (50% NPK+FYM+AZB+PSB) recorded the maximum shelf life and vase life of flower. However both these treatments were statistically at par.

## **D. Biochemical parameters**

### **Marigold**

**El-saeid et al. (1996)** recorded the maximum carotenoid content, volatile oil and biomass yield with the application of 238 kg N/ha in *Tagetes patula*.

**Naik (2003)** reported that, petal meal yield per hectare and xanthophyll content per kilogram of petal meal was increased with increase in the level of N and P which was maximum (22.36gm and 19.90g/ka petal meal) at a treatment combination of 'N' 250 kg and P at 120 kg/ha in marigold.

**Ahmad et al. (2011)** studied the effects of various NPK levels on growth, flowering, and xanthophyll contents of African marigold (*Tagetes erecta*, 'Double Eagle') and French marigold (*Tagetes patula*, 'Yellow'). They reported that leaf nitrogen, phosphorus, and potassium contents reached the highest values with 15:20:10, 5:20:10, and 10:20:10 g/m<sup>2</sup> NPK application, respectively. Xanthophyll contents were higher in plants fertilized with 15:20:10 g m<sup>-2</sup> NPK application. Results suggested that NPK fertilization enhanced growth and improved yield, quality, and xanthophyll contents of marigold.

**Sunil et al. (2013)** reported that organic manures showed significant response especially well rotten farm yard manure against vermicompost. Flower yield (206.83 q ha<sup>-1</sup>), carotenoids content in fresh petal (166.04g) and dried petal (16.53g) were maximum with farm yard manure, whereas, vermicompost showed maximum dry weight of single flower (1.38g) and dried petal yield (12.83q ha<sup>-1</sup>) of marigold.

**Sardoei et al. (2014)** studied the effects of vermicompost origin on the growth and flowering of *Tagetes erecta* grown under glasshouse conditions. Marigold seeds were germinated, transplanted into media and grown for 150 days. Results indicated that vermicompost had significant effect on photosynthetic pigments (p<0.05). The highest content of Chl. (a), total Chl. a+b, Carotenoids and total pigments was achieved in 60% vermicompost.

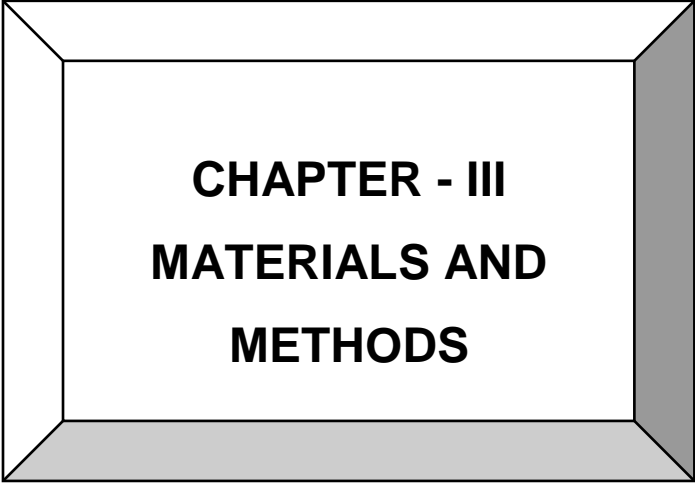
## **Other flower crops.**

### **Jasmine**

**Jayamma et al. (2014)** conducted field experiments to study the effect of biofertilizers on growth, yield, quality and nutrient content in Jasmine. Biofertilizer application improved chlorophyll content by 4.7 percent due to T<sub>6</sub> treatment (50% RDF+ biofertilizers).

### **Carnation**

**Roelants (1973)** reported increased colour intensity with increase in phosphorus levels. He also recorded increase in pigment yielding attributes like maximum flower yield, flower diameter, fresh flower weight and number of petals per flower in carnation.



**CHAPTER - III**  
**MATERIALS AND**  
**METHODS**

## CHAPTER - III

### MATERIALS AND METHODS

---

This chapter encloses materials used and methods employed during the course of investigation the “**Effect of Integrated Nutrient Management on Growth and Flowering of French Marigold (*Tagetes patula*)cv. Pusa Arpita**”

The investigation carried out is being elaborated under the following heads.

#### 3.1 Experimental Site

The present investigation was carried out during August 2018 to February 2019 at K.N.K. College of Horticulture, Mandsaur (M.P.). Mandsaur is situated in Malwa plateau in western part of M.P. at north latitude of 23.45<sup>0</sup> to 24.13<sup>0</sup> and 74.44<sup>0</sup> to 75.18<sup>0</sup> East longitude and an altitude of 435.20 m meters above mean sea level.

#### 3.2 Climate of the region

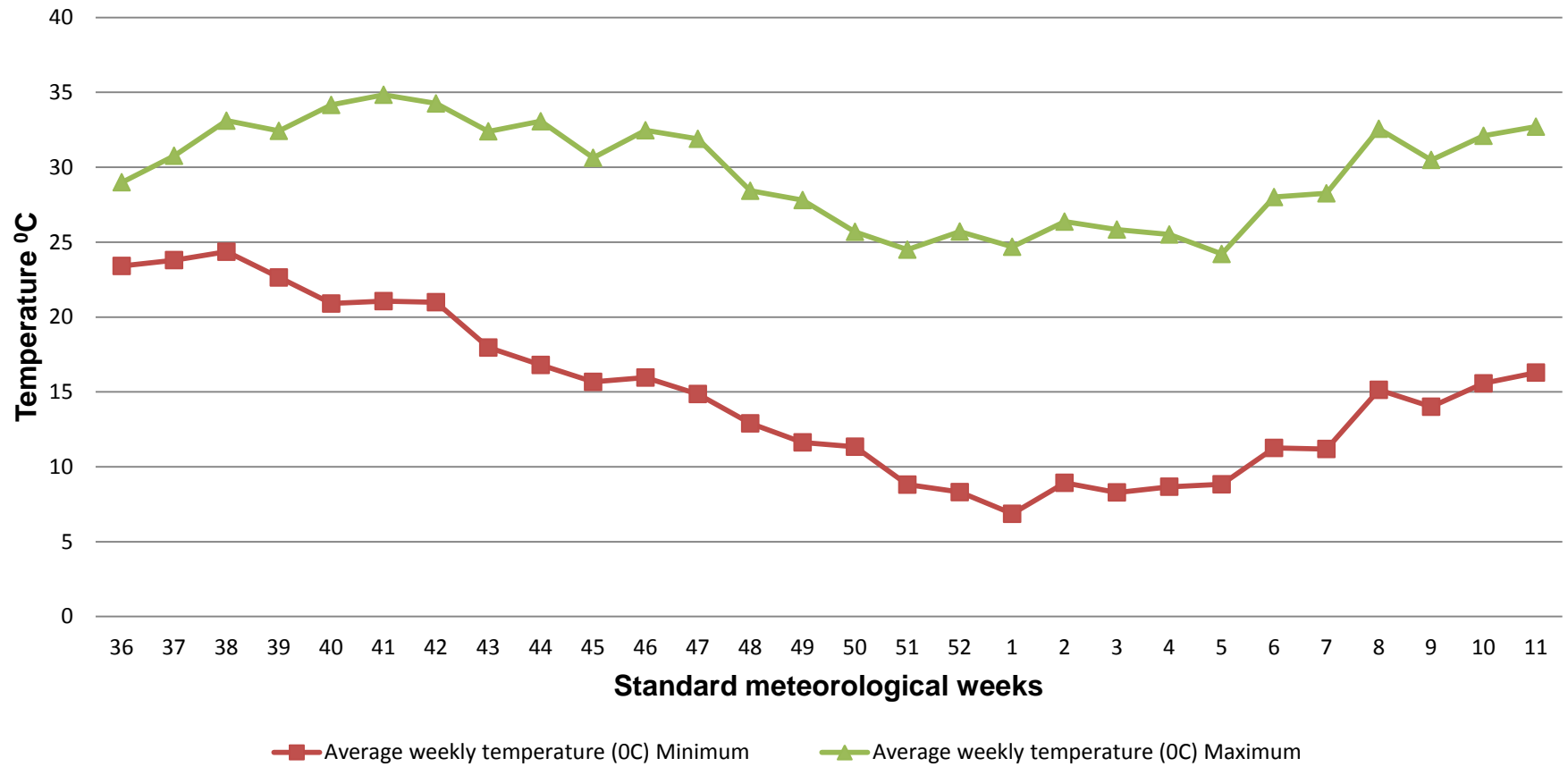
Mandsaur belongs to sub-tropical climate having a mean temperature range of minimum 5<sup>0</sup>C and maximum 44<sup>0</sup>C in winter and summer, respectively. In this area most of the rainfall is received during mid June to early October with occasional showers in winter. Southwest monsoon is responsible for major part of annual precipitation. The average annual rainfall is 544.05 mm. Meteorological data recorded during the period of investigation are presented in table 3.1 and are graphically shown in Fig. 3.1, Fig. 3.2 and Fig. 3.3.

**Table 3.1 Meteorological observations during the period of investigation.****Weekly temperature, relative humidity and rainfall at Mandsaur.**

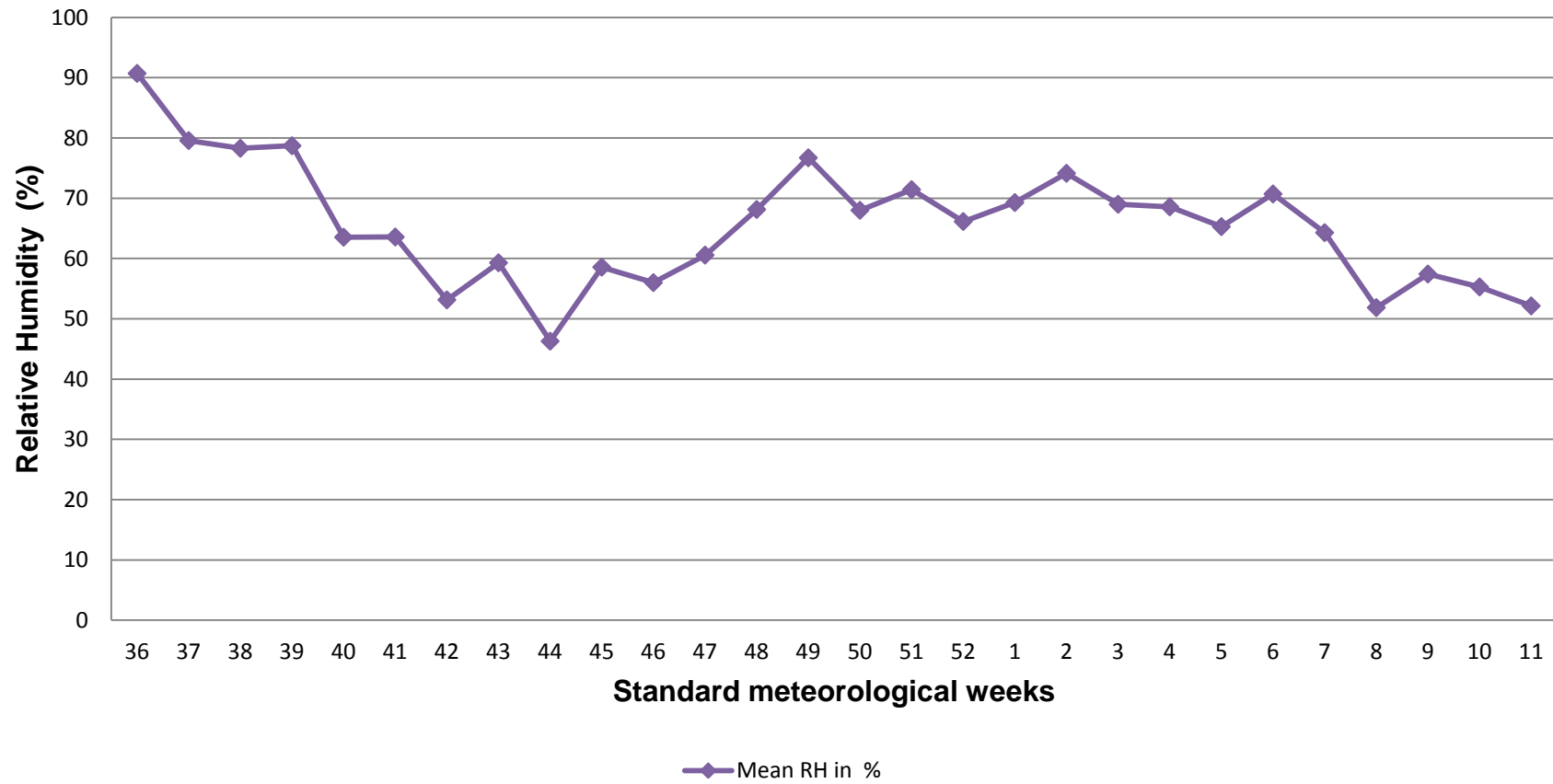
| Week | Week                     | Average weekly temperature (°C) |       | Mean RH in % | Weekly Rainfall in mm |
|------|--------------------------|---------------------------------|-------|--------------|-----------------------|
|      |                          | Mini                            | Maxi  |              |                       |
| 36   | 03-09-2018 to 09-09-2018 | 23.41                           | 29.00 | 90.71        | 499.5                 |
| 37   | 10-09-2018 to 16-09-2018 | 23.80                           | 30.77 | 79.57        |                       |
| 38   | 17-09-2018 to 23-09-2018 | 24.36                           | 33.11 | 78.29        | 122.05                |
| 39   | 24-09-2018 to 30-09-2018 | 22.64                           | 32.43 | 78.71        | 664                   |
| 40   | 01-10-2018 to 07-10-2018 | 20.90                           | 34.16 | 63.54        |                       |
| 41   | 08-10-2018 to 14-10-2018 | 21.06                           | 34.84 | 63.57        |                       |
| 42   | 15-10-2018 to 21-10-2018 | 20.99                           | 34.26 | 53.14        |                       |
| 43   | 22-10-2018 to 28-10-2018 | 17.96                           | 32.40 | 59.29        |                       |
| 44   | 29-10-2018 to 04-11-2018 | 16.80                           | 33.07 | 46.29        |                       |
| 45   | 05-11-2018 to 11-11-2018 | 15.67                           | 30.63 | 58.57        |                       |
| 46   | 12-11-2018 to 18-11-2018 | 15.96                           | 32.47 | 56.00        |                       |
| 47   | 19-11-2018 to 25-11-2018 | 14.86                           | 31.90 | 60.57        |                       |
| 48   | 26-11-2018 to 02-12-2018 | 12.90                           | 28.43 | 68.14        |                       |
| 49   | 03-12-2018 to 09-12-2018 | 11.63                           | 27.81 | 76.71        |                       |
| 50   | 10-12-2018 to 16-12-2018 | 11.34                           | 25.69 | 68.00        |                       |
| 51   | 17-12-2018 to 23-12-2018 | 8.81                            | 24.50 | 71.43        |                       |
| 52   | 24-12-2018 to 31-12-2018 | 8.31                            | 25.71 | 66.14        |                       |
| 1    | 01-01-2019 to 07-01-2019 | 6.86                            | 24.69 | 69.29        |                       |
| 2    | 08-01-2019 to 14-01-2019 | 8.93                            | 26.37 | 74.14        |                       |
| 3    | 15-01-2019 to 21-01-2019 | 8.29                            | 25.84 | 69.00        |                       |
| 4    | 22-01-2019 to 28-01-2019 | 8.67                            | 25.51 | 68.57        |                       |
| 5    | 29-01-2019 to 04-02-2019 | 8.83                            | 24.21 | 65.29        |                       |
| 6    | 05-02-2019 to 11-02-2019 | 11.26                           | 28.01 | 70.71        |                       |
| 7    | 12-02-2019 to 18-02-2019 | 11.19                           | 28.26 | 64.29        |                       |
| 8    | 19-02-2019 to 25-02-2019 | 15.14                           | 32.57 | 51.86        |                       |
| 9    | 26-02-2019 to 04-03-2019 | 14.01                           | 30.49 | 57.43        |                       |
| 10   | 05-03-2019 to 11-03-2019 | 15.57                           | 32.10 | 55.29        |                       |
| 11   | 12-03-2019 to 18-03-2019 | 16.29                           | 32.71 | 52.14        |                       |

**Source:** Meteorological observatory, College of Horticulture, Mandsaur (M.P)

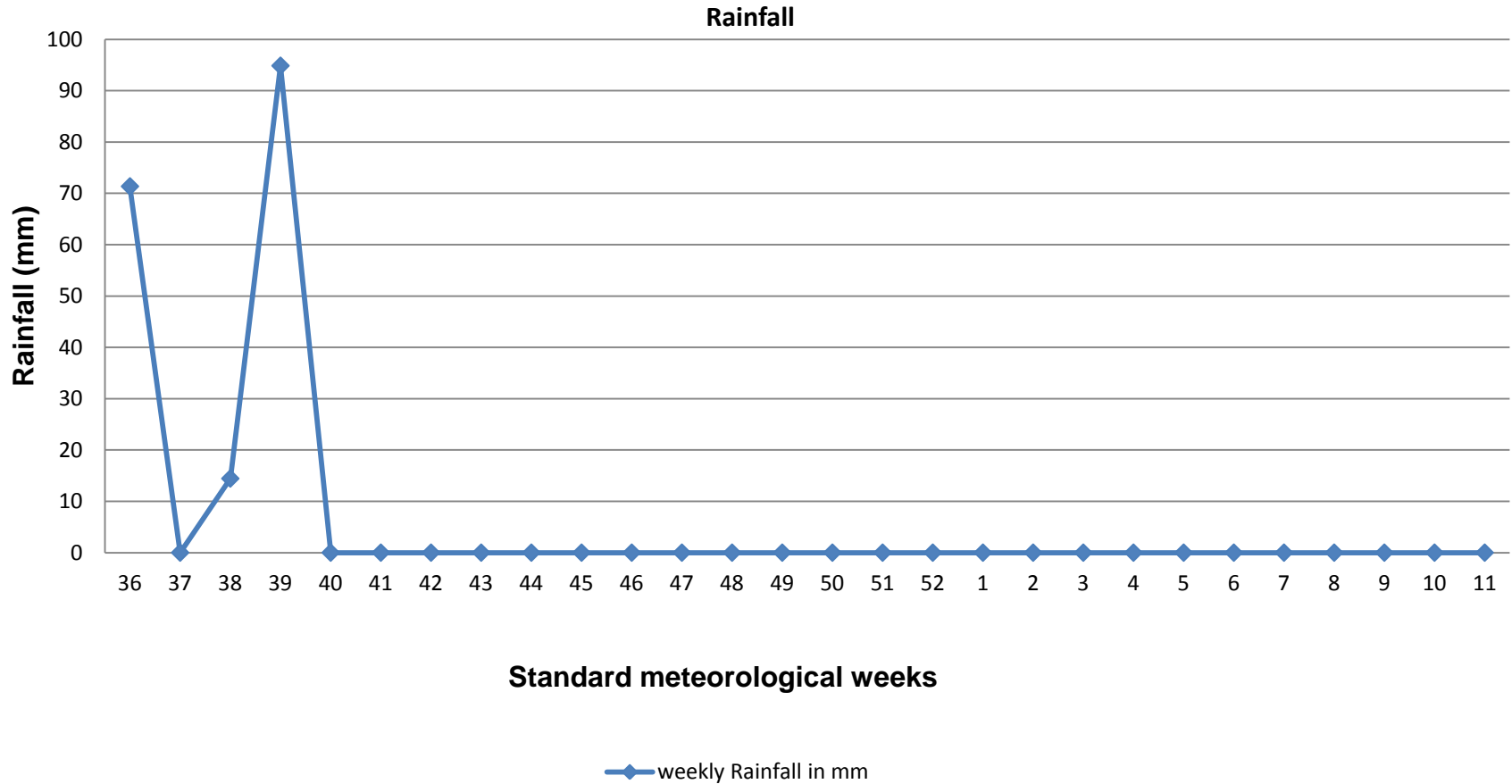
**Figure 3.1 Weekly meteorological observations during the period of investigation  
(September 2018 to March 2019)  
Temperature**



**Figure 3.2 Weekly meteorological observations during the period of investigation  
(September 2018 to March 2019)  
Relative Humidity**



**Figure 3.3 Weekly meteorological observations during the period of investigation  
(September 2018 to March 2019)**



### 3.3 Soil characteristics of the experimental site

To ascertain physiochemical characteristics of soil during the year of study, soil samples from 0-15 cm depth were taken from different spots of the experimental field before application of fertilizers. A representative sample was prepared by processing and mixing them together and the sample was analyzed for physical and chemical properties. The result of analysis, presented in table 3.2, showed that the soil was light black loamy in texture, with low availability of nitrogen, medium in phosphorus and low in potassium status.

**Table 3.2: Physical and chemical composition of the Soil sample of the experimental site**

| Particulars   | Value obtained | Method  |
|---|----------------|---|
| Physical Charecters   |                |   |
| Sand%   | 47%            | By international Pipette method (Piper,1950)        |
| Silt%   | 24%            |   |
| Clay%   | 29%            |   |
| Chemical Characters   |                |   |
| Soil pH   | 8.08           | Method No. 4 USDA Handbook No. 60 (Richards, 1954)  |
| Electrical Conductivity (dsm <sup>-1</sup> )                              | 0.23           | EC Meter  |
| Available Nitrgen (kg N ha <sup>-1</sup> )                                | 114            | Alkaline KMnO <sub>4</sub> (Subbiah & Asija, 1956)  |
| Available Phosphorus (kg P <sub>2</sub> O <sub>5</sub> ha <sup>-1</sup> ) | 20.5           | Olsen extraction method (Olsen <i>et. al.</i> 1954) |
| Available potash (kg K <sub>2</sub> O ha <sup>-1</sup> )                  | 141            | Flame photometer method Metson, 1956)               |

### 3.4 Details of layout

The experiment was laid out in Randomized Block Design (RBD) with different dose of nitrogen, phosphorus, potash, FYM, vermicompost and biofertilizers replicated three times.

**Table 3.3: Details of experiment**

| Particulars                            | Details                                     |
|--|---|
| Name of crop                           | French marigold ( <i>Tagetes patula</i> L.) |
| Name of variety                        | Pusa Arpita                                 |
| Experimental design                    | Randomized Block Design                     |
| No. of Treatments                      | 9   |
| No. of Replications                    | 3   |
| Total no. of Plots                     | 27  |
| Total number of plants                 | 432   |
| No. of plants per plot                 | 16  |
| No. of plants selected for study/ plot | 5 plants                                    |
| Distance between replication           | 1 m   |
| Distance between plots                 | 0.3 m                                       |
| Plot size                              | 1.8m×2.4m = 4.32 m <sup>2</sup>             |
| Net area of experiment                 | 7.4×24 = 177m <sup>2</sup>                  |
| Planting Distance                      | 60 cm x 45 cm (row to row x plant to plant) |
| Date of sowing (Nursery)               | 08 October 2018                             |
| Date of transplanting                  | 01 November 2018                            |

**Table 3.4: Details of treatments**

| Symbol         | Treatments  |
|----------------|---|
| T <sub>1</sub> | 100 % RDF (200:80:80 Kg/ha N: P <sub>2</sub> O <sub>5</sub> :K <sub>2</sub> O)  |
| T <sub>2</sub> | 75 % RDF + 25% RDN by FYM   |
| T <sub>3</sub> | 75 % RDF + 25% RDN by FYM+ Biofertilizer(1.5 kg/ha <i>Azotobacter</i> + 1.5 kg/ha <i>Phosphobacterium</i> )           |
| T <sub>4</sub> | 75 % RDF + 25% RDN by Vermicompost  |
| T <sub>5</sub> | 75 % RDF + 25% RDN by Vermicompost+ Biofertilizer(1.5 kg/ha <i>Azotobacter</i> + 1.5 kg/ha <i>Phosphobacterium</i> )  |
| T <sub>6</sub> | 50 % RDF + 50% RDN by FYM   |
| T <sub>7</sub> | 50 % RDF + 50% RDN by FYM+ Biofertilizer(1.5 kg/ha <i>Azotobacter</i> + 1.5kg/ha <i>Phosphobacterium</i> )            |
| T <sub>8</sub> | 50 % RDF + 50% RDN by Vermicompost  |
| T <sub>9</sub> | 50 % RDF + 50% RDN by Vermicompost+ Biofertilizer (1.5 kg/ha <i>Azotobacter</i> + 1.5 kg/ha <i>Phosphobacterium</i> ) |

## **3.5 Agronomical Operations**

### **3.5.1 Nursery raising**

The seedlings of French marigold were raised in nursery beds. The beds were prepared thoroughly by deep digging and removing of Stones, brick pieces, clods, weeds and such other undesirable materials. Seeds are treated with chemicals to avoid soil borne pathogens. The seeds were sown on 08<sup>th</sup> October 2018. After sowing; the seeds were covered with a fine mixture of soil and FYM.

First irrigation was given immediately after sowing. Subsequently irrigations were done at regular intervals. Care was taken to avoid insect pests and to get healthy plants of uniform size.

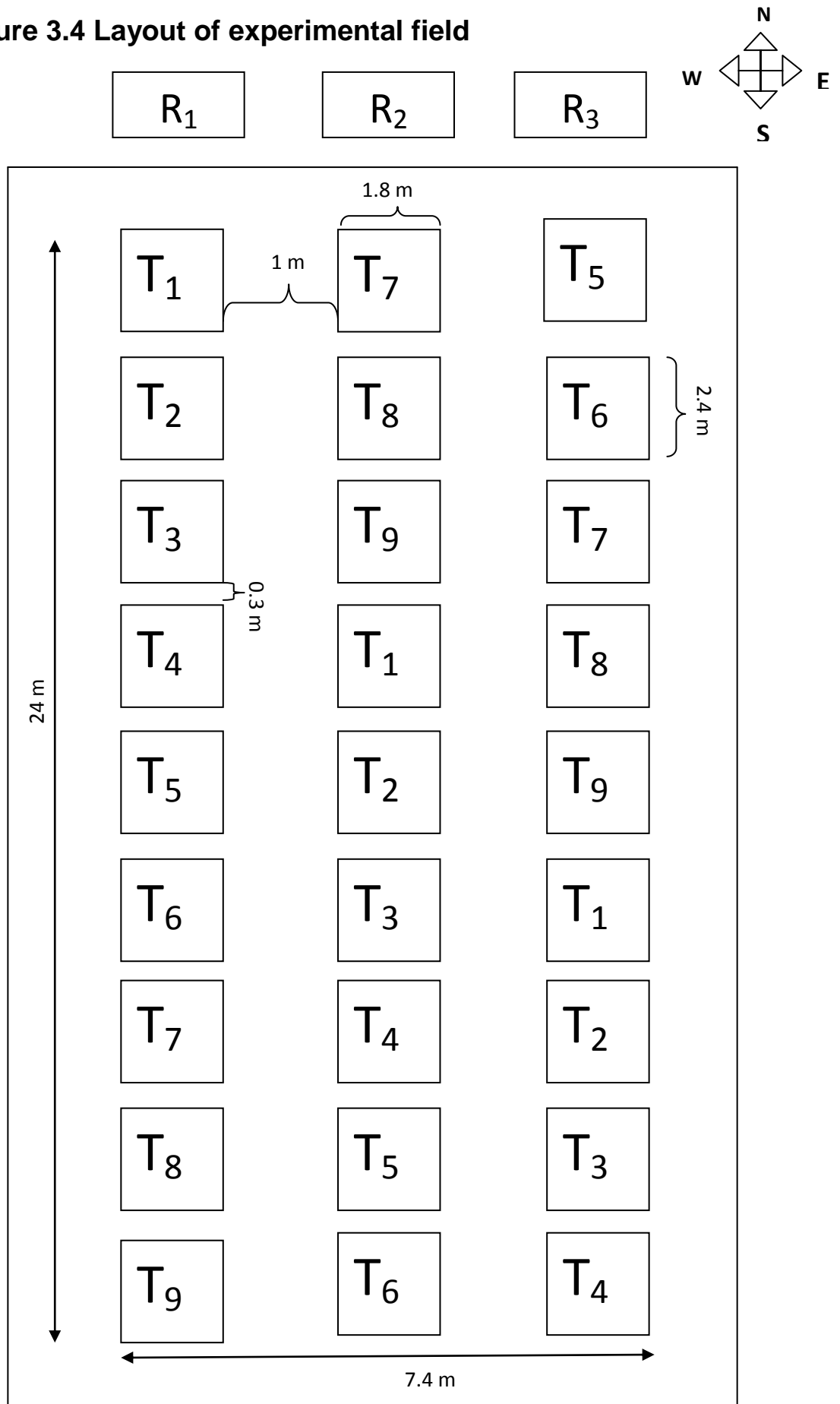
### **3.5.2 Field preparation**

The experimental area was well ploughed twice with the help of tractor drawn cultivator in both directions and harrowing was done to break the clods, and leveling was done.

### **3.5.3 Layout**

The experimental area was finally divided in to treatment plots and replications with the help of measuring tape marking the block borders and channels. The plan of layout as shown in figure 1.2 was executed on 1<sup>st</sup> November 2018.

Figure 3.4 Layout of experimental field



#### **3.5.4 Manures and fertilizers**

After executing the plan of layout, the calculated quantities of manures and fertilizers were applied to the respective plots marked for giving the nutrient treatments mentioned. Well decomposed farm yard manure, vermicompost, NPK and biofertilizers were applied in to plots during field preparation and mixed well with soil. The sources of nitrogen, phosphorus and potash were urea (46% N), single super phosphate (16% P<sub>2</sub>O<sub>5</sub>) and muriate of potash (60% K<sub>2</sub>O), respectively. The half dose of nitrogen with full doses of P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O were applied as basal, at the time of transplanting. The remaining dose of N was top dressed at 35 days after transplanting (DAT).

#### **3.5.5 Transplanting**

The 23 days old uniform healthy seedlings of Pusa Arpita were transplanted at a distance of 60 x 45 cm singly in experimental plots on 01<sup>st</sup> November 2018. The operation of transplanting was carried out in evening and followed by a light irrigation with a view to encourage the establishment of seedlings.

#### **3.5.6 Gap filling**

Those seedlings, which died within the first five days of transplanting, were replaced by new ones to maintain uniform crop stand in all the plots.

#### **3.5.7 Irrigation**

This experiment was conducted in during November 2018 to March 2019. Irrigation was given after 10-15 days interval depending upon the rainfall and soil moisture conditions. (The details of irrigation schedule are given in table 3.5)

#### **3.5.8 Weeding**

Two hand weeding were given to remove the weeds during the entire growth period by Khurpi and kudali.



**Plate 1:- An overview of field at transplanting**

### 3.5.9 Plant protection

Mancozeb @ 0.25% was sprayed as a prophylactic measure for control of leaf blight and spot disease, and wettable sulphur 80% w/w @ 0.3% was dusted to control powdery mildew of marigold at 45 and 60 days after transplanting. Spraying of Trizophos 40EC @ 2 ml/litre of water was given to control the attack of hairy caterpillar and Nuvacron 40EC @ 1ml/l of water was given to control the attack of sucking pests like aphids, thrips, and mites 30 and 60 days after transplanting.

**Table 3.5: Schedule of operations carried out in course of Investigation.**

| <b>Operation</b>  | <b>Date</b>              | <b>Remark</b>            |
|---|--------------------------|--------------------------|
| Nursery raising (seed sowing)   | 08 October               | Manually                 |
| Field operation<br>(a) Ploughings (two)<br>(b) Harrowing                            | 20 October<br>21 October | By tractor<br>By tractor |
| Soil sample collection for physio-chemical studies of the soil before transplanting | 18 October               | Hand Auger               |
| Layout  | 29 October               | Manually                 |
| Manure and fertilizer application   | 29 October               | Manually                 |
| Transplanting   | 01 November              | Manually                 |
| Gap filling   | 07 October               | Manually                 |
| Observations recorded   | As per requirement       | Manually                 |

|   |   |                         |
|---|---|-------------------------|
| <b>Irrigation</b><br>(a) First<br>(b) Second<br>(c) Third<br>(d) Fourth<br>(e) Fifth<br>(f) Sixth<br>(g) Seventh<br>(h) Eighth<br>(i) Ninth           | 01 November<br>10 November<br>25 November<br>10 December<br>25 December<br>10 January<br>25 January<br>10 February<br>25 February | Manually                |
| Intercultural<br>Weeding and hoeing-I<br>Weeding and hoeing-II  | 25 November<br>10 January   | By Khurpi and<br>Kudali |
| <b>Plant protection</b><br>(a) Insecticide and fungicide spray-I<br>(b) Insecticide and fungicide spray-II<br>(c) Insecticide and fungicide spray-III | 20 November<br>15 December<br>10 February   | By Sprayer              |

### 3.6 Observations recorded

To make critical analysis of crop performance as affected by different treatments five plants were tagged by random method under each plot and all the observations under characters given below were recorded on these plants.

#### A. Growth characters at 15 days interval (30, 45 and 60 days after transplanting)

- I. Plant height (cm)
- II. Plant spread (cm)
- III. Stem diameter (mm)
- IV. No. of primary branches per plant
- V. No. of secondary branches per plant

### **I. Plant height (cm)**

The height of the tagged plant was measured from ground level to the growing tip of the plant and the height was recorded at 30, 45 and 60 DAT. Height was measured with the help of metre scale in cm.

### **II. Plant spread (cm)**

Plant spread was calculated by measuring the spread of foliage in East-West and North-south direction at 30, 45 and 60 DAT with the help of metre scale in cm.

### **III. Stem diameter (mm)**

The stem diameter of five selected plants from each plot was measured by using vernier calipers at 30, 45 and 60 DAT and average was determined.

### **IV. No. of primary branches per plant**

Number of primary branches per plant was counted at 30, 45 and 60 DAT

### **V. No. of secondary branches per plant**

Number of secondary branches per plant was counted 30, 45 and 60 DAT

## **B. Flowering parameters**

- I. Days to bud appearance
- II. Days to 50% flowering
- III. Flowering duration (days)
- IV. Individual flower weight (g)
- V. Flower yield per plant (kg)
- VI. Flower yield per plot (kg)

### **I. Days to bud appearance**

In this observation days to bud appearance was counted from the date of transplanting of seedling to the first pea stage flower bud initiation on the plant.

## **II. Days to 50% flowering**

In this observation number of days taken to 50% flowering was counted from the date of transplanting of seedling to the appearance of flower on 50% plants on a single plot.

## **III. Flowering duration (days)**

The number of days from first flower bud appearance to the end of flowering was counted and recorded from the tagged plants and the average was calculated

## **IV. Individual flower weight (g)**

The Individual flower weight of flowers per plant was measured by means of electronic balance and average was calculated.

## **V. Flower yield per plant (kg)**

Flower yield per plant was calculated on the basis of fresh weight of flower per plant from each experimental plot.

## **VI. Flower yield per plot (kg)**

Flower yield per plot was calculated on the basis of fresh weight of flower per plot from experimental field.

## **C. Flower quality characters.**

- I. Flower diameter (cm)
- II. Length of peduncle (cm)
- III. Shelf life of flowers (days)

### **I. Flower diameter (cm)**

Maximum breadth across the flower was taken as the diameter of five flowers per plot in each treatment and was measured in centimeter by using cm scale and average was worked out.

## **II. Length of peduncle (cm)**

Length of peduncle was calculated by measuring the length from the base of peduncle to the neck of the flower.

## **III. Shelf life of flowers (days)**

The number of days until flower remains fresh (keeping quality of flowers) in vases containing simple room temperature was counted and recorded.

## **D. BIOCHEMICAL PARAMETERS:**

- I. Chlorophyll content of leaves (SPAD value).
- II. Total Carotenoid content in leaves (mg/g).

### **I. Chlorophyll content in leaves (SPAD value).**

Chlorophyll content was estimated in 4<sup>th</sup> leaf from the top (fully expended leaf) with the help of chlorophyll meter (SPAD-502 plus) by clamping the meter over leafy tissue in selected plants. Readings measured in 5 plants per pot at after flowering 60 days of transplanting

### **II. Total carotenoids in petals (mg/g).**

#### **Principle:**

The total carotenoids are extracted and partitioned in organic solvent such as 80% acetone. The amount of carotenoids is estimated spectrophotometrically at 663 and 645 nm wavelengths.

#### **Materials required:**

Plant leaf, distilled water, 80% acetone, mortar and pestle, funnels, Whatman filter papers grade1, volumetric flasks, measuring cylinders, pipettes, spectrophotometer etc.

#### **Procedure:**

Prepare 80% acetone. Weigh 250 mg of fresh petals material, grind the pieces of plant material in pestle and mortar using 5 ml of 80% acetone.

Filter the homogenate in 25 ml volumetric flask by using Whatman paper grade 1. Wash out the homogenate 3-4 times with 5 ml of 80% acetone each time. Grind the tissue once again with minimum quantity of acetone if required as it helps in complete extraction of plant pigments. Centrifuge the tubes (2000 rpm) for 10 minutes. Collect the supernatant in 25 ml volumetric flask and makeup the volume with 80% acetone.

Record the absorbance of supernatant at two different wavelengths (663 and 645 nm) using spectrophotometer by keeping 80% acetone as blank.

The total carotenoid content can be calculated by the formula given by Kirk and Allen (1965):

$$C = \{A_{480} + (0.114 \times A_{663}) - (0.638 \times A_{645})\}$$

Where, C=Total amount of carotenoids (mg), A<sub>480</sub> = Absorbance at 480 nm, A<sub>645</sub> = Absorbance at 645 nm and A<sub>663</sub> = Absorbance at 663 nm.

### **3.7 Statistical Analysis**

The data obtained from present experiment were subjected to “Analysis of Variance” as advocated by Panse and Sukhatme (1984). The Skeleton of ANOVA as per design is as given in Table 3.6 below

**Table 3.6 : Skeleton of analysis of variance**

| ANOVA                      |                        |                    |                           |                               |  |
|----------------------------|------------------------|--------------------|---------------------------|-------------------------------|--|
| Source of Variation (S.V.) | Degree of freedom (Df) | Sum of Square (SS) | Mean sum of Squares (MSS) | "F" value (Calculated) (Fcal) | "F" value (Table) at 5% level of significance (Ftab) |
| Replication                | (r-1)                  | RSS                | RMS                       | RMS/EMS                       |  |
| Treatment                  | (t-1)                  | TSS                | TMS                       | TMS/EMS                       |  |
| Error                      | (r-1) (t-1)            | ESS                | EMS                       |                               |  |
| Total                      |                        |                    |                           |                               |  |

The critical difference (C.D.) was calculated to assess the significance of difference between treatments, whenever the results were found significant through 'F' test, CD at 5 % level of significance was determined. S.Em. and CD are calculated using the following formula.

**(i) C.D. for Treatment**

$$S. Em. \pm = \sqrt{\frac{EMS}{R}}$$

$$CD = S.Em. \pm \times \sqrt{2} \times t_{5\%} (edf)$$

Where

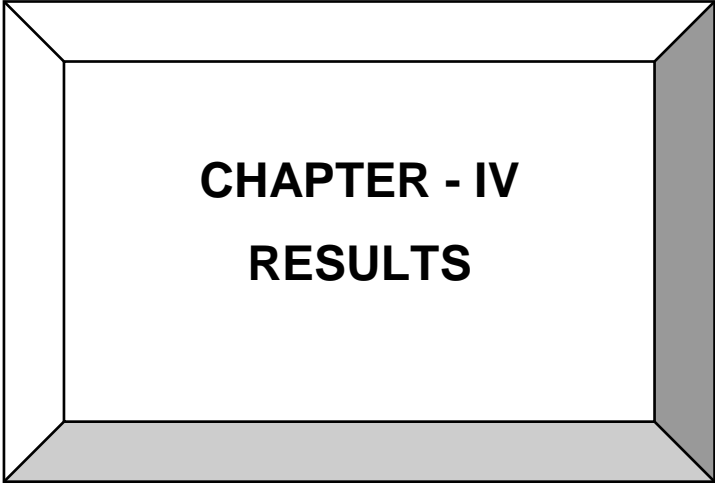
EMS = Error mean sum of squares

R = Replications

S.Em.  $\pm$  = Standard error of mean

CD = Critical difference

$t_{5\%} (edf)$  = Table value at error degree of freedom



**CHAPTER - IV**  
**RESULTS**

## CHAPTER - IV

### RESULTS

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The results of the field experiment entitled “**Effect of Integrated Nutrient Management on Growth and Flowering of French Marigold (*Tagetes patula*) cv. Pusa Arpita**” conducted at the College farm, College of Horticulture Mandsaur during the year 2018-2019, are presented in this chapter under following headings:

- 4.1 Vegetative parameters
- 4.2 Flowering parameters
- 4.3 Post harvest parameters
- 4.4 Biochemical parameters

#### 4.1 Vegetative parameters:

##### 4.1 (a) Plant height (cm):

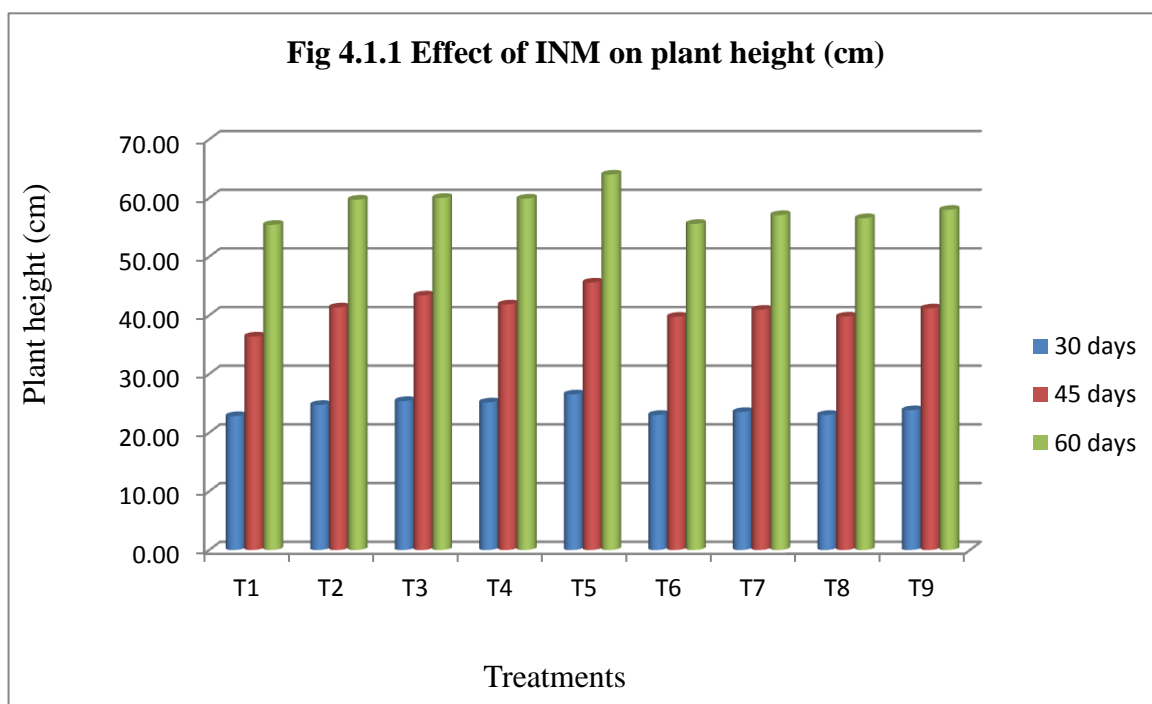
Plant height is an important growth parameter and contributes much towards the vigour of the plant. Height of the plant was recorded after 30 days of transplanting and subsequent observations were recorded at an interval of 15 days. The height of the plant as affected by the different treatments is given in Table 4.1.1 and depicted in Fig. 4.1.1

It can be observed from the Table 4.1.1 that all the INM treatments employed were significantly superior to the control (RDF) in terms of plant height (cm) recorded during the different stages i.e. 30, 45 and 60 days after transplanting. There is a steady increase in plant height regardless of INM treatment during the crop growth period (Fig. 4.1.1).

At 30 DAT the maximum plant height (26.53 cm) was recorded by T<sub>5</sub> (75% RDF + 25% RDN by Vermicompost + 1.5 kg/ha *Azotobacter* + 1.5 kg/ha *Phosphobacterium*) followed by T<sub>3</sub> (75 % RDF + 25% RDN by FYM+ 1.5 kg/ha *Azotobacter* + 1.5 kg/ha *Phosphobacterium*), T<sub>4</sub> (75 % RDF + 25% RDN by Vermicompost) and T<sub>2</sub> (75 % RDF + 25% RDN by FYM) which recorded values of 25.40 cm, 25.17 cm and 24.73 cm respectively. However these

**Table 4.1.1 Effect of INM on plant height (cm) at 30, 45 and 60 DAT in French marigold.**

| <b>Plant height (cm)</b>  |                |                |                |
|---|----------------|----------------|----------------|
| <b>Treatments</b>   | <b>30 days</b> | <b>45 days</b> | <b>60 days</b> |
| T <sub>1</sub> - 100 % RDF (200:80:80 Kg/ha N: P <sub>2</sub> O <sub>5</sub> :K <sub>2</sub> O)   | 22.83          | 36.40          | 55.44          |
| T <sub>2</sub> - 75 % RDF + 25% RDN by FYM  | 24.73          | 41.36          | 59.73          |
| T <sub>3</sub> - 75 % RDF + 25% RDN by FYM+ Biofertilizers(1.5 kg/ha <i>Azotobacter</i> + 1.5 kg/ha <i>Phosphobacterium</i> )           | 25.40          | 43.40          | 60.03          |
| T <sub>4</sub> - 75 % RDF + 25% RDN by Vermicompost   | 25.17          | 41.87          | 59.91          |
| T <sub>5</sub> -75 % RDF + 25% RDN by Vermicompost+ Biofertilizers(1.5 kg/ha <i>Azotobacter</i> + 1.5 kg/ha <i>Phosphobacterium</i> )   | 26.53          | 45.60          | 64.00          |
| T <sub>6</sub> - 50 % RDF + 50% RDN by FYM  | 23.03          | 39.77          | 55.59          |
| T <sub>7</sub> - 50 % RDF + 50% RDN by FYM+ Biofertilizers(1.5 kg/ha <i>Azotobacter</i> + 1.5kg/ha <i>Phosphobacterium</i> )            | 23.53          | 40.97          | 57.10          |
| T <sub>8</sub> - 50 % RDF + 50% RDN by Vermicompost   | 23.03          | 39.80          | 56.57          |
| T <sub>9</sub> - 50 % RDF + 50% RDN by Vermicompost+ Biofertilizers (1.5 kg/ha <i>Azotobacter</i> + 1.5 kg/ha <i>Phosphobacterium</i> ) | 23.83          | 41.20          | 58.00          |
| <b>Mean</b>   | <b>24.23</b>   | <b>41.15</b>   | <b>58.49</b>   |
| <b>S.Em.±</b>   | <b>0.69</b>    | <b>1.38</b>    | <b>1.37</b>    |
| <b>CD at 5%</b>   | <b>2.07</b>    | <b>4.13</b>    | <b>4.09</b>    |



treatments were statistically at par. The minimum plant height (22.83 cm) at this stage was recorded by T<sub>1</sub> i.e. 100 % RDF (200:80:80 kg/ha N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O)

At 45 DAT the maximum plant height (45.60 cm) was recorded by T<sub>5</sub> (75% RDF + 25% RDN by Vermicompost + 1.5 kg/ha *Azotobacter* + 1.5 kg/ha *Phosphobacterium*) followed by T<sub>3</sub> (75 % RDF + 25% RDN by FYM+ 1.5 kg/ha *Azotobacter* + 1.5 kg/ha *Phosphobacterium*) and T<sub>4</sub> (75 % RDF + 25% RDN by Vermicompost) which recorded values of 43.40 cm and 41.87 cm respectively. However these treatments were statistically at par. The minimum plant height (36.40 cm) at this stage was recorded by T<sub>1</sub> i.e. 100 % RDF.

At 60 DAT the maximum plant height (64 cm) was recorded by T<sub>5</sub> (75% RDF + 25% RDN by Vermicompost + 1.5 kg/ha *Azotobacter* + 1.5 kg/ha *Phosphobacterium*) followed by T<sub>3</sub> (75 % RDF + 25% RDN by FYM+ 1.5 kg/ha *Azotobacter* + 1.5 kg/ha *Phosphobacterium*) and T<sub>4</sub> (75 % RDF + 25% RDN by Vermicompost) which recorded values of 60.03 cm and 59.91 cm respectively. However these treatments were statistically at par. The minimum plant height (55.44 cm) at this stage was recorded by T<sub>1</sub> i.e. 100 % RDF.

#### **4.1 (b) Plant spread:**

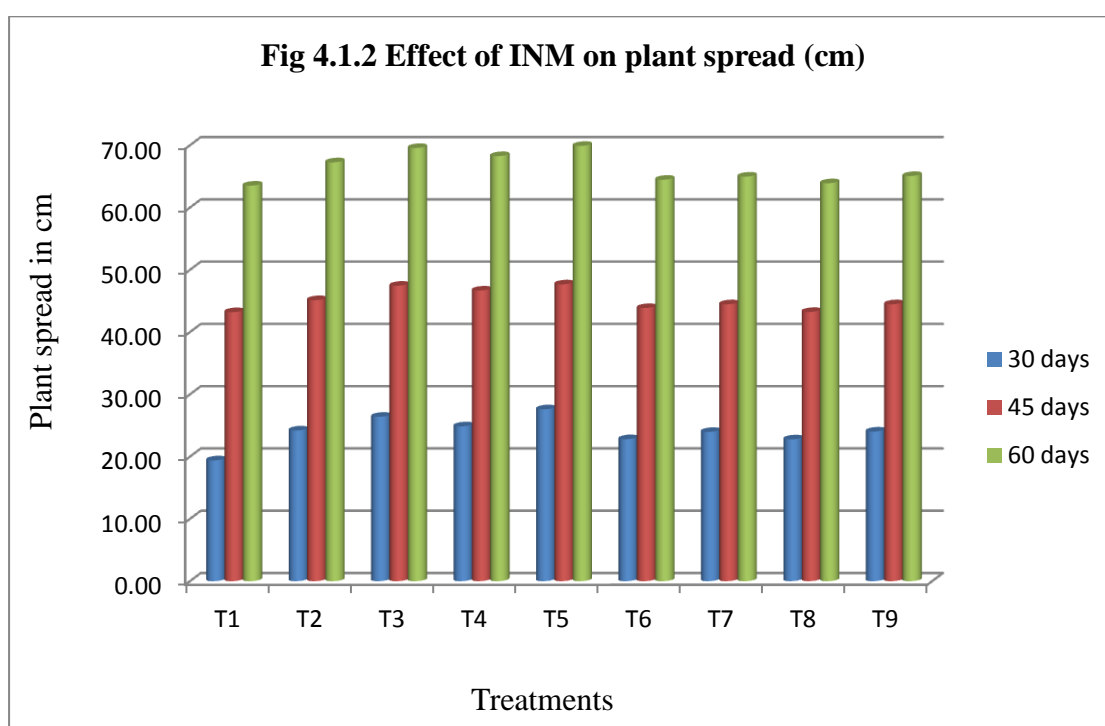
The plant spread indicates the growth of the plant and it may affect the yield also. Observations on the plant spread were recorded at 30 days after transplanting and subsequent observations were recorded at 15 days interval. The plant spread as affected by different treatments has been given in Table 4.1.2 and depicted in Fig 4.1.2

The results presented in the Table 4.1.2 revealed that different treatments significantly influenced the plant spread during the entire period of plant growth. There is a steady increase in plant spread irrespective of INM treatment during the entire crop growth period.

At 30 DAT the maximum plant spread (27.60 cm) was recorded by T<sub>5</sub> (75% RDF + 25% RDN by Vermicompost + 1.5 kg/ha *Azotobacter* + 1.5 kg/ha *Phosphobacterium*) followed by T<sub>3</sub> (75 % RDF + 25% RDN by FYM+ 1.5 kg/ha *Azotobacter* + 1.5 kg/ha *Phosphobacterium*), T<sub>4</sub> (75 % RDF + 25%

**Table 4.1.2 Effect of INM on plant spread (cm) at 30, 45 and 60 DAT in French marigold.**

| <b>Plant spread (cm)</b>  |                |                |                |
|---|----------------|----------------|----------------|
| <b>Treatments</b>   | <b>30 days</b> | <b>45 days</b> | <b>60 days</b> |
| T <sub>1</sub> - 100 % RDF (200:80:80 Kg/ha N: P <sub>2</sub> O <sub>5</sub> :K <sub>2</sub> O)   | 19.40          | 43.20          | 63.52          |
| T <sub>2</sub> - 75 % RDF + 25% RDN by FYM  | 24.20          | 45.13          | 67.27          |
| T <sub>3</sub> - 75 % RDF + 25% RDN by FYM+ Biofertilizers(1.5 kg/ha <i>Azotobacter</i> + 1.5 kg/ha <i>Phosphobacterium</i> )           | 26.40          | 47.44          | 69.57          |
| T <sub>4</sub> - 75 % RDF + 25% RDN by Vermicompost   | 24.87          | 46.67          | 68.27          |
| T <sub>5</sub> -75 % RDF + 25% RDN by Vermicompost+ Biofertilizers(1.5 kg/ha <i>Azotobacter</i> + 1.5 kg/ha <i>Phosphobacterium</i> )   | 27.60          | 47.67          | 69.90          |
| T <sub>6</sub> - 50 % RDF + 50% RDN by FYM  | 22.80          | 43.87          | 64.47          |
| T <sub>7</sub> - 50 % RDF + 50% RDN by FYM+ Biofertilizers(1.5 kg/ha <i>Azotobacter</i> + 1.5kg/ha <i>Phosphobacterium</i> )            | 23.97          | 44.47          | 64.97          |
| T <sub>8</sub> - 50 % RDF + 50% RDN by Vermicompost   | 22.77          | 43.23          | 63.90          |
| T <sub>9</sub> - 50 % RDF + 50% RDN by Vermicompost+ Biofertilizers (1.5 kg/ha <i>Azotobacter</i> + 1.5 kg/ha <i>Phosphobacterium</i> ) | 24.03          | 44.47          | 65.07          |
| <b>Mean</b>   | <b>24.00</b>   | <b>45.13</b>   | <b>66.32</b>   |
| <b>S.Em.±</b>   | <b>1.35</b>    | <b>1.05</b>    | <b>1.48</b>    |
| <b>CD at 5%</b>   | <b>4.06</b>    | <b>3.15</b>    | <b>4.44</b>    |



RDN by Vermicompost), T<sub>2</sub> (75 % RDF + 25% RDN by FYM), T<sub>9</sub> (50% RDF + 50% RDN by Vermicompost + 1.5 kg/ha *Azotobacter* + 1.5 kg/ha *Phosphobacterium*), and T<sub>7</sub> (50% RDF + 50% RDN by FYM + 1.5 kg/ha *Azotobacter* + 1.5 kg/ha *Phosphobacterium*), which recorded values of 26.40 cm, 24.87 cm, 24.20 cm, 24.03 cm and 23.97 cm respectively. However these treatments were statistically at par. The minimum plant spread (19.40 cm) at this stage was recorded by T<sub>1</sub> i.e. 100 % RDF.

At 45 DAT the maximum plant spread (47.67 cm) was recorded by T<sub>5</sub> (75% RDF + 25% RDN by Vermicompost + 1.5 kg/ha *Azotobacter* + 1.5 kg/ha *Phosphobacterium*) followed by T<sub>3</sub> (75 % RDF + 25% RDN by FYM+ 1.5 kg/ha *Azotobacter* + 1.5 kg/ha *Phosphobacterium*), T<sub>4</sub> (75 % RDF + 25% RDN by Vermicompost ) and T<sub>2</sub> (75 % RDF + 25% RDN by FYM), which recorded values of 47.44 cm, 46.67 cm and 45.13 cm respectively. However these treatments were statistically at par. The minimum plant spread (43.20 cm) at this stage was recorded by T<sub>1</sub> i.e. 100 % RDF.

At 60 DAT the maximum plant spread (69.90 cm) was recorded by T<sub>5</sub> (75% RDF + 25% RDN by Vermicompost + 1.5 kg/ha *Azotobacter* + 1.5 kg/ha *Phosphobacterium*) followed by T<sub>3</sub> (75 % RDF + 25% RDN by FYM+ 1.5 kg/ha *Azotobacter* + 1.5 kg/ha *Phosphobacterium*), T<sub>4</sub> (75 % RDF + 25% RDN by Vermicompost) and T<sub>2</sub> (75 % RDF + 25% RDN by FYM), which recorded values of 69.57 cm, 68.27 cm and 67.27 cm respectively. However these treatments were statistically at par. The minimum plant spread (63.52 cm) at this stage was recorded by T<sub>1</sub> i.e. 100 % RDF.

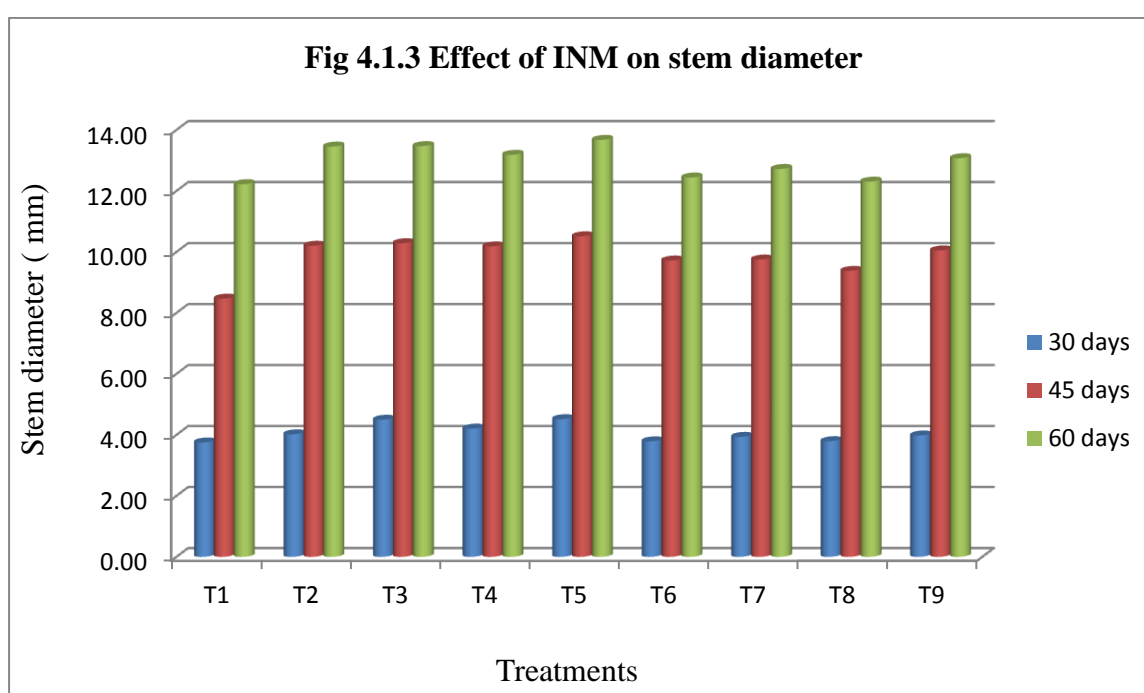
#### **4.1 (c) Stem diameter (mm):**

The plant stem diameter indicates the growth of plant and it may affect the yield also. Observations on plant stem diameter were recorded on 30 days after transplanting and subsequent observations were recorded at 15 days interval. The plant stem diameter as affected by different treatments has been given in table 4.1.3 and depicted in Fig 4.1.3.

The results presented in the Table 4.1.3 revealed that during 45 and 60 days of plant growth period different treatments significantly influenced the plant stem diameter, whereas at 30 days the effect was statistically non

**Table 4.1.3 Effect of INM on stem diameter (mm) at 30, 45 and 60 DAT in French marigold.**

| <b>Stem diameter (mm)</b>   |                |                |                |
|---|----------------|----------------|----------------|
| <b>Treatments</b>   | <b>30 days</b> | <b>45 days</b> | <b>60 days</b> |
| T <sub>1</sub> - 100 % RDF (200:80:80 Kg/ha N: P <sub>2</sub> O <sub>5</sub> :K <sub>2</sub> O)   | 3.75           | 8.47           | 12.22          |
| T <sub>2</sub> - 75 % RDF + 25% RDN by FYM  | 4.02           | 10.20          | 13.46          |
| T <sub>3</sub> - 75 % RDF + 25% RDN by FYM+ Biofertilizers(1.5 kg/ha <i>Azotobacter</i> + 1.5 kg/ha <i>Phosphobacterium</i> )           | 4.50           | 10.29          | 13.47          |
| T <sub>4</sub> - 75 % RDF + 25% RDN by Vermicompost   | 4.21           | 10.18          | 13.19          |
| T <sub>5</sub> -75 % RDF + 25% RDN by Vermicompost+ Biofertilizers(1.5 kg/ha <i>Azotobacter</i> + 1.5 kg/ha <i>Phosphobacterium</i> )   | 4.52           | 10.51          | 13.68          |
| T <sub>6</sub> - 50 % RDF + 50% RDN by FYM  | 3.79           | 9.72           | 12.44          |
| T <sub>7</sub> - 50 % RDF + 50% RDN by FYM+ Biofertilizers(1.5 kg/ha <i>Azotobacter</i> + 1.5kg/ha <i>Phosphobacterium</i> )            | 3.93           | 9.75           | 12.72          |
| T <sub>8</sub> - 50 % RDF + 50% RDN by Vermicompost   | 3.79           | 9.38           | 12.31          |
| T <sub>9</sub> - 50 % RDF + 50% RDN by Vermicompost+ Biofertilizers (1.5 kg/ha <i>Azotobacter</i> + 1.5 kg/ha <i>Phosphobacterium</i> ) | 3.98           | 10.05          | 13.07          |
| <b>Mean</b>   | <b>4.05</b>    | <b>9.84</b>    | <b>12.95</b>   |
| <b>S.Em.±</b>   | <b>0.35</b>    | <b>0.32</b>    | <b>0.25</b>    |
| <b>CD at 5%</b>   | <b>NS</b>      | <b>0.97</b>    | <b>0.74</b>    |



significant. There is a steady increase in plant stem diameter irrespective of INM treatment during the entire crop growth period.

At 30 DAT the maximum plant stem diameter (4.52 mm) was recorded by T<sub>5</sub> (75% RDF + 25% RDN by Vermicompost + 1.5 kg/ha *Azotobacter* + 1.5 kg/ha *Phosphobacterium*) followed by T<sub>3</sub> (75 % RDF + 25% RDN by FYM+ 1.5 kg/ha *Azotobacter* + 1.5 kg/ha *Phosphobacterium*) and T<sub>4</sub> (75 % RDF + 25% RDN by Vermicompost) which recorded values of 4.50 mm and 4.21 mm respectively. The minimum plant stem diameter (3.75 cm) at this stage was recorded by T<sub>1</sub> i.e. 100 % RDF (200:80:80 kg/ha N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O)

At 45 DAT the maximum plant stem diameter (10.51 mm) was recorded by T<sub>5</sub> (75% RDF + 25% RDN by Vermicompost + 1.5 kg/ha *Azotobacter* + 1.5 kg/ha *Phosphobacterium*) followed by T<sub>3</sub> (75 % RDF + 25% RDN by FYM+ 1.5 kg/ha *Azotobacter* + 1.5 kg/ha *Phosphobacterium*), T<sub>2</sub> (75 % RDF + 25% RDN by FYM), T<sub>4</sub> (75 % RDF + 25% RDN by Vermicompost), T<sub>9</sub> (50% RDF + 50% RDN by Vermicompost + 1.5 kg/ha *Azotobacter* + 1.5 kg/ha *Phosphobacterium*), T<sub>7</sub> (50% RDF + 50% RDN by FYM + 1.5 kg/ha *Azotobacter* + 1.5 kg/ha *Phosphobacterium*) and T<sub>6</sub> (50 % RDF + 50% RDN by FYM) which recorded values of 10.29 mm, 10.20 mm, 10.18 mm, 10.05 mm, 9.75 mm and 9.72 respectively. However these treatments were statistically at par. The minimum plant stem diameter (8.47 mm) at this stage was recorded by T<sub>1</sub> i.e. 100 % RDF.

At 60 DAT the maximum plant stem diameter (13.68 mm) was recorded by T<sub>5</sub> (75% RDF + 25% RDN by Vermicompost + 1.5 kg/ha *Azotobacter* + 1.5 kg/ha *Phosphobacterium*) followed by T<sub>3</sub> (75 % RDF + 25% RDN by FYM+ 1.5 kg/ha *Azotobacter* + 1.5 kg/ha *Phosphobacterium*), T<sub>2</sub> (75 % RDF + 25% RDN by FYM), T<sub>4</sub> (75 % RDF + 25% RDN by Vermicompost), T<sub>9</sub> (50% RDF + 50% RDN by Vermicompost + 1.5 kg/ha *Azotobacter* + 1.5 kg/ha *Phosphobacterium*), which recorded values of 13.47 mm, 13.46 mm, 13.19 mm and 13.07 respectively. However these treatments are statistically at par. The minimum plant stem diameter (12.22 mm) at this stage was recorded by T<sub>1</sub> i.e. 100 % RDF.

#### 4.1 (d) Number of primary branches per plant.

The data pertaining to number of primary branches per plant are presented in Table 4.1.4. It can be observed from Table 4.1.4 and Fig. 4.1.4 that the effect of INM on number of primary branches per plant at 30, 45 and 60 days after transplanting was statistically significant.

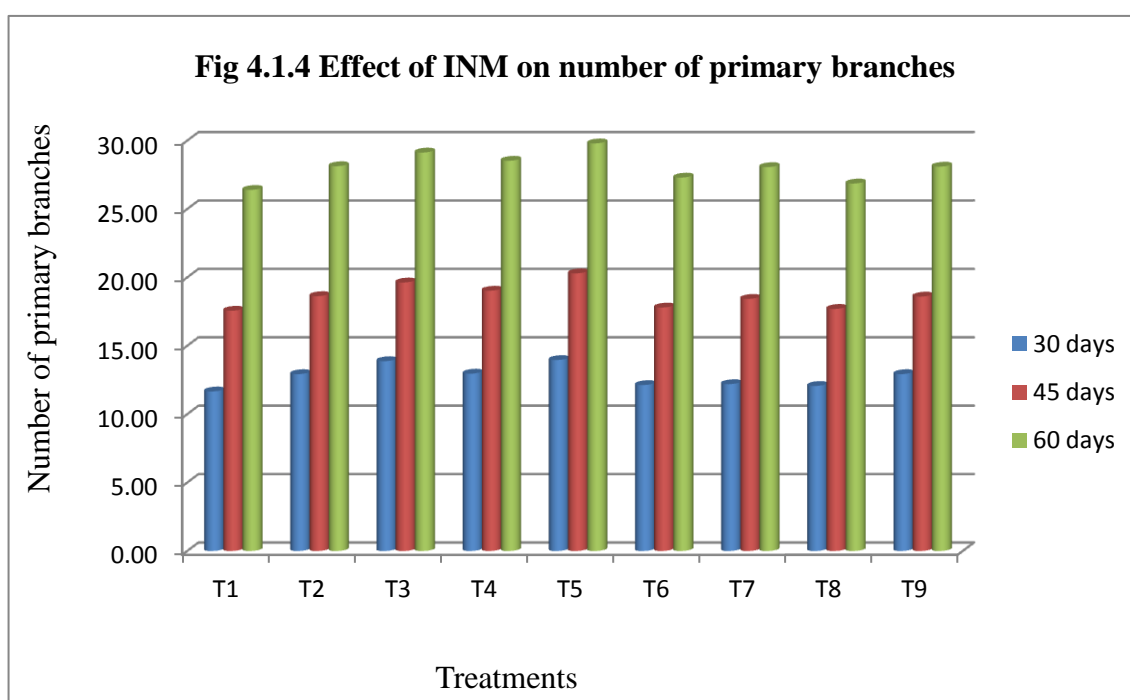
At 30 DAT the maximum number of primary branches (13.96) was recorded by T<sub>5</sub> (75% RDF + 25% RDN by Vermicompost + 1.5 kg/ha *Azotobacter* + 1.5 kg/ha *Phosphobacterium*) followed by T<sub>3</sub> (75 % RDF + 25% RDN by FYM+ 1.5 kg/ha *Azotobacter* + 1.5 kg/ha *Phosphobacterium*), T<sub>4</sub> (75 % RDF + 25% RDN by Vermicompost), T<sub>2</sub> (75 % RDF + 25% RDN by FYM), and T<sub>9</sub> (50% RDF + 50% RDN by Vermicompost + 1.5 kg/ha *Azotobacter* + 1.5 kg/ha *Phosphobacterium*), which recorded values of 13.88, 12.97 , 12.93 and 12.93 respectively. However these treatments were statistically at par. The minimum number of primary branches (11.67) at this stage was recorded by T<sub>1</sub> i.e. 100 % RDF (200:80:80 kg/ha N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O)

At 45 DAT the maximum number of primary branches (20.30) was recorded by T<sub>5</sub> (75% RDF + 25% RDN by Vermicompost + 1.5 kg/ha *Azotobacter* + 1.5 kg/ha *Phosphobacterium*) followed by T<sub>3</sub> (75 % RDF + 25% RDN by FYM+ 1.5 kg/ha *Azotobacter* + 1.5 kg/ha *Phosphobacterium*) and T<sub>4</sub> (75 % RDF + 25% RDN by Vermicompost) which recorded values of 19.63 and 19.03 respectively. However these treatments are statistically at par. The minimum number of primary branches (17.57) at this stage was recorded by T<sub>1</sub> i.e. 100 % RDF.

At 60 DAT the maximum number of primary branches (29.80) was recorded by T<sub>5</sub> (75% RDF + 25% RDN by Vermicompost + 1.5 kg/ha *Azotobacter* + 1.5 kg/ha *Phosphobacterium*) followed by T<sub>3</sub> (75 % RDF + 25% RDN by FYM+ 1.5 kg/ha *Azotobacter* + 1.5 kg/ha *Phosphobacterium*) and T<sub>4</sub> (75 % RDF + 25% RDN by Vermicompost) which recorded values of 29.13 and 28.53 respectively. However these treatments are statistically at par. The minimum number of primary branches (26.40) at this stage was recorded by T<sub>1</sub> i.e. 100 % RDF.

**Table 4.1.4 Effect of INM on number of primary branches per plant at 30, 45 and 60 DAT in French marigold.**

| Number of primary branches  |              |              |              |
|---|--------------|--------------|--------------|
| Treatments  | 30 days      | 45 days      | 60 days      |
| T <sub>1</sub> - 100 % RDF (200:80:80 Kg/ha N: P <sub>2</sub> O <sub>5</sub> :K <sub>2</sub> O)   | 11.67        | 17.57        | 26.40        |
| T <sub>2</sub> - 75 % RDF + 25% RDN by FYM  | 12.93        | 18.63        | 28.13        |
| T <sub>3</sub> - 75 % RDF + 25% RDN by FYM+ Biofertilizers(1.5 kg/ha <i>Azotobacter</i> + 1.5 kg/ha <i>Phosphobacterium</i> )           | 13.88        | 19.63        | 29.13        |
| T <sub>4</sub> - 75 % RDF + 25% RDN by Vermicompost   | 12.97        | 19.03        | 28.53        |
| T <sub>5</sub> -75 % RDF + 25% RDN by Vermicompost+ Biofertilizers(1.5 kg/ha <i>Azotobacter</i> + 1.5 kg/ha <i>Phosphobacterium</i> )   | 13.96        | 20.30        | 29.80        |
| T <sub>6</sub> - 50 % RDF + 50% RDN by FYM  | 12.13        | 17.80        | 27.30        |
| T <sub>7</sub> - 50 % RDF + 50% RDN by FYM+ Biofertilizers(1.5 kg/ha <i>Azotobacter</i> + 1.5kg/ha <i>Phosphobacterium</i> )            | 12.20        | 18.43        | 28.07        |
| T <sub>8</sub> - 50 % RDF + 50% RDN by Vermicompost   | 12.07        | 17.70        | 26.87        |
| T <sub>9</sub> - 50 % RDF + 50% RDN by Vermicompost+ Biofertilizers (1.5 kg/ha <i>Azotobacter</i> + 1.5 kg/ha <i>Phosphobacterium</i> ) | 12.93        | 18.60        | 28.10        |
| <b>Mean</b>   | <b>12.75</b> | <b>18.63</b> | <b>28.04</b> |
| <b>S.Em.±</b>   | <b>0.36</b>  | <b>0.54</b>  | <b>0.55</b>  |
| <b>CD at 5%</b>   | <b>1.09</b>  | <b>1.61</b>  | <b>1.66</b>  |



#### 4.1 (e) Number of secondary branches per plant.

The data pertaining to number of secondary branches per plant are presented in Table 4.1.5. It can be observed from Table 4.1.5 and Fig. 4.1.5 that the effect of INM on number of secondary branches per plant at 45 and 60 days after transplanting was statistically significant.

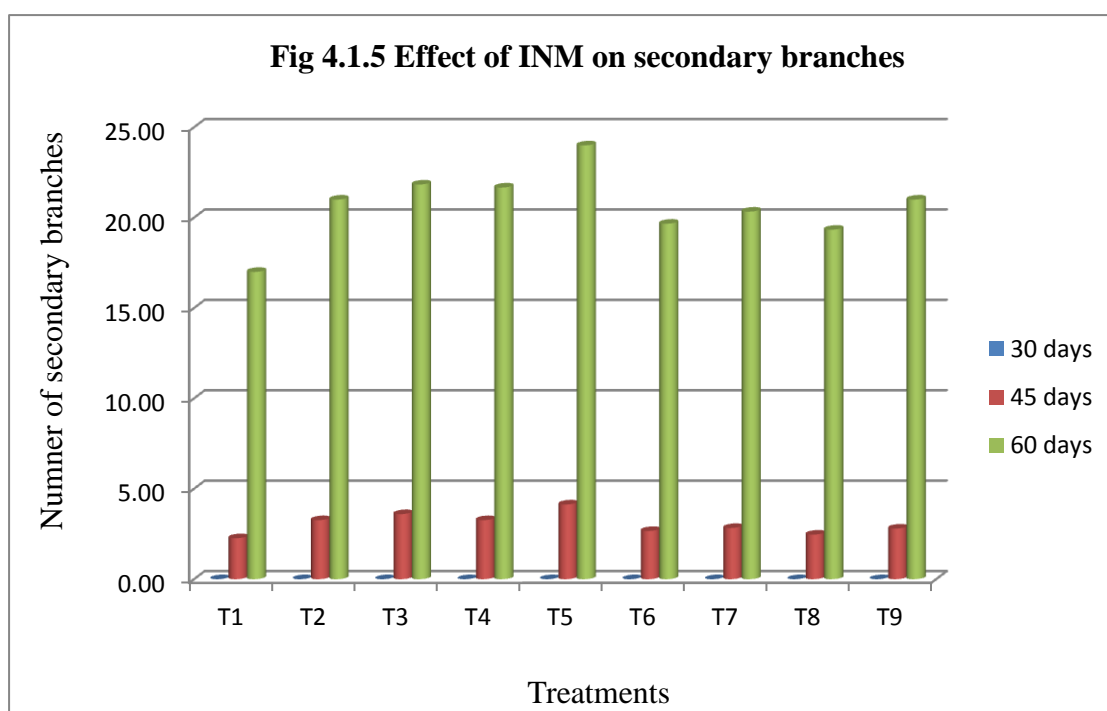
At 30 DAT there were no secondary branches in any treatment or control plants.

At 45 DAT the maximum number of secondary branches (4.13) was recorded by T<sub>5</sub> (75% RDF + 25% RDN by Vermicompost + 1.5 kg/ha *Azotobacter* + 1.5 kg/ha *Phosphobacterium*) followed by T<sub>3</sub> (75 % RDF + 25% RDN by FYM+ 1.5 kg/ha *Azotobacter* + 1.5 kg/ha *Phosphobacterium*), T<sub>4</sub> (75 % RDF + 25% RDN by Vermicompost), T<sub>2</sub> (75 % RDF + 25% RDN by FYM) and T<sub>7</sub> (50% RDF + 50% RDN by FYM + 1.5 kg/ha *Azotobacter* + 1.5 kg/ha *Phosphobacterium*), which recorded values of 3.60, 3.27, 3.27 and 2.83 respectively. However T<sub>5</sub> and T<sub>3</sub> are statistically at par and T<sub>7</sub> are statistically at par with T<sub>4</sub> and T<sub>2</sub>. The minimum number of secondary branches (2.27) at this stage was recorded by T<sub>1</sub> i.e. 100 % RDF (200:80:80 kg/ha N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O).

At 60 DAT the maximum number of secondary branches (24) was recorded by T<sub>5</sub> (75% RDF + 25% RDN by Vermicompost + 1.5 kg/ha *Azotobacter* + 1.5 kg/ha *Phosphobacterium*) followed by T<sub>3</sub> (75 % RDF + 25% RDN by FYM+ 1.5 kg/ha *Azotobacter* + 1.5 kg/ha *Phosphobacterium*), T<sub>4</sub> (75 % RDF + 25% RDN by Vermicompost), T<sub>2</sub> (75 % RDF + 25% RDN by FYM), and T<sub>9</sub> (50% RDF + 50% RDN by Vermicompost + 1.5 kg/ha *Azotobacter* + 1.5 kg/ha *Phosphobacterium*), which recorded values of 21.83, 21.67, 21 and 21 respectively. However these treatments are statistically at par. The minimum number of secondary branches (17) at this stage was recorded by T<sub>1</sub> i.e. 100 % RDF (200:80:80 kg/ha N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O).

**Table 4.1.5 Effect of INM on number of secondary branches per plant at 30, 45 and 60 DAT in French marigold.**

| Number of secondary branches  |         |             |              |
|---|---------|-------------|--------------|
| Treatments  | 30 days | 45 days     | 60 days      |
| T <sub>1</sub> - 100 % RDF (200:80:80 Kg/ha N: P <sub>2</sub> O <sub>5</sub> :K <sub>2</sub> O)   | -       | 2.27        | 17.00        |
| T <sub>2</sub> - 75 % RDF + 25% RDN by FYM  | -       | 3.27        | 21.00        |
| T <sub>3</sub> - 75 % RDF + 25% RDN by FYM+ Biofertilizers(1.5 kg/ha <i>Azotobacter</i> + 1.5 kg/ha <i>Phosphobacterium</i> )           | -       | 3.60        | 21.83        |
| T <sub>4</sub> - 75 % RDF + 25% RDN by Vermicompost   | -       | 3.27        | 21.67        |
| T <sub>5</sub> -75 % RDF + 25% RDN by Vermicompost+ Biofertilizers(1.5 kg/ha <i>Azotobacter</i> + 1.5 kg/ha <i>Phosphobacterium</i> )   | -       | 4.13        | 24.00        |
| T <sub>6</sub> - 50 % RDF + 50% RDN by FYM  | -       | 2.67        | 19.67        |
| T <sub>7</sub> - 50 % RDF + 50% RDN by FYM+ Biofertilizers(1.5 kg/ha <i>Azotobacter</i> + 1.5kg/ha <i>Phosphobacterium</i> )            | -       | 2.83        | 20.33        |
| T <sub>8</sub> - 50 % RDF + 50% RDN by Vermicompost   | -       | 2.47        | 19.33        |
| T <sub>9</sub> - 50 % RDF + 50% RDN by Vermicompost+ Biofertilizers (1.5 kg/ha <i>Azotobacter</i> + 1.5 kg/ha <i>Phosphobacterium</i> ) | -       | 2.80        | 21.00        |
| <b>Mean</b>   | -       | <b>3.03</b> | <b>20.65</b> |
| <b>S.Em.±</b>   | -       | <b>0.28</b> | <b>1.20</b>  |
| <b>CD at 5%</b>   | -       | <b>0.84</b> | <b>3.60</b>  |



## 4.2 Flowering parameters:

### 4.2 (a) First flower bud appearance (days).

It is clear from the Table 4.2.1 and Fig 4.2.1 that appearance of first flower bud was significantly influenced by the different INM treatments. All the INM treatments employed were significantly superior to the control (RDF) in terms of days to flower bud appearance.

Days to first flower bud appearance ranged from 55 to 62.67. The treatment T<sub>6</sub> (50 % RDF + 50% RDN by FYM) was first to show its visible flower bud (55 days) and was statistically on par with T<sub>8</sub> (50 % RDF + 50% RDN by Vermicompost), T<sub>7</sub> (50 % RDF + 50% RDN by FYM+ 1.5 kg/ha *Azotobacter* + 1.5kg/ha *Phosphobacterium*), T<sub>9</sub> (50% RDF + 50% RDN by Vermicompost + 1.5 kg/ha *Azotobacter* + 1.5 kg/ha *Phosphobacterium*), T<sub>1</sub> (200:80:80 kg/ha N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O), T<sub>2</sub> (75 % RDF + 25% RDN by FYM), and T<sub>4</sub> (75 % RDF + 25% RDN by Vermicompost). which recorded values of 55.33, 55.67, 56, 56.67, 58.33 and 60 days respectively. The treatment T<sub>5</sub> (75 % RDF + 25% RDN by Vermicompost + 1.5 kg/ha *Azotobacter* + 1.5 kg/ha *Phosphobacterium*) recorded the most delayed first flower bud appearance (62.67 days).

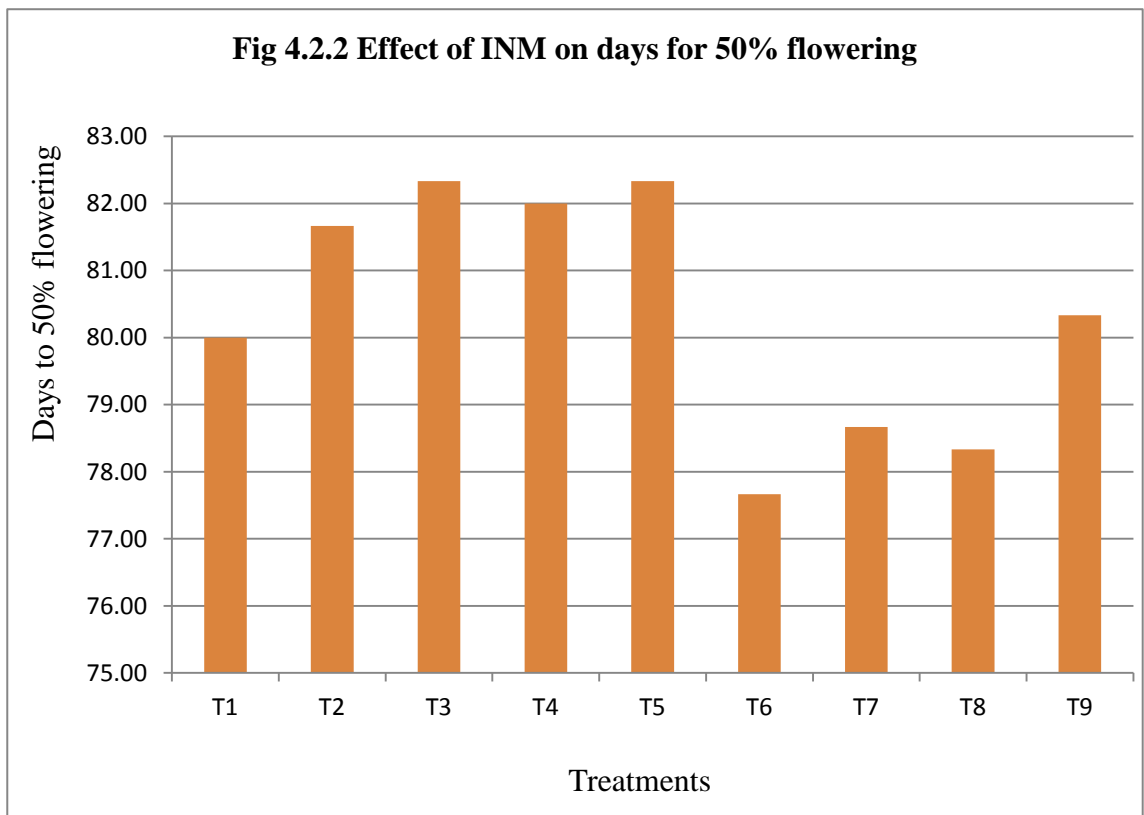
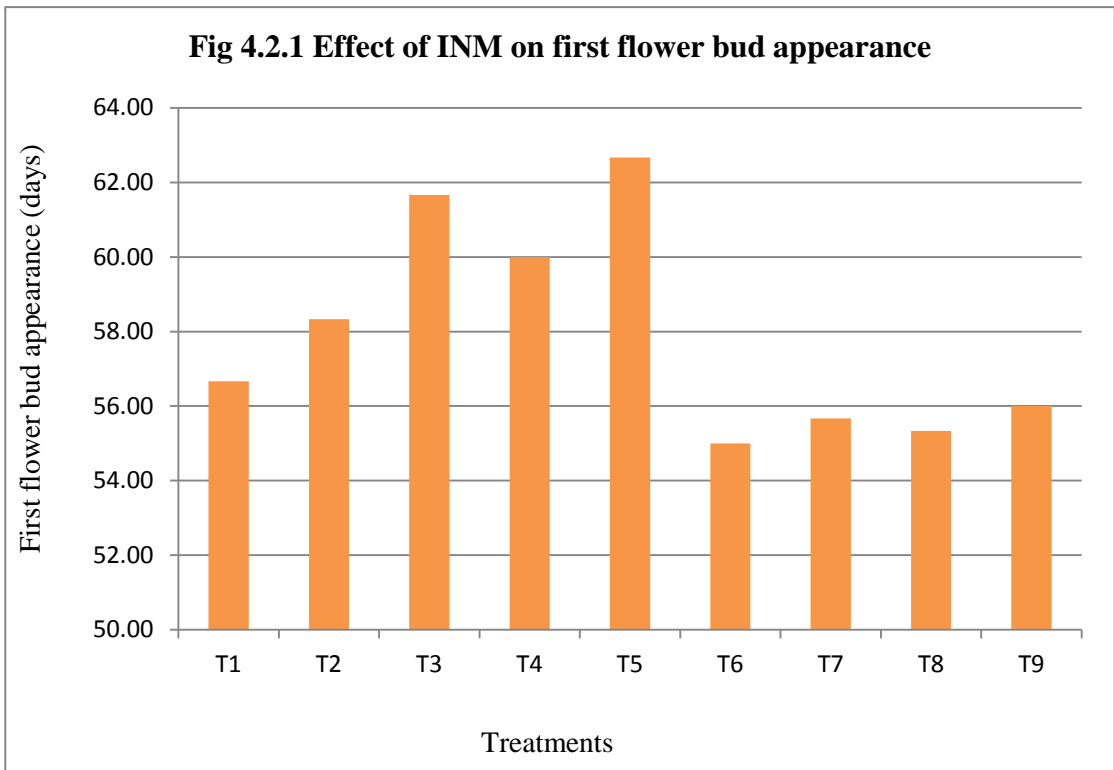
### 4.2 (b) Days for 50% flowering

It is clear from the Table 4.2.1 and Fig 4.2.2 that 50% of flowering was significantly influenced by the different INM treatments. All the INM treatments employed were significantly superior to the control (RDF) in terms of days 50% of flowering.

Days to 50% flowering ranged from 77.67 to 82.33. The treatment T<sub>6</sub> (50 % RDF + 50% RDN by FYM) was the first to show 50% flowering (77.67 days) and it was statistically on par with T<sub>8</sub> (50 % RDF + 50% RDN by Vermicompost), T<sub>7</sub> (50 % RDF + 50% RDN by FYM+ 1.5 kg/ha *Azotobacter* + 1.5kg/ha *Phosphobacterium*) and T<sub>1</sub> (200:80:80 kg/ha N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O) which recorded values of 78.33, 78.67 and 80 respectively. The treatment T<sub>5</sub> (75 % RDF + 25% RDN by Vermicompost + 1.5 kg/ha *Azotobacter* + 1.5 kg/ha *Phosphobacterium*) recorded the most delayed 50% flowering (82.33 days).

**Table 4.2.1 Effect of INM on first flower bud appearance (days) and Days for 50% flowering.**

| <b>First flower bud appearance and days to 50% flowering</b>  |  |                              |
|---|--|------------------------------|
| <b>Treatments</b>   | <b>First flower bud appearance in days</b> | <b>Days to 50% flowering</b> |
| T <sub>1</sub> - 100 % RDF (200:80:80 Kg/ha N: P <sub>2</sub> O <sub>5</sub> :K <sub>2</sub> O)   | 56.67                                      | 80.00                        |
| T <sub>2</sub> - 75 % RDF + 25% RDN by FYM  | 58.33                                      | 81.67                        |
| T <sub>3</sub> - 75 % RDF + 25% RDN by FYM+ Biofertilizers(1.5 kg/ha <i>Azotobacter</i> + 1.5 kg/ha <i>Phosphobacterium</i> )           | 61.67                                      | 82.33                        |
| T <sub>4</sub> - 75 % RDF + 25% RDN by Vermicompost   | 60.00                                      | 82.00                        |
| T <sub>5</sub> -75 % RDF + 25% RDN by Vermicompost+ Biofertilizers(1.5 kg/ha <i>Azotobacter</i> + 1.5 kg/ha <i>Phosphobacterium</i> )   | 62.67                                      | 82.33                        |
| T <sub>6</sub> - 50 % RDF + 50% RDN by FYM  | 55.00                                      | 77.67                        |
| T <sub>7</sub> - 50 % RDF + 50% RDN by FYM+ Biofertilizers(1.5 kg/ha <i>Azotobacter</i> + 1.5kg/ha <i>Phosphobacterium</i> )            | 55.67                                      | 78.67                        |
| T <sub>8</sub> - 50 % RDF + 50% RDN by Vermicompost   | 55.33                                      | 78.33                        |
| T <sub>9</sub> - 50 % RDF + 50% RDN by Vermicompost+ Biofertilizers (1.5 kg/ha <i>Azotobacter</i> + 1.5 kg/ha <i>Phosphobacterium</i> ) | 56.00                                      | 80.33                        |
| <b>Mean</b>   | <b>57.93</b>                               | <b>80.30</b>                 |
| <b>S.Em.±</b>   | <b>1.73</b>                                | <b>0.85</b>                  |
| <b>CD at 5%</b>   | <b>5.19</b>                                | <b>2.54</b>                  |



#### **4.2 (c) Flowering duration (days).**

It is clear from the Table 4.2.2 and Fig 4.2.3 that flowering duration was significantly influenced by the different INM treatments. All the INM treatments employed were significantly superior to the control (RDF) in terms of flowering duration.

Flowering duration ranged from 71.33 to 77.33. The longest flowering duration (77.33 days) was recorded by T<sub>5</sub> (75% RDF + 25% RDN by Vermicompost + 1.5 kg/ha *Azotobacter* + 1.5 kg/ha *Phosphobacterium*) followed by T<sub>3</sub> (75 % RDF + 25% RDN by FYM+ 1.5 kg/ha *Azotobacter* + 1.5 kg/ha *Phosphobacterium*), T<sub>4</sub> (75 % RDF + 25% RDN by Vermicompost) , T<sub>9</sub> (50% RDF + 50% RDN by Vermicompost + 1.5 kg/ha *Azotobacter* + 1.5 kg/ha *Phosphobacterium*), T<sub>2</sub> (75 % RDF + 25% RDN by FYM) and T<sub>7</sub> (50% RDF + 50% RDN by FYM + 1.5 kg/ha *Azotobacter* + 1.5 kg/ha *Phosphobacterium*) which recorded values of 77 days, 75.33 days, 75 days, 74 days and 73.67 days respectively. However these treatments are statistically at par. The minimum flowering duration (71.33 days) was recorded by T<sub>1</sub> i.e. 100 % RDF (200:80:80 kg/ha N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O).

#### **4.2 (d) Individual flower weight (g)**

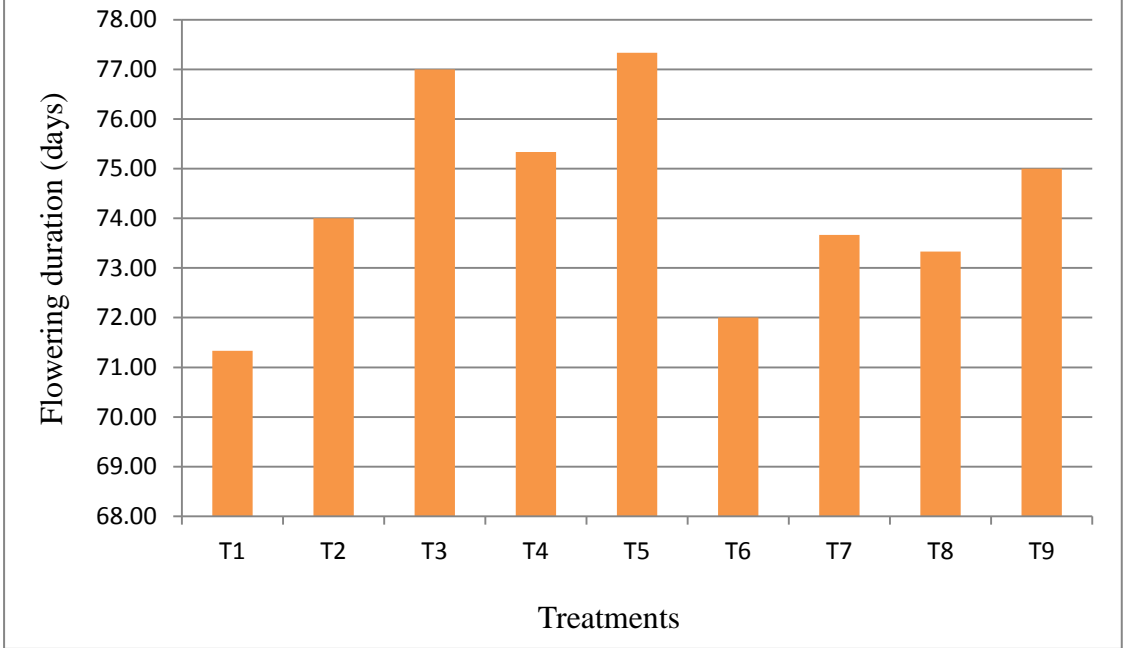
It is clear from the Table 4.2.2 and Fig 4.2.4 that individual flower weight was significantly influenced by different INM treatments. All the INM treatments employed were significantly superior to the control (RDF) in terms of individual flower weight.

Individual flower weight ranged from 4.01 to 7.47 g. The maximum individual flower weight (7.47 g) was recorded by T<sub>5</sub> (75% RDF + 25% RDN by Vermicompost + 1.5 kg/ha *Azotobacter* + 1.5 kg/ha *Phosphobacterium*) followed by T<sub>3</sub> (75 % RDF + 25% RDN by FYM+ 1.5 kg/ha *Azotobacter* + 1.5 kg/ha *Phosphobacterium*), T<sub>2</sub> (75 % RDF + 25% RDN by FYM), T<sub>4</sub> (75 % RDF + 25% RDN by Vermicompost), T<sub>9</sub> (50% RDF + 50% RDN by Vermicompost + 1.5 kg/ha *Azotobacter* + 1.5 kg/ha *Phosphobacterium*) and T<sub>8</sub> (50 % RDF + 50% RDN by Vermicompost) which recorded values of 7.25 g, 6.52 g, 6.32 g, 6.31 g and 5.23 respectively. However these treatments are statistically at par. The minimum individual flower weight (4.01 g) was recorded by T<sub>1</sub> i.e. 100 % RDF (200:80:80 kg/ha N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O).

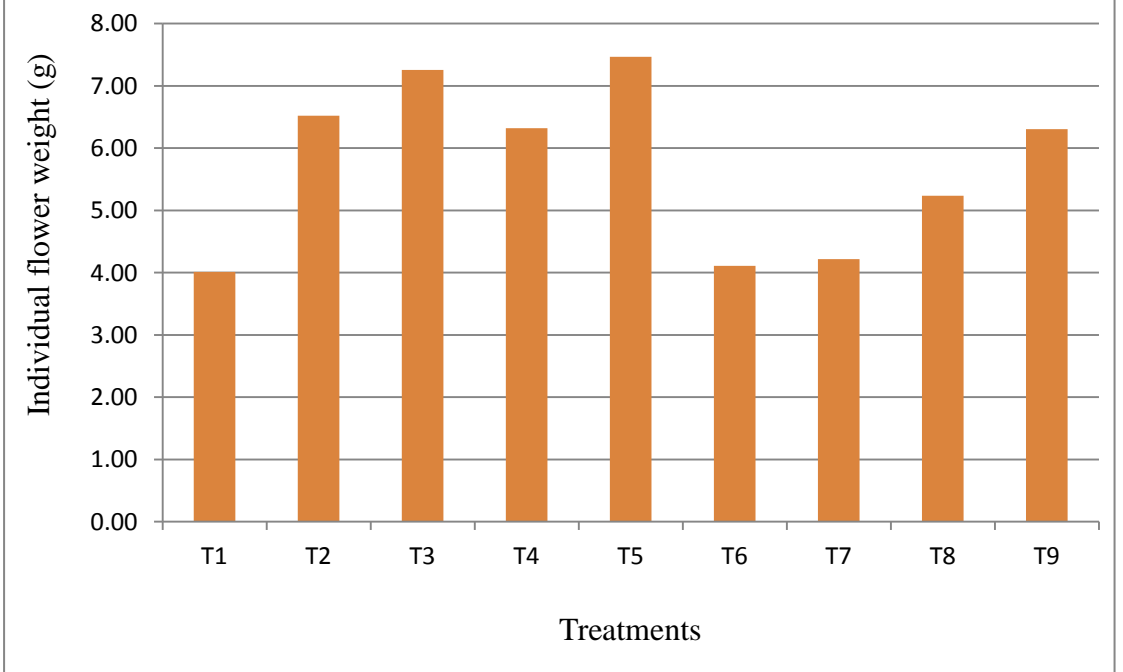
**Table 4.2.2 Effect of INM on flowering duration (days) and individual flower weight (g)**

| <b>Flowering duration and individual flower weight</b>  |                                  |   |
|---|----------------------------------|---|
| <b>Treatments</b>   | <b>Flowering duration (days)</b> | <b>Individual flower weight (grams)</b> |
| T <sub>1</sub> - 100 % RDF (200:80:80 Kg/ha N: P <sub>2</sub> O <sub>5</sub> :K <sub>2</sub> O)   | 71.33                            | 4.01                                    |
| T <sub>2</sub> - 75 % RDF + 25% RDN by FYM  | 74.00                            | 6.52                                    |
| T <sub>3</sub> - 75 % RDF + 25% RDN by FYM+ Biofertilizers(1.5 kg/ha <i>Azotobacter</i> + 1.5 kg/ha <i>Phosphobacterium</i> )           | 77.00                            | 7.25                                    |
| T <sub>4</sub> - 75 % RDF + 25% RDN by Vermicompost   | 75.33                            | 6.32                                    |
| T <sub>5</sub> -75 % RDF + 25% RDN by Vermicompost+ Biofertilizers(1.5 kg/ha <i>Azotobacter</i> + 1.5 kg/ha <i>Phosphobacterium</i> )   | 77.33                            | 7.47                                    |
| T <sub>6</sub> - 50 % RDF + 50% RDN by FYM  | 72.00                            | 4.11                                    |
| T <sub>7</sub> - 50 % RDF + 50% RDN by FYM+ Biofertilizers(1.5 kg/ha <i>Azotobacter</i> + 1.5kg/ha <i>Phosphobacterium</i> )            | 73.67                            | 4.22                                    |
| T <sub>8</sub> - 50 % RDF + 50% RDN by Vermicompost   | 73.33                            | 5.23                                    |
| T <sub>9</sub> - 50 % RDF + 50% RDN by Vermicompost+ Biofertilizers (1.5 kg/ha <i>Azotobacter</i> + 1.5 kg/ha <i>Phosphobacterium</i> ) | 75.00                            | 6.31                                    |
| <b>Mean</b>   | <b>74.33</b>                     | <b>5.72</b>                             |
| <b>S.Em.±</b>   | <b>1.27</b>                      | <b>0.79</b>                             |
| <b>CD at 5%</b>   | <b>3.80</b>                      | <b>2.37</b>                             |

**Fig 4.2.3 Effect of INM on flowering duration (days)**



**Fig 4.2.4 Effect of INM on individual flower weight (grams)**



#### 4.2 (e) Flower yield per plant (grams).

It is clear from the Table 4.2.3 and Fig. 4.2.5 that flower yield per plant was significantly influenced by different INM treatments. All the INM treatments employed were significantly superior to the control (RDF) in terms of flower yield per plant.

Flower yield per plant ranged from 594.60 g to 784.53 g. The highest flower yield per plant (784.53 g) was recorded by T<sub>5</sub> (75% RDF + 25% RDN by Vermicompost + 1.5 kg/ha *Azotobacter* + 1.5 kg/ha *Phosphobacterium*) followed by T<sub>3</sub> (75 % RDF + 25% RDN by FYM+ 1.5 kg/ha *Azotobacter* + 1.5 kg/ha *Phosphobacterium*), T<sub>9</sub> (50 % RDF + 50 % RDN by Vermicompost + 1.5 kg/ha *Azotobacter* + 1.5 kg/ha *Phosphobacterium*), T<sub>7</sub> (50 % RDF + 50 % RDN by FYM + 1.5 kg/ha *Azotobacter* + 1.5 kg/ha *Phosphobacterium*), T<sub>4</sub> (75 % RDF + 25% RDN by Vermicompost) and T<sub>2</sub> (75 % RDF + 25% RDN by FYM) which recorded values of 750.70 g, 744.83 g, 741.90 g, 678.67 g and 658.33 g respectively. However these treatments are statistically at par. The lowest flower yield per plant (594.60 g) was recorded by T<sub>1</sub> i.e. 100 % RDF (200:80:80 kg/ha N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O).

#### 4.2 (f) Flower yield per plot (kg)

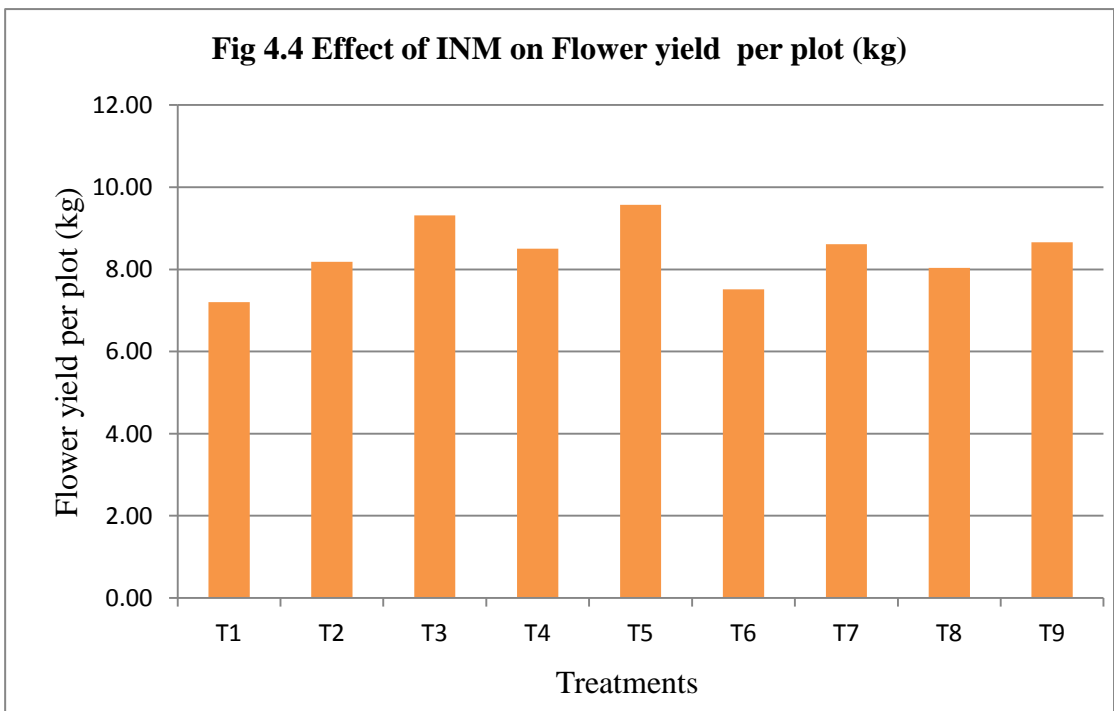
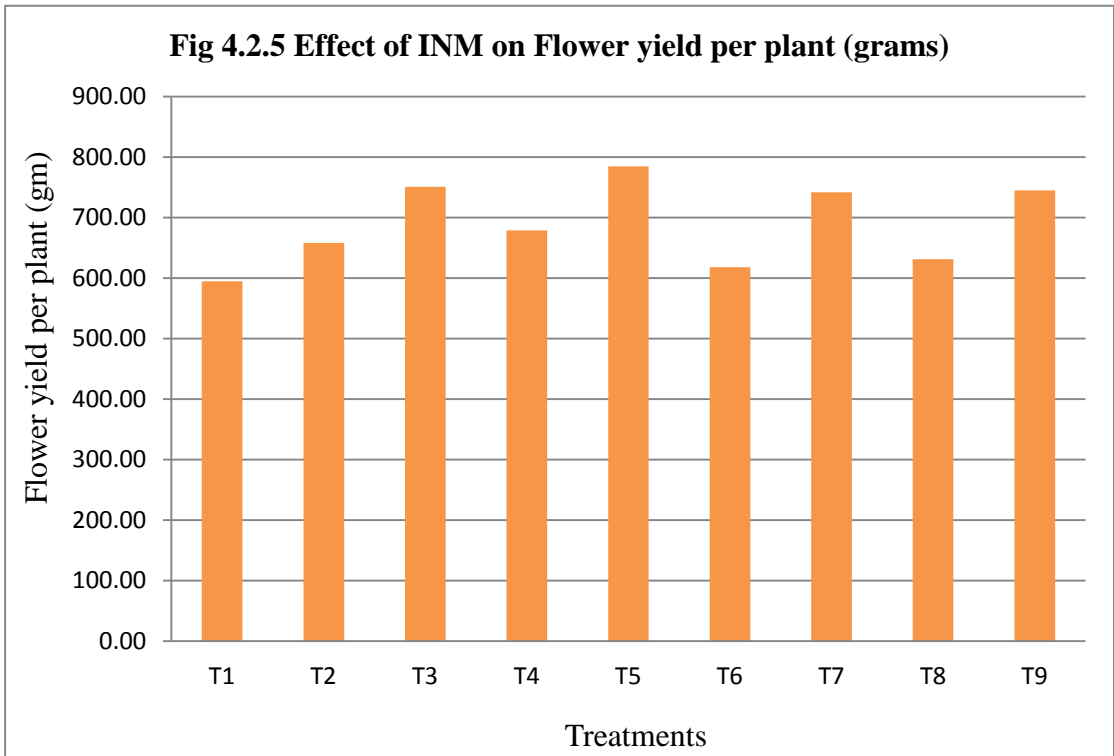
It is clear from the Table 4.2.3 and Fig. 4.2.6 that flower yield per plot was significantly influenced by different INM treatments. All the INM treatments employed were significantly superior to the control (RDF) in terms of flower yield per plot.

Flower yield per plot ranged from 7.20 kg to 9.57 kg. The highest flower yield per plot (9.57 kg) was recorded by T<sub>5</sub> (75% RDF + 25% RDN by Vermicompost + 1.5 kg/ha *Azotobacter* + 1.5 kg/ha *Phosphobacterium*) followed by T<sub>3</sub> (75 % RDF + 25% RDN by FYM+ 1.5 kg/ha *Azotobacter* + 1.5 kg/ha *Phosphobacterium*), T<sub>9</sub> (50 % RDF + 50 % RDN by Vermicompost + 1.5 kg/ha *Azotobacter* + 1.5 kg/ha *Phosphobacterium*), T<sub>7</sub> (50 % RDF + 50 % RDN by FYM + 1.5 kg/ha *Azotobacter* + 1.5 kg/ha *Phosphobacterium*), and T<sub>4</sub> (75 % RDF + 25% RDN by Vermicompost) which recorded values of 9.31 kg, 8.66 kg, 8.61 kg and 8.50 kg respectively. However T<sub>5</sub> and T<sub>3</sub> are statistically at par and T<sub>4</sub> is statistically at par with T<sub>3</sub>, T<sub>9</sub> and T<sub>7</sub>. The lowest

flower yield per plot (7.20 kg) was recorded by T<sub>1</sub> i.e. 100 % RDF (200:80:80 kg/ha N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O).

**Table 4.2.3 Effect of INM on flower yield per plant (grams) and flower yield per plot (kg)**

| <b>Flower yield per plant and flower yield per plot</b>   |                                       |                                   |
|---|---------------------------------------|-----------------------------------|
| <b>Treatments</b>   | <b>Flower yield per plant (grams)</b> | <b>Flower yield per plot (kg)</b> |
| T <sub>1</sub> - 100 % RDF (200:80:80 Kg/ha N: P <sub>2</sub> O <sub>5</sub> :K <sub>2</sub> O)   | 594.60                                | 7.20                              |
| T <sub>2</sub> - 75 % RDF + 25% RDN by FYM  | 658.33                                | 8.18                              |
| T <sub>3</sub> - 75 % RDF + 25% RDN by FYM+ Biofertilizers(1.5 kg/ha <i>Azotobacter</i> + 1.5 kg/ha <i>Phosphobacterium</i> )           | 750.70                                | 9.31                              |
| T <sub>4</sub> - 75 % RDF + 25% RDN by Vermicompost   | 678.67                                | 8.50                              |
| T <sub>5</sub> -75 % RDF + 25% RDN by Vermicompost+ Biofertilizers(1.5 kg/ha <i>Azotobacter</i> + 1.5 kg/ha <i>Phosphobacterium</i> )   | 784.53                                | 9.57                              |
| T <sub>6</sub> - 50 % RDF + 50% RDN by FYM  | 618.00                                | 7.51                              |
| T <sub>7</sub> - 50 % RDF + 50% RDN by FYM+ Biofertilizers(1.5 kg/ha <i>Azotobacter</i> + 1.5kg/ha <i>Phosphobacterium</i> )            | 741.90                                | 8.61                              |
| T <sub>8</sub> - 50 % RDF + 50% RDN by Vermicompost   | 631.33                                | 8.03                              |
| T <sub>9</sub> - 50 % RDF + 50% RDN by Vermicompost+ Biofertilizers (1.5 kg/ha <i>Azotobacter</i> + 1.5 kg/ha <i>Phosphobacterium</i> ) | 744.83                                | 8.66                              |
| <b>Mean</b>   | <b>689.21</b>                         | <b>8.40</b>                       |
| <b>S.Em.±</b>   | <b>42.13</b>                          | <b>0.30</b>                       |
| <b>CD at 5%</b>   | <b>126.31</b>                         | <b>0.90</b>                       |





**Plate 2:- A panoramic view of the experimental plot**

### 4.3 Post harvest parameters

#### 4.3 (a) Flower diameter (mm):

The effect of INM on flower diameter was statistically significant. Data presented on flower diameter as influenced by integrated nutrient management are presented in Table 4.3.1 and Fig. 4.3.1

Maximum flower diameter (52 mm) was recorded in treatment T<sub>5</sub> (75 % RDF + 25% RDN by Vermicompost + 1.5 kg/ha *Azotobacter* + 1.5 kg/ha *Phosphobacterium*) and followed by T<sub>3</sub> (75 % RDF + 25% RDN by FYM+ 1.5 kg/ha *Azotobacter* + 1.5 kg/ha *Phosphobacterium*), T<sub>4</sub> (75 % RDF + 25% RDN by Vermicompost) and T<sub>2</sub> (75 % RDF + 25% RDN by FYM) which recorded values of 45.76 mm, 45 mm and 42.98 mm, respectively. However T<sub>5</sub>, and T<sub>3</sub> are statistically at par and T<sub>2</sub> is statistically at par with T<sub>3</sub> and T<sub>4</sub>. The minimum flower diameter (37.63 mm) was recorded by T<sub>1</sub> i.e. 100 % RDF (200:80:80 kg/ha N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O).

#### 4.3 (b) Length of peduncle (cm):

The effect of INM on peduncle length was statistically significant. Data presented on peduncle length as influenced by integrated nutrient management are presented in Table 4.3.1 and Fig. 4.3.2

Maximum peduncle length (10.80 cm) was recorded by T<sub>5</sub> (75% RDF + 25% RDN by Vermicompost + 1.5 kg/ha *Azotobacter* + 1.5 kg/ha *Phosphobacterium*) followed by T<sub>3</sub> (75 % RDF + 25% RDN by FYM+ 1.5 kg/ha *Azotobacter* + 1.5 kg/ha *Phosphobacterium*), T<sub>2</sub> (75 % RDF + 25% RDN by FYM), and T<sub>9</sub> (50% RDF + 50% RDN by Vermicompost + 1.5 kg/ha *Azotobacter* + 1.5 kg/ha *Phosphobacterium*) which recorded values of 9.81 cm, 9.55 cm and 9.32 cm respectively. However these treatments are statistically at par. The minimum peduncle length (7.45 cm) was recorded by T<sub>1</sub> i.e. 100 % RDF (200:80:80 kg/ha N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O).

#### 4.3 (b) Shelf life (days):

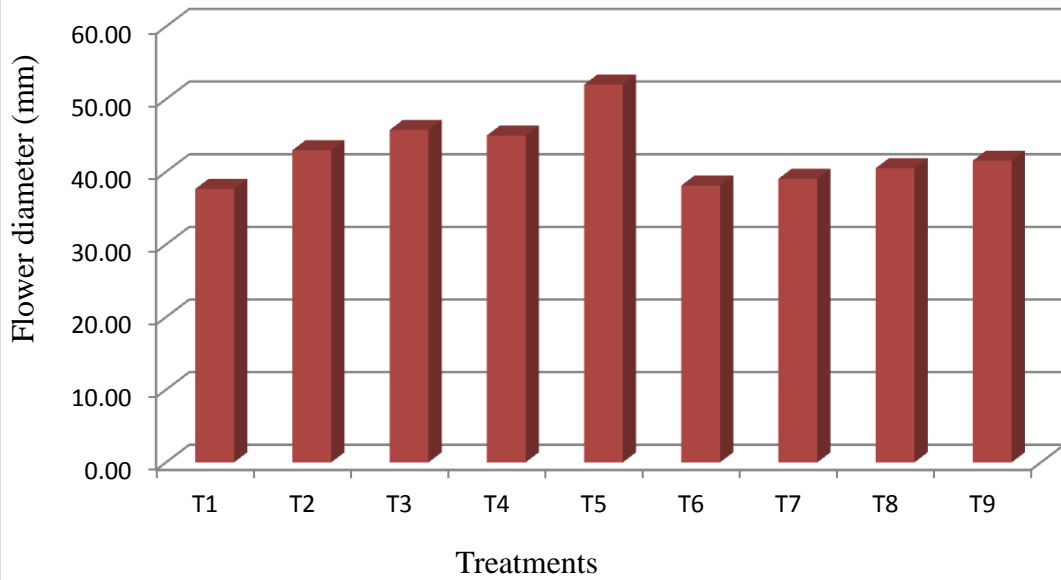
The effect of INM on shelf life of flowers was statistically significant. Data presented on shelf life as influenced by integrated nutrient management are presented in Table 4.3.1 and Fig. 4.3.3

Maximum shelf life (5.57 days) was recorded by T<sub>5</sub> (75% RDF + 25% RDN by Vermicompost + 1.5 kg/ha *Azotobacter* + 1.5 kg/ha *Phosphobacterium*) followed by T<sub>4</sub> (75 % RDF + 25% RDN by Vermicompost) and T<sub>7</sub> (50% RDF + 50% RDN by FYM + 1.5 kg/ha *Azotobacter* + 1.5 kg/ha *Phosphobacterium*) which recorded values of 4.75 days and 4.66 days respectively. However these treatments are statistically at par. The minimum shelf life (3.87 days) at this stage was recorded by T<sub>1</sub> i.e. 100 % RDF (200:80:80 kg/ha N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O).

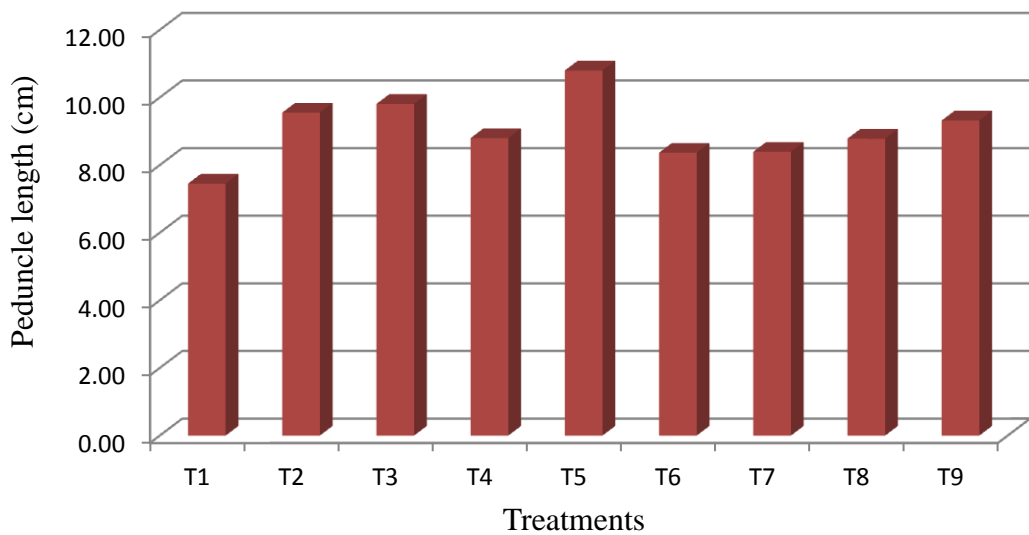
**Table 4.3.1 Effect of INM on flower diameter, peduncle length and shelf life:**

| <b>Flower diameter, peduncle length and shelf life</b>  |                             |                             |                          |
|---|-----------------------------|-----------------------------|--------------------------|
| <b>Treatments</b>   | <b>Flower diameter (mm)</b> | <b>Peduncle length (cm)</b> | <b>Shelf life (days)</b> |
| T <sub>1</sub> - 100 % RDF (200:80:80 Kg/ha N: P <sub>2</sub> O <sub>5</sub> :K <sub>2</sub> O)   | 37.63                       | 7.45                        | 3.87                     |
| T <sub>2</sub> - 75 % RDF + 25% RDN by FYM  | 42.98                       | 9.55                        | 4.50                     |
| T <sub>3</sub> - 75 % RDF + 25% RDN by FYM+ Biofertilizers(1.5 kg/ha <i>Azotobacter</i> + 1.5 kg/ha <i>Phosphobacterium</i> )           | 45.76                       | 9.81                        | 4.18                     |
| T <sub>4</sub> - 75 % RDF + 25% RDN by Vermicompost   | 45.00                       | 8.80                        | 4.75                     |
| T <sub>5</sub> -75 % RDF + 25% RDN by Vermicompost+ Biofertilizers(1.5 kg/ha <i>Azotobacter</i> + 1.5 kg/ha <i>Phosphobacterium</i> )   | 52.00                       | 10.80                       | 5.57                     |
| T <sub>6</sub> - 50 % RDF + 50% RDN by FYM  | 38.11                       | 8.37                        | 4.18                     |
| T <sub>7</sub> - 50 % RDF + 50% RDN by FYM+ Biofertilizers(1.5 kg/ha <i>Azotobacter</i> + 1.5kg/ha <i>Phosphobacterium</i> )            | 39.04                       | 8.39                        | 4.66                     |
| T <sub>8</sub> - 50 % RDF + 50% RDN by Vermicompost   | 40.49                       | 8.78                        | 4.20                     |
| T <sub>9</sub> - 50 % RDF + 50% RDN by Vermicompost+ Biofertilizers (1.5 kg/ha <i>Azotobacter</i> + 1.5 kg/ha <i>Phosphobacterium</i> ) | 41.53                       | 9.32                        | 4.61                     |
| <b>Mean</b>   | 42.51                       | <b>9.03</b>                 | <b>4.51</b>              |
| <b>S.Em.±</b>   | <b>1.58</b>                 | <b>0.59</b>                 | <b>0.29</b>              |
| <b>CD at 5%</b>   | <b>4.74</b>                 | <b>1.78</b>                 | <b>0.87</b>              |

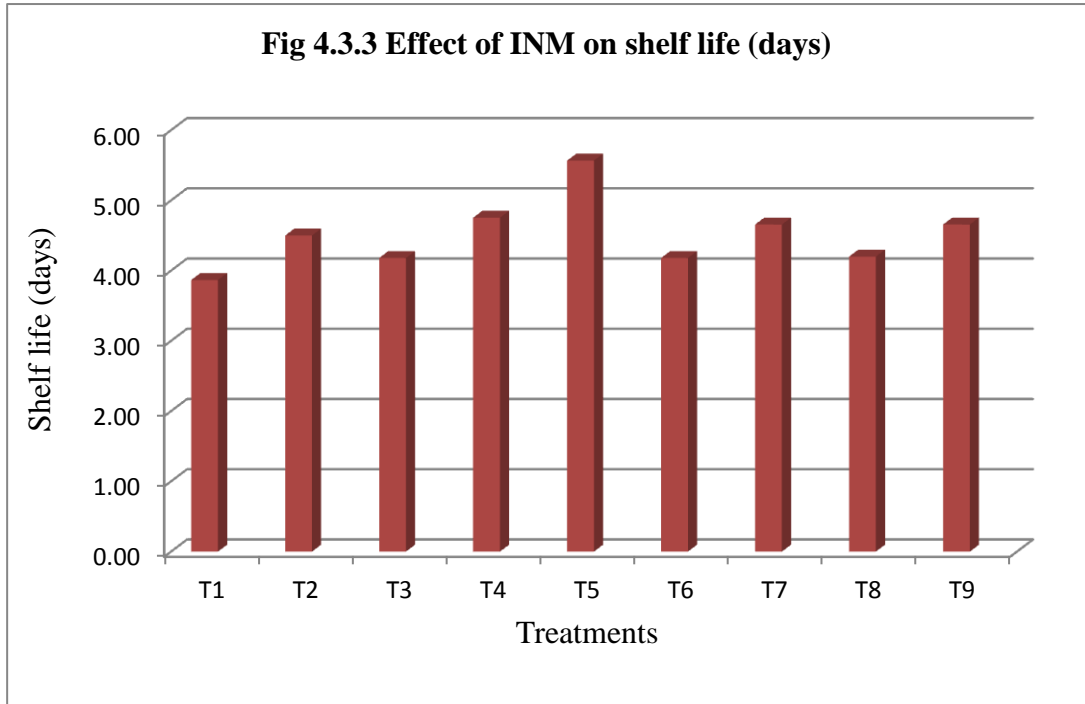
**Fig 4.3.1 Effect of INM on flower diameter (mm)**



**Fig 4.3.2 Effect of INM on peduncle length (cm)**



**Fig 4.3.3 Effect of INM on shelf life (days)**





**Plate 3 :- Shelf life studies in French marigold**

## 4.4 Biochemical parameters

### 4.4 (a) Chlorophyll content of leaves (SPAD value):

The results revealed that effect of different treatments of INM on chlorophyll content were found statistically significant. (Table 4.4.1 and Fig. 4.4.1)

Maximum chlorophyll content (66.70) was recorded in treatment T<sub>5</sub> (75 % RDF + 25% RDN by Vermicompost + 1.5 kg/ha *Azotobacter* + 1.5 kg/ha *Phosphobacterium*) and followed by T<sub>3</sub> (75 % RDF + 25% RDN by FYM+ 1.5 kg/ha *Azotobacter* + 1.5 kg/ha *Phosphobacterium*), T<sub>4</sub> (75 % RDF + 25% RDN by Vermicompost) and T<sub>2</sub> (75 % RDF + 25% RDN by FYM) which recorded values of 66.37, 66.23 and 66.03, respectively. However these treatments are statistically at par. The minimum chlorophyll content (64.07) at this stage was recorded by T<sub>1</sub> i.e. 100 % RDF (200:80:80 kg/ha N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O).

### 4.4 (b) Total carotenoids in petals (mg/g):

Total carotenoids content in petals was estimated spectrophotometrically from organic solvent. The value of carotenoid content was subjected to statistical analysis.

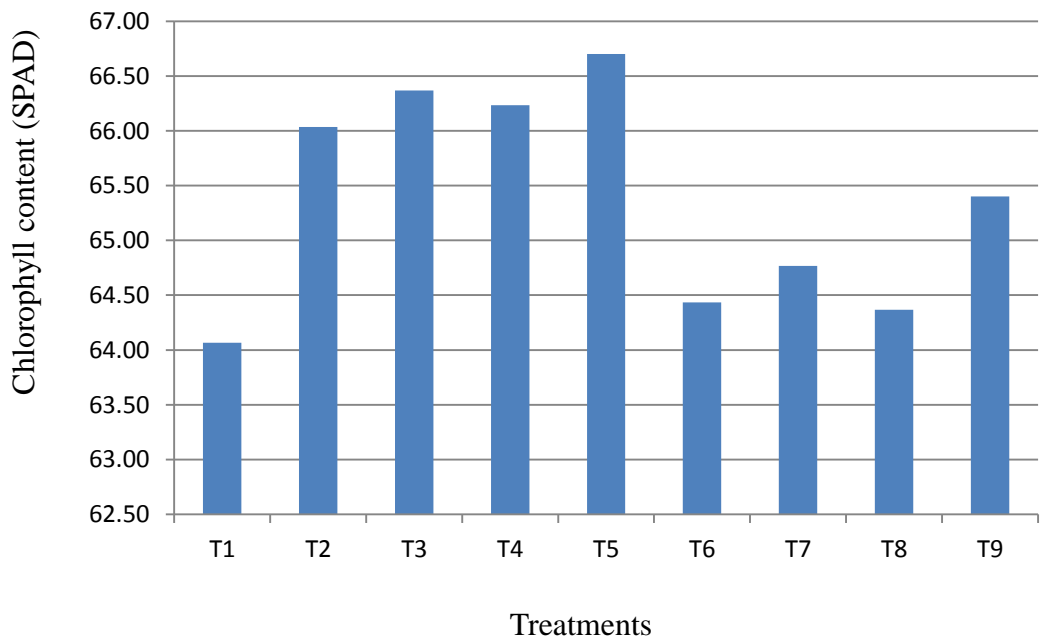
The results revealed that effect of different treatments of INM on total carotenoid content were found statistically non significant. (Table 4.4.1 and Fig. 4.4.2)

Carotenoid content in petals ranged from 7.67 to 13.50 mg/g. the maximum carotenoids content (13.50 mg/g) was recorded in treatment T<sub>5</sub> (75 % RDF + 25% RDN by Vermicompost + 1.5 kg/ha *Azotobacter* + 1.5 kg/ha *Phosphobacterium*) followed by T<sub>3</sub> (75 % RDF + 25% RDN by FYM+ 1.5 kg/ha *Azotobacter* + 1.5 kg/ha *Phosphobacterium*), T<sub>4</sub> (75 % RDF + 25% RDN by Vermicompost) and T<sub>2</sub> (75 % RDF + 25% RDN by FYM) which recorded values of 13.33 mg/g, 13.17 mg/g and 12 mg/g, respectively. The minimum carotenoid content (7.67 mg/g) was recorded by T<sub>1</sub> i.e. 100 % RDF (200:80:80 kg/ha N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O).

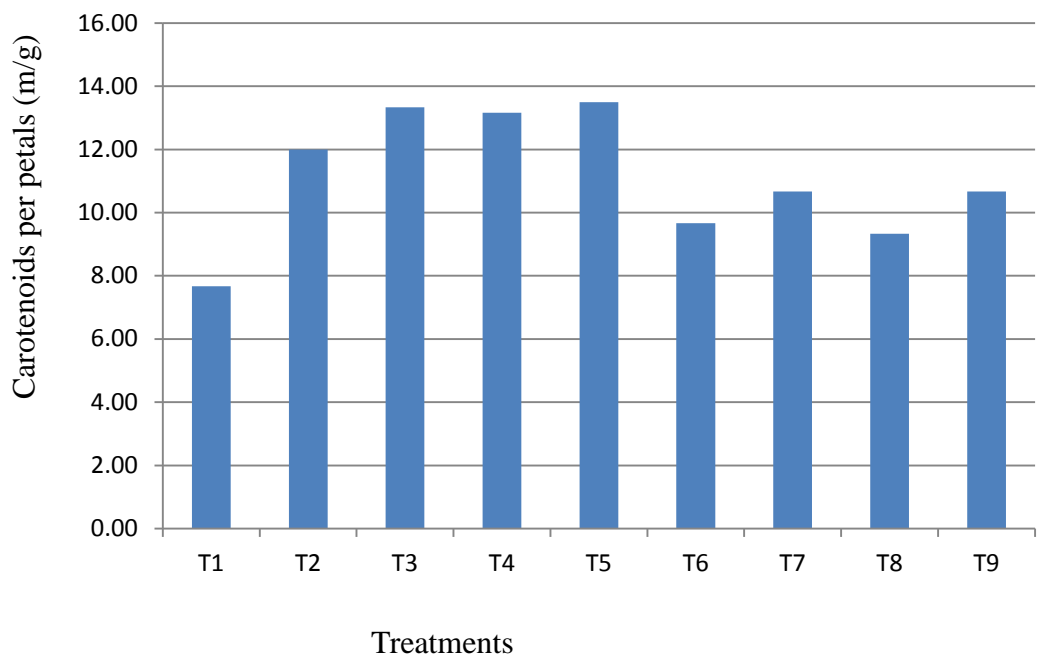
**Table 4.4.1 Effect of INM on chlorophyll content of leaves (SPAD value) and total carotenoids content in petals (mg/g)**

| <b>chlorophyll content of leaves and total carotenoids content in petals</b>  |                                   |  |
|---|-----------------------------------|--|
| <b>Treatments</b>   | <b>Chlorophyll content (SPAD)</b> | <b>Carotenoid content in petals (mg/g)</b> |
| T <sub>1</sub> - 100 % RDF (200:80:80 Kg/ha N: P <sub>2</sub> O <sub>5</sub> :K <sub>2</sub> O)   | 64.07                             | 7.67                                       |
| T <sub>2</sub> - 75 % RDF + 25% RDN by FYM  | 66.03                             | 12.00                                      |
| T <sub>3</sub> - 75 % RDF + 25% RDN by FYM+ Biofertilizers(1.5 kg/ha <i>Azotobacter</i> + 1.5 kg/ha <i>Phosphobacterium</i> )           | 66.37                             | 13.33                                      |
| T <sub>4</sub> - 75 % RDF + 25% RDN by Vermicompost   | 66.23                             | 13.17                                      |
| T <sub>5</sub> -75 % RDF + 25% RDN by Vermicompost+ Biofertilizers(1.5 kg/ha <i>Azotobacter</i> + 1.5 kg/ha <i>Phosphobacterium</i> )   | 66.70                             | 13.50                                      |
| T <sub>6</sub> - 50 % RDF + 50% RDN by FYM  | 64.43                             | 9.67                                       |
| T <sub>7</sub> - 50 % RDF + 50% RDN by FYM+ Biofertilizers(1.5 kg/ha <i>Azotobacter</i> + 1.5kg/ha <i>Phosphobacterium</i> )            | 64.77                             | 10.67                                      |
| T <sub>8</sub> - 50 % RDF + 50% RDN by Vermicompost   | 64.37                             | 9.33                                       |
| T <sub>9</sub> - 50 % RDF + 50% RDN by Vermicompost+ Biofertilizers (1.5 kg/ha <i>Azotobacter</i> + 1.5 kg/ha <i>Phosphobacterium</i> ) | 65.40                             | 10.67                                      |
| <b>Mean</b>   | <b>65.37</b>                      | <b>11.11</b>                               |
| <b>S.Em.±</b>   | <b>0.39</b>                       | <b>2.32</b>                                |
| <b>CD at 5%</b>   | <b>1.16</b>                       | <b>NS</b>                                  |

**Fig 4.4.1 Effect of INM on chlorophyll content in leaves**



**Fig 4.4.2 Effect of INM on carotenoids content in petals**





**CHAPTER - V**

**DISCUSSION**

## CHAPTER - V

### DISCUSSION

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The present study was carried out to identify the appropriate and judicious set of treatments for INM (Integrated Nutrient Management) of marigold under Malwa conditions. The role of INM in promoting growth and flowering has been remarkable.

This chapter consists of the probable explanations of the effect of treatments being briefly discussed presently in light of the research work done in the past.

#### 5.1 Vegetative parameters:

It is evident from the data that the different treatments of INM (Integrated Nutrient Management) showed significant variations in growth characters viz. plant height, plant spread, stem diameter, number of primary branches per plant, and number of secondary branches per plant recorded as per schedule and revealed that these parameters gradually increased with increase in crop age till flower development in French marigold.

##### 5.1 (a) Plant height (cm):

In the present investigation it was found that the plant height at 30, 45 and 60 days after transplanting was significantly affected by various INM treatments. Among the INM treatments maximum plant height was recorded under the treatment T<sub>5</sub> (75% RDF + 25% RDN by Vermicompost + 1.5 kg/ha *Azotobacter* + 1.5 kg/ha *Phosphobacterium*) and the minimum plant height was recorded by T<sub>1</sub> i.e. 100 % RDF (200:80:80 kg/ha N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O).

The increase in the plant height in the treatment T<sub>5</sub> might be due to the beneficial effect of vermicompost and biofertilizers in combination with recommended dose of (RDF) inorganic fertilizers while, the decrease in the plant height in control may be due to unavailability of sufficient nutrients at critical stages to plant for its luxuriant growth. Similar findings were reported by Ajit Kumar (2002) with respect to application of vermicompost and inorganic RDF in marigold and Suthar *et al.* (2005)

in marigold, Panchal (2009) in chrysanthemum. Seetha (1999) reported similar results with the application of biofertilizers and vermicompost in gladiolus.

### **5.1 (b) Plant spread:**

In the present investigation it was found that the plant spread at 30, 45 and 60 days after transplanting was significantly affected by various INM treatments. Among the INM treatments maximum plant spread was recorded under the treatment T<sub>5</sub> (75% RDF + 25% RDN by Vermicompost + 1.5 kg/ha *Azotobacter* + 1.5 kg/ha *Phosphobacterium*) and the minimum plant spread was recorded by T<sub>1</sub> i.e. 100 % RDF (200:80:80 kg/ha N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O).

This could be mainly due to the combined effect of biofertilizers, inorganic fertilizers and vermicompost. Biofertilizers secrete certain biochemicals which are growth promoting in nature that promoted good vegetative growth. Proper dose of inorganic fertilizers is important for vigorous growth of plants. Vermicompost also enhanced the micro flora and enzymatic activity which might have augmented the plant spread. This was in conformity to the findings of Rathi *et al.* (2005), Suthar (2005) and Yadav *et al.* (2017) in marigold and Panchal (2009) in chrysanthemum.

### **5.1 (c) Stem diameter (mm):**

In the present investigation it was found that the stem diameter at 30, 45 and 60 days after transplanting was influenced by various INM treatments. Among the INM treatments maximum stem diameter was recorded under the treatment T<sub>5</sub> (75% RDF + 25% RDN by Vermicompost + 1.5 kg/ha *Azotobacter* + 1.5 kg/ha *Phosphobacterium*) and the minimum stem diameter was recorded by T<sub>1</sub> i.e. 100 % RDF (200:80:80 kg/ha N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O).

Stem diameter is also a part of growth. When the plant height, number of leaves and plant spread were increased there was an increase in stem diameter also. Nitrogen being a growth promoting nutrient helps in synthesis of protein and increases the cell division and cell enlargement which results in the increased growth

of the plant. Similar results were obtained by Chadha *et al.* (1999). The combination of N and P with *Azotobacter* gave additive effect in increasing the plant height, spread and stem diameter due to secretion of certain growth promoting substances like auxin, gibberellins, vitamins, and organic acids in soil with bio inoculation. Similar findings were reported by Kumar *et al.* (2013), Kumar *et al.* (2016), Mittal *et al.* (2010) and Yadav *et al.* (2017) in marigold and Singh *et al.* (2013) in gladiolus.

#### **5.1 (d) Number of primary branches per plant.**

In the present investigation it was found that the number of primary branches at 30, 45 and 60 days after transplanting was influenced by various INM treatments. The maximum number of primary branches per plant was recorded with the treatment T<sub>5</sub> (75% RDF + 25% RDN by Vermicompost + 1.5 kg/ha *Azotobacter* + 1.5 kg/ha *Phosphobacterium*), while the minimum number of primary branches per plant was recorded in T<sub>1</sub> control i.e. 100 % RDF (200:80:80 kg/ha N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O).

This might be due to high physiological activity synchronized with maximum nutrient conversion to available form. Incorporation of vermicompost and biofertilizers in soil may enhance microbial activity which in turn may lead to proper utilization of supplied nutrients to the plants. Thereby it might have favoured stimulation and production of auxiliary buds resulting in formation of more number of branches. The above results are also corroborated with the findings of Kale *et al.*, (1987) and Nethra (1996) in China aster, Patel *et al.* (2017), Vishnu *et al.* 2015) and Sharma *et al.* (2017) in marigold.

#### **5.1 (e) Number of secondary branches per plant.**

The maximum number of secondary branches per plant was recorded at 45 and 60 DAT with the treatment T<sub>5</sub> (75% RDF + 25% RDN by Vermicompost + 1.5 kg/ha *Azotobacter* + 1.5 kg/ha *Phosphobacterium*), while the minimum number of secondary branches per plant was recorded in T<sub>1</sub> control i.e. 100 % RDF (200:80:80 kg/ha N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O).

This might be due to high physiological activity synchronized with maximum nutrient conversion to available form. Incorporation of vermicompost and biofertilizers in soil may enhance microbial activity which in turn may lead to proper utilization of supplied nutrients to the plants. This was in conformity to the findings of Jadhav *et al.* (2014), Patel *et al.* (2017), Vishnu *et al.* (2015) and Sharma *et al.* (2017) in marigold

## **5.2 Flowering parameters:**

### **5.2 (a) First flower bud appearance (days).**

The findings of the present investigation revealed that days to first flower bud appearance varied due to different INM treatments. The earliest flower bud appearance was recorded under the treatment T<sub>6</sub> (50 % RDF + 50% RDN by FYM), while the most delayed first flower bud appearance was recorded in the treatment T<sub>5</sub> (75 % RDF + 25% RDN by Vermicompost + 1.5 kg/ha *Azotobacter* + 1.5 kg/ha *Phosphobacterium*).

The earliest first flower bud appearance by the treatment T<sub>6</sub> (50 % RDF + 50% RDN by FYM) might be due to the presence of lower nitrogen supply resulting in early stress condition in plants thus inducing early flowering, while delayed flowering in treatment T<sub>5</sub> might be due to the presence of higher amount of nitrogen which in turn might have helped in prolonging the vegetative phase of the plant. The results are similar to the findings of Pooja *et al.* (2012), Vishnu *et al.* (2015) and Mohanty *et al.* (2013) in marigold and Singh *et al.* (2013) in gladiolus.

### **5.2 (b) Days for 50% flowering.**

The findings of the present investigation revealed that days to 50% flowering varied due to different INM treatments. The earliest 50% of flowering was recorded under the treatment T<sub>6</sub> (50 % RDF + 50% RDN by FYM), while the most delayed

50% of flowering was recorded in the treatment T<sub>5</sub> (75 % RDF + 25% RDN by Vermicompost + 1.5 kg/ha *Azotobacter* + 1.5 kg/ha *Phosphobacterium*).

The earliest 50% of flowering by the treatment T<sub>6</sub> might be due to the presence of lower nitrogen supply leading to early stress condition in plants thus inducing early flowering, while delayed flowering in treatment T<sub>5</sub> might be due to the presence of higher amount of nitrogen which might have helped in prolonging the vegetative phase of the plant. The results are similar to the findings of Pooja *et al.* (2012), Vishnu *et al.* (2015) and Mohanty *et al.* (2013) in marigold and Singh *et al.* (2013) in gladiolus.

### **5.2 (c) Flowering duration (days).**

The findings of the present investigation revealed that flowering duration varied due to different INM treatments. The maximum flowering duration was recorded under the treatment T<sub>5</sub> (75% RDF + 25% RDN by Vermicompost + 1.5 kg/ha *Azotobacter* + 1.5 kg/ha *Phosphobacterium*), while the minimum flowering duration was recorded in the treatment T<sub>1</sub> control (100 % RDF).

The longest duration of flowering by the treatment T<sub>5</sub> (75% RDF + 25% RDN by Vermicompost + 1.5 kg/ha *Azotobacter* + 1.5 kg/ha *Phosphobacterium*) might be because of the fact that the combined application of organic and chemical fertilizer improved the soil health, water retention capacity and availability of micro organisms. The beneficial effect of organic sources on growth parameters might be attributed due to the fact that after proper decomposition and mineralization of organic fertilizer such as vermicompost, the micro and macro nutrients were made available to plants and also helped in solubilizing the fix form of nutrient in the soil (Hedge *et al.*, 2007). The present results are supported by the findings of Naik *et al.*, (2008) in African marigold and Verma and Thomas, (2009) in carnation, Kumar *et al.* (2013) and Sharma *et al.* (2017) in marigold

### **5.2 (d) Individual flower weight (g)**

The findings of the present investigation revealed that individual flower weight varied due to different INM treatments. The maximum individual flower weight was recorded under the treatment T<sub>5</sub> (75% RDF + 25% RDN by Vermicompost + 1.5 kg/ha *Azotobacter* + 1.5 kg/ha *Phosphobacterium*), while the minimum individual flower weight was recorded in the treatment T<sub>1</sub> control (100 % RDF).

The increase in flower size and weight due to N is explained on the basis of the fact that appropriate dose of N resulted in assimilation of more carbohydrates, which results in the increased vegetative growth. These carbohydrates when translocated to reproductive organs undergo hydrolysis and get converted into reproductive sugars, which ultimately help in increasing flower size and weight in marigold (Yadav *et al.*, 1999). These findings corroborate results obtained by Rolaniya *et al.* (2017) and Yadav *et al.* (2017) in marigold, Nethra *et al.* (1999) and Kumar *et al.* (2003) in china aster and Gadagi *et al.* (2004) and Parmar (2006) in gaillardia.

### **5.2 (e) Flower yield per plant (grams).**

The findings of the present investigation revealed that flower yield per plant varied due to different INM treatments. The maximum flower yield per plant was recorded under the treatment T<sub>5</sub> (75% RDF + 25% RDN by Vermicompost + 1.5 kg/ha *Azotobacter* + 1.5 kg/ha *Phosphobacterium*), while the minimum flower yield per plant was recorded in the treatment T<sub>1</sub> control (100 % RDF).

This might be due to the fact that biofertilizers produce growth promoting substances such as IAA, gibberellins like substances as well as vitamin B12, thiamine, riboflavin (B2) etc. which enhance the soil fertility. When vermicompost was applied with balanced dose of inorganic fertilizers, it increased the availability of essential plant nutrients which, enhanced root and shoot development and thereby growth. Thereafter, it might have influenced the reproductive phase and induced flowering which resulted in increased number of flowers per plant, flower yield per

plot and per plant. These findings are in accordance with those of Jadhav *et al.* (2014), Kumar *et al.* (2016), Mittal *et al.* (2010), Gupta (1997), Gaur *et al.* (2008) and Sunitha *et al.* (2007), in marigold, Panchal (2006) and Chaitra and Patil (2007) in china aster, Parmar (2006) in gaillardia.

### **5.2 (f) Flower yield per plot (kg)**

The findings of the present investigation revealed that flower yield per plot varied due to different INM treatments. The maximum flower yield per plot was recorded under the treatment T<sub>5</sub> (75% RDF + 25% RDN by Vermicompost + 1.5 kg/ha *Azotobacter* + 1.5 kg/ha *Phosphobacterium*) while the minimum flower yield per plot was recorded in the treatment T<sub>1</sub> control (100 % RDF).

This might be due to the fact that biofertilizers produce growth promoting substances such as IAA, gibberellins like substances and also vitamin B12, thiamine, riboflavin (B2) etc. which enhances the soil fertility. When vermicompost was applied with balanced dose of inorganic fertilizers it increased the availability of essential plant nutrients which enhanced root and shoot development and thereby growth. Thereafter, it might have influenced the reproductive phase and induced flowering which resulted in increased number of flowers per plant, flower yield per plot and per plant. These findings are in accordance with those of Jadhav *et al.* (2014), Kumar *et al.* (2016), Mittal *et al.* (2010), Gupta (1997), Gaur *et al.* (2008) and Sunitha *et al.* (2007) in marigold, Panchal (2006) and Chaitra and Patil (2007) in china aster, Parmar (2006) in gaillardia.

## **5.3 Post harvest parameters**

### **5.3 (a) Flower diameter (mm):**

In the present investigation it was found that the flower diameter was significantly influenced by various INM treatments. Among the INM treatments maximum flower diameter was recorded under the treatment T<sub>5</sub> (75% RDF + 25%

RDN by Vermicompost + 1.5 kg/ha *Azotobacter* + 1.5 kg/ha *Phosphobacterium*) and the minimum flower diameter was recorded by T<sub>1</sub> control (100 % RDF).

The increase in flower diameter might be due to the fact that the balanced application of fertilizers resulted in increased carbohydrate assimilation leading to increased vegetative growth. These carbohydrates when translocated to reproductive organs underwent hydrolysis and got converted into the reducing sugars which ultimately helped in increasing flower size (Yadav *et al.* 1999). The present results are supported by the findings of Singh (2007), Singh and Kumar, (2008) in rose, Verma and Thomas, (2009) in China aster, Kumar *et al.* (2016) and Mittal *et al.* (2010), in marigold.

### **5.3 (b) Length of peduncle (cm):**

In the present investigation it was found that the peduncle length was significantly influenced by various INM treatments. Among the INM treatments maximum peduncle length was recorded under the treatment T<sub>5</sub> (75% RDF + 25% RDN by Vermicompost + 1.5 kg/ha *Azotobacter* + 1.5 kg/ha *Phosphobacterium*) and the minimum peduncle length was recorded by T<sub>1</sub> control (100 % RDF).

This might be due to the beneficial effect of vermicompost and biofertilizers in combination with recommended dose of (RDF) inorganic fertilizers. The present findings are indirectly supported by the work of Naik *et al.*, (2008) in African marigold, Singh (2007) in rose, Gupta *et al.* (1999), Yadav and Bose (1997) and Yadav *et al.* (2017) in marigold and Mishra (1998) and Singotker *et al.* (1995) in *Gaillardia pulchella*.

### **5.3 (b) Shelf life (days):**

In the present investigation it was found that shelf life of flowers was significantly influenced by various INM treatments. Among the INM treatments maximum shelf life was recorded under the treatment T<sub>5</sub> (75% RDF + 25% RDN by

Vermicompost + 1.5 kg/ha *Azotobacter* + 1.5 kg/ha *Phosphobacterium*) and the minimum shelf life was recorded by T<sub>1</sub> control (100 % RDF).

This might be due to the reason that higher dose of nitrogen keeps the flower soft and succulent in texture and this type of flower texture resulted in higher and faster respiration and dehydration. These findings corroborate the results obtained by Parmar (2007) in China aster, Mittal *et al.*, (2010), and Patel *et al.* (2008) in marigold and Panchal (2009) in chrysanthemum.

## 5.4 Biochemical parameters

### 5.4 (a) Chlorophyll content of leaves (SPAD value):

The findings of the present investigation revealed that chlorophyll content of leaves varied due to different INM treatments. The maximum chlorophyll content was recorded under the treatment T<sub>5</sub> (75% RDF + 25% RDN by Vermicompost + 1.5 kg/ha *Azotobacter* + 1.5 kg/ha *Phosphobacterium*), while the minimum chlorophyll content was recorded in the T<sub>1</sub> control (100 % RDF).

The reason for highest chlorophyll content by the treatment combination T<sub>5</sub> (75% RDF + 25% RDN by Vermicompost + 1.5 kg/ha *Azotobacter* + 1.5 kg/ha *Phosphobacterium*) might be the fact that after proper decomposition and mineralization, the vermicompost manure supplied available nutrients directly to the plants and also had solubilizing effect on fixed form of nutrients in soil. The application of *Azotobacter* provides more amounts of nitrogen by fixing it through atmosphere. Similarly, PSB helped in increasing phosphorus availability by releasing enzymes which increased the content of phosphate in soil which helps to keep the plant in healthy growing condition which ultimately increased the chlorophyll content of leaves. These results are supported by the findings of Sharma *et al.* (2006) and Sardoei *et al.* (2014) in marigold, Jayamma *et al.* (2014) in jasmine, Roelants (1973) in carnation.

#### **5.4 (b) Total Carotenoids in petals (mg/g):**

The findings of the present investigation revealed that total carotenoid content in petals varied due to different INM treatments. The maximum total carotenoid content in petals was recorded under the treatment T<sub>5</sub> (75% RDF + 25% RDN by Vermicompost + 1.5 kg/ha *Azotobacter* + 1.5 kg/ha *Phosphobacterium*), while the minimum total carotenoid content was recorded in the T<sub>1</sub> control (100 % RDF).

It has been reported that a positive correlation existed between nitrogen application and flower carotenoid content in marigold. Plants supplied with a higher nitrogen rate produced higher quantity of carotenoids (Ahmad *et al.*, 2011). Effect of nitrogen and phosphorus depletion on pigment composition of marine dinoflagellate (*Heterocapsa* sp) was studied by Latasa and Berdalet (1994) who found that nitrogen deficiency resulted in greater pigment loss than did P deficiency, there by corroborating the relationship between pigment synthesis and nitrogen metabolism. In the present study carotenoid content was observed to be maximum in T<sub>5</sub> (75% RDF + 25% RDN by Vermicompost + 1.5 kg/ha *Azotobacter* + 1.5 kg/ha *Phosphobacterium*). It might be due to the combined effect of inorganic and organic source of nutrients and biofertilizers. These results are supported by the findings of Ahmad *et al.* (2011), El-saeid *et al.* (1996), Sharma *et al.* (2006) and Karuppaiah (2006) in marigold and Roelants (1973) in carnation.



**CHAPTER - VI**

**SUMMARY, CONCLUSIONS  
AND SUGGESTIONS FOR  
FURTHER WORK**

## CHAPTER - VI

### SUMMARY, CONCLUSIONS AND SUGGESTIONS FOR FUTURE WORK

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#### SUMMARY

A field experiment entitled “Effect of Integrated Nutrient Management on Growth and Flowering of French Marigold (*Tagetes patula*) cv. Pusa Arpita” was carried out at the College farm, K.N.K. College of Horticulture, Mandasaur (M.P.) during the Kharif season of 2018-2019. Nine treatments were laid out in a Randomized Block Design (RBD) with three replications.

It is clear from the appendix that all the characters were significantly affected by different INM treatments. The effect of different treatment combinations on various characters of French marigold has been summarized below

#### **Growth characters:**

In the present investigation the different treatments of integrated nutrient management showed significant variations in growth characters viz. plant height, plant spread, stem diameter, number of primary branches, and number of secondary branches recorded as per schedule and revealed that these parameters gradually increased with increase in crop age till flower development in French marigold.

The vegetative parameters viz., plant height, plant spread, stem diameter, number of primary branches and number of secondary branches per plant were found to be maximum in T<sub>5</sub> that is 75% RDF + 25% RDN by Vermicompost + 1.5 kg/ha *Azotobacter* + 1.5 kg/ha *Phosphobacterium* at 30, 45 and 60 days after transplanting. It was significantly superior to all other treatments including control.

### **Flowering parameters:**

The flowering parameters such as first flower bud appearance and 50 per cent flowering were found to be early in the treatment combination T<sub>6</sub> that is 50 % RDF + 50% RDN by FYM, while delayed first flower bud initiation and 50 per cent flowering was recorded in T<sub>5</sub> that is 75% RDF + 25% RDN by Vermicompost + 1.5 kg/ha *Azotobacter* + 1.5 kg/ha *Phosphobacterium*.

The characters such as flowering duration, individual flower weight, flower yield per plant and flower yield per plot were found to be maximum in T<sub>5</sub> that is 75% RDF + 25% RDN by Vermicompost + 1.5 kg/ha *Azotobacter* + 1.5 kg/ha *Phosphobacterium*. It was significantly superior to all other treatments including control.

### **Post harvest parameters:**

The post harvest parameters such as flower diameter, length of peduncle and shelf life were found to be maximum in T<sub>5</sub> that is 75% RDF + 25% RDN by Vermicompost + 1.5 kg/ha *Azotobacter* + 1.5 kg/ha *Phosphobacterium*. It was significantly superior to all other treatments including control.

### **Biochemical parameters:**

The biochemical parameters such as chlorophyll content of leaves and total carotenoid content in petals were found to be maximum in T<sub>5</sub> that is 75% RDF + 25% RDN by Vermicompost + 1.5 kg/ha *Azotobacter* + 1.5 kg/ha *Phosphobacterium*. It was superior to all other treatments including control.

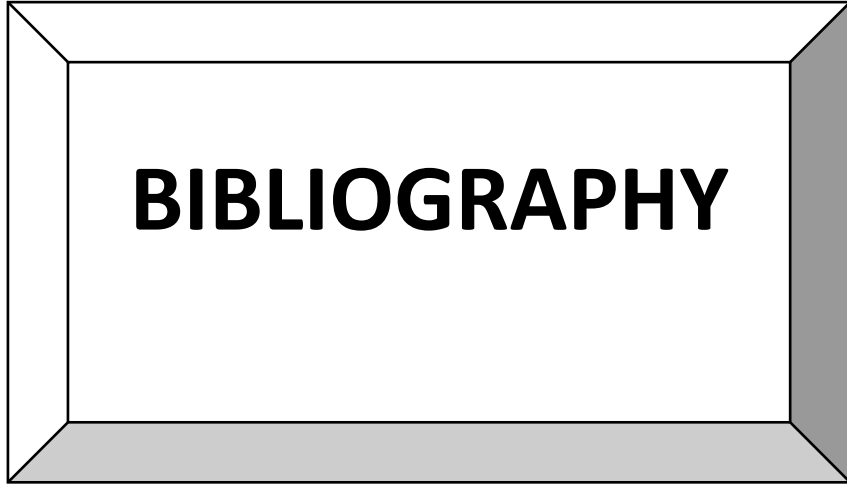
## **CONCLUSIONS**

It was concluded from the present study that the role of different treatments of integrated nutrient management is of vital importance for growth and flowering of French marigold. In the present investigation it was found that application of 75% RDF + 25% RDN by Vermicompost + 1.5 kg/ha *Azotobacter* + 1.5 kg/ha

*Phosphobacterium* in the treatment T<sub>5</sub> was observed to be the best with respect of most of the parameters examined under this investigation i.e. plant height (30, 60 and 45 DAT), plant spread (30, 45 and 60 DAT), stem diameter (30, 45 and 60 DAT), number of primary branches per plant (30, 45 and 60 DAT), number of secondary branches per plant (45 and 60 DAT), flowering duration, individual flower weight, flower yield per plant, flower yield per plot, flower diameter, length of peduncle, shelf life, chlorophyll content of leaves and total carotenoid content in petals, With respect to days to first flower bud initiation and 50 per cent flowering the best result was recorded with T<sub>6</sub> i.e. 50 % RDF + 50% RDN by FYM in French marigold cv. Pusa Arpita.

## **SUGGESTIONS FOR FUTURE WORK**

1. The effect of INM on other varieties of marigold may be exploited.
2. More number of nutrients with different nutrient combination and concentration may be tested for improvement of growth and yield of marigold flower.
3. Since it was the first year of the trial it is suggested that the findings of the present study must be tested over years and locations for confirmation.
4. Root: shoot ratio, leaf nutrient analysis and more floral characters such as number of florets per flower may also be included in the study.



# **BIBLIOGRAPHY**

## BIBLIOGRAPHY

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- A.K. Singh. (2006) Flower Crops Cultivation and Management, New Indian Publishing agency.
- Agrawal, S.I., Agrawal, A. Dixit and Yadav, R.N. (2002). Effect of N and K on African marigold in Chhattisgarh region. *Journal of Ornamental Horticulture*, **5** (1): 86.
- Ahmad, I., Asif, M., Amjad, A. and Ahmad, S., (2011). Fertilization enhances growth, yield, and xanthophylls contents of marigold. *Turkish Journal of Agriculture*; **35**:641-648.
- Ahmed, R., Hussain, M. J., Ahmed, S., Karim, M. R., & Siddiky, M. A. (2017). Effect of nitrogen, phosphorus and potassium fertilizers on yield and yield attributes of marigold (*Tagetes patula* L.). *The Agriculturists*, **15**(1), 101-109.
- Ajit Kumar, (2002). Effect of organic and inorganic fertilizers on growth, yield and post harvest life of marigold. *M.Sc. (Agri) Thesis*, University of Agricultural Sciences, Bangalore.
- Arya, S. and Rajesh K Dubey (2017). Scientific studies on effective application of some important essential elements Nitrogen (N), Phosphorus (P) and Zinc (Zn) Nutritional values on spike and Floret development in gladiolus crop, *International Journal of Innovative Research in Science*, **6**(4).
- Balaji, S. Kulkarni, Reddy, B.S., Patil, B.C. and Divakara, A. (2006). Influence of vermicompost and *in situ* vermiculture on the quality attributes and saleable yield in china aster. *Scientific Hort.*, **10**: 217-221.
- Bohra, M. and Kumar, A. (2014). Studies on effect of organic manures and bioinoculants on vegetative and floral attributes of cv. Little Darling. *The Bioscan*, **9**(3): 1007-1010, 2014
- Chadha, A.P.S., Rathore, N.K. and Ganesh, R.K. (1999). Influence of N and P fertilization and ascorbic acid on growth and flowering of African marigold (*Tagetes erecta* L.). *South Indian Horticulture*, **47**(1/6): 342-344.
- Chaitra, R. and Patil, V.S. (2007). Integrated nutrient management studies in China aster (*Callistephus chinensis* Nees) cv. Kamini. *Karnataka J. Agril. Sci.*, **20**(3): 689-690.
- Chamakumari, N., Saravanan, S and Ravi, J. (2017). Effect of NPK and organic manures on plant growth, flower yield and flower quality parameters of jasmine (*Jasminum sambac*) var. Double mogra, *Agriculture Update*, Volume **12**(2), 524-529.

- Chauhan, P. A. (2005). Effect of biofertilizers and chemical nitrogenous fertilizer on growth and flower yield of chrysanthemum (*Chrysanthemum morifolium* Ramat). M.Sc. (Agri.). Thesis, AAU, Anand.
- Desai, B. L., (1967). Flower description of *Tagetes erecta* In: Seasonal flowers, Indian Agricultural Research Institute, New Delhi.
- Dhanumjaya Rao, K., Lalitha Kameswari, P., & Baby Rani, T. (2015). Impact of integrated nutrient management on growth, flowering, yield and economics of tuberose. *Agricultural Science Digest*, **35**(1).
- Dikr, W., & Belete, K. (2017). Review on the Effect of Organic fertilizers, Biofertilizers and Inorganic Fertilizers (NPK) on Growth and Flower Yield of Marigold (*Tagetes erecta* L.). *Acad. Res. J. Agric. Sci. Res.*, **5**(3), 192-204.
- El-Saeid, H.M, Hussein, MS., Sterbeny, S.E. and Omer, E.A. (1996). Effect of nitrogen on yield and active constituents of *Tagetes patula*. *Egyptian Journal of Horticulture*, **23** (1): 101-112.
- Gadagi, R.S., Krishnaraj, P.U., Kulkarni, J.H and Sa-TongMin (2004). The effect of combined *Azospirillum* inoculation and nitrogen fertilizer on plant growth promotion and yield response of the blanket flower *Gaillardia pulchella*. *Hort. Sci.*, **100**(1-4): 323-332.
- Gaur, A., Rathore, S. V. S. and Kumar, P. N. (2008). Integrated nutrient management of African marigold cv. Pusa Narangi Gainda. *Nat. Symp. on Recent Advances in Floriculture*, Navsari, pp. 69.
- Gupta, N.S. (1997). Performance of marigold (*Tagetes erecta* L.) at graded levels of nitrogen and bioinoculants. *M.Sc. (Agri.). Thesis*, Dr. P.D.K.V., Akola.
- Gupta, N.S., Sadavarte, K.L., Mahorkar, V.K., Jadhao, B.J. and Dorak, S.V.(1999). Effect of graded levels of nitrogen and bioinoculants on growth and yield of marigold. *J. Soi. Cro*, **9**(1): 80-83.
- Hassan, A. E., Bhiah, K. M., & Al-Zurfya, M. T. H. (2014). Effect of organic extracts on the growth and flowering of marigold plants (*Calendula officinalis* L.). *Journal of Organics*, **1**(1), 22-30.
- Hedge, D. M. (2007). Nutrient requirements of solanaceous crops. *F. F. I. C., data base*. Nethra, N.N.; Jayaprasad, K.V. and Kale, R.D. (1999). China aster (*Callistephus chinensis* L. Nees.). cultivation using vermicompost as organic amendment *Crop Res.*, **17** (2) : 209-215.
- Idan, R. O., Prasad, V. M., & Saravanan, S. (2014). Effect of organic manures on flower yield of African marigold (*Tagetes erecta* L.) cv. Pusa Narangi Gainda. *Int J Agric Sci Res*, **4**(1), 39-50.

- Jadhav, P. B., Alka, S., Mangave, B. D., Patil, N. B., Patel, D. J., Dekhane, S. S., & Kireeti, A. (2014). Effect of organic and inorganic fertilizers on growth and yield of African Marigold (*Tagetes erecta* L.) Cv. Pusa Basanti Gainda. *Annals of Biological Research*, **5**(9), 10-14.
- Jayamma., Nagaraj M. Naik, and Jagadeesh, K. S. (2014). Influence of Biofertilizer Application on Growth, Yield and Quality Parameters of Jasmine (*Jasminum auriculatum*). International Conference on Food, Biological and Medical Sciences, Bangkok (Thailand)
- Kale, R. D., Bano, K., Sreenivasa, M. N. and Bagyaraj, D. J. (1987). Influence of worm cast on the growth and mycorrhizal colonization of two ornamental plants. *South. Indian Hort.*, **35**: 433-437.
- Karuppaiyah, P. (2006). Effect of spacing and nitrogen levels on flower yield and carotenoid content, nutrient uptake and residual soil fertility in French marigold. *Internat.J. agric. Sci.*, **2**(2): (375-376).
- Keisam, P., Manivannan, K., & Kumar, S. R. (2014). Effect of organic nutrients on growth, flowering and yield of *Gladiolus grandiflorus* L. *Asian Journal of Horticulture*, **9**(2): 416-420.
- Khanna, P. R., Bohra, M., Punetha, P. and Nautiyal, B. P. (2016). Studies on the effect of organic manures and psb on vegetative and floral parameters of china aster (*Callistephus chinensis* (L.) Ness.) Cv. Kamini under mid hills region of Himalaya. *The Bioscan* **11**(4): 2707-2710 N.
- Kishore Goutham B.K., Punetha Parul and Bohra Mamta. (2018). Efficacy of azotobacter and phosphate solubilizing bacteria on vegetative and floral attributes of African marigold (*Tagetes erecta* L) Cv. Pusa Narangi Gainda under hilly regions of Uttarakhand. *International Journal of Agriculture Sciences*, **10**(4) pp.-5212-5215.
- Kumar, D., Singh, B. P., & Singh, V. N. (2009). Effect of integrated nutrient management on growth, flowering behaviour and yield of African marigold (*Tagetes erecta* L.) cv. African Giant Double Orange. *Journal of Horticultural Science*, **4**(2), 134-137.
- Kumar, J., Chauhan, S.S. and Singh, P.V. (2003). Response of N and P fertilization on China aster. *J. Ornamental Hort.*, **6** (1): 82.
- Kumar, M., Kasera, S., Mishra, S., Singh, N. V., & Singh, D. (2014). Effect of Organic Manure and Inorganic Fertilizer on Growth and Yield Traits of *Gladiolus grandiflora* L.) Cv. Plumtart, *International Journal of Current Microbiology and Applied Sciences*, ISSN: 2319-7706 Special Issue-7 pp. 1430-1435.
- Kumar, M., Singh, S., Sharma, S. K., Dahiya, D. S. and Beniwal, L. S. (2006). Effect of biofertilizers on growth and flowering of marigold cv. Pusa Narangi. *Haryana J. Hort. Sci.*, **35** (1-2): 71-72.

- Kumar, P., Kumar, V and Kumar, D. (2016). Response of INM to Plant growth, Flower yield and Shelf life of African marigold (*Tagetes erecta* L.) cv. Pusa Basanti Gainda , *International Journal of Agricultural Invention* , 1(1): 108 – 112.
- Kumar, S., Singh, J. P. and Braj, M. (2013). "Influence of integrated nutrient management on growth, flowering and yield parameters of marigold (*Tagetes erecta* L.) cv. Pusa Basanti gainda." *Asian Journal of Horticulture*, 8(1) (2013): 118-121.
- Latsa, M. and Berdalet, E., (1994). Effect of nitrogen and phosphorous starvation on pigment composition of cultured *Heperocaosa* sp. *J. Plankton research*, 16(1): 83- 93.
- Metson, A. J., Arbuckle, R. H. and Saunders, M. L. (1956). The potassium-supplying power of New Zealand soils as determined by a modified normal-nitric acid method. *Transactions of the 6th International Congress of Soil Science*, B: 619-627.
- Mittal, R., Patel, H. C., Nayee, D. D., & Sitapara, H. H. (2010). Effect of integrated nutrient management on flowering yield and vase life of African marigold (*Tagetes erecta* L.) cv. Local under middle Gujarat Agroclimatic conditions. *Asian Sciences*, 5(1): 22-24.
- Mohammadreza, N., Mohammad, M. S., Houseyn, Z., & Bahari, B. (2012). Effects of different levels of nitrogen, phosphorus and potassium fertilizers on some agromorphological and biochemical traits of German chamomile (*Matricaria chamomilla* L.). *Journal of Medicinal Plants Research*, 6(2): 277-283.
- Mohanaty, A., S. Srichandan., and P. Behera., (2018). Effect of integrated nutrient management on nutrient uptake in marigold in different seasons. *The Pharma Innovation Journal*, 7(5): 13-16.
- Mohanty, A., Mohanty, C. R., & Mohapatra, P. K. (2013). Studies on the response of integrated nutrient management on growth and yield of marigold (*Tagetes erecta* L.). *Res. J. Agric. Sci*, 4, 383-385.
- Naik, B., (2003) Stability analysis and standardization of production technology for flower and xanthophyll yield in marigold (*Tagetes* spp.) *Ph.D. Thesis*, University of Agricultural Sciences, Dharwad.
- Naik, B.H., Shubha, B.M., Patil, B.C., Patil, A.A. and Chandrashekar, S.Y. (2008). Effect of integrated nutrient management for carotenoid content in African marigold. *Karnatka J. of Horticulture*, 1(2): 24-27.
- Nandre, D.R., Jogdande, N.D., Dalal, S.R., Bansode, A.B. and Chaudhale, B.S. (2005). Effect of *Azotobactoron* growth and yield of China aster under reduced nitrogen doses. *Crop Res.*, 29 (2): 272-274.
- Nethra, N.N. (1996). Effect organic and inorganic fertilizers on growth, yield and postharvest life of China aster. *M.Sc. (Agri.) Thesis*, Univ., Agric. Sci., Dharwad.

- Niak, B.H. and Patil, A.A. (1995) *karnatka J. of Horticulture*, 1(2): 24-27.
- Olsen, S.R., Cole, S.V., Watanabe, F.S. and Dean, L.A. (1954). Estimation of available phosphorus in soil by extraction with sodium bicarbonate. USDA Circular No. 939.
- Panchal, K.J. (2006). Effect of biofertilizer and nitrogenous fertilizers on growth and flower yield of China aster (*Callistephus chinensis* L. Nees.) cv. Purnima. *M.Sc. (Agri.). Thesis*, AAU, Anand.
- Panchal, R.V. (2009). Effect of biofertilizers and chemical nitrogenous fertilizer on growth, flowering and yield of annual white chrysanthemum (*Chrysanthemum coronarium* L.) under middle Gujarat condition. *M.Sc. (Ag.) Thesis*, Anand Agriculture University, Anand (Gujarat).
- Pandey, S. K., Prasad, V. M., Singh, V. K., Kumar, M., & Saravanan, S. (2018). Effect of bio-fertilizers and inorganic manures on plant growth and flowering of chrysanthemum (*Chrysanthemum grandiflora*) cv. Haldighati. *Journal of Pharmacognosy and Phytochemistry*, SP1: 637-642.
- Panse, V.G. and Sukhatme, P.V. (1984). *Statistical methods for agricultural workers*, New Delhi, India: Indian Council Agriculture Research, p 381.
- Panse, V.G. and Sukhatme, P.V. (1984). *Statistical methods for agricultural workers*, New Delhi, India: Indian Council Agriculture Research, p 381.
- Parmar, N. A. (2007). Response of biofertilizers and nitrogenous fertilizer on growth, flower yield and quality of China aster (*Callistephus chinensis* L. Nees.) under South Gujarat condition. *M.Sc. (Ag.) Thesis*, Navsari Agricultural University, Navsari (Gujarat).
- Parmar, S., Patel, R. B., Chawla, S. L., Bhatt, D., & Patel, K. (2017). Effect of chemical and bio-fertilizers on growth and flowering of golden rod (*Solidago canadensis* L.) CV. "Local". *IJCS*, 5(5), 104-108.
- Parmar, V.R. (2006). Influence of biofertilizers and nitrogenous fertilizer on growth, and flower yield of gaillardia (*Gaillardia pulchella* Fouger) cv. "Local". *M.Sc. (Agri.). Thesis*, AAU, Anand.
- Patel, H.C. (1998). Response of nitrogen, phosphorus and pinching n growth, flower production and vase life of chrysanthemum. *Ph.D. Thesis*, GAU, Sardar Krushinagar.
- Patel, P.R., Patel, N.K., Valia, R.Z. and Parmar, B.R. (2008). Effect of nitrogen and vermicompost on floral and yield parameters on marigold. National Symposium on Recent Advances in Floriculture, Navsari, pp. 71.
- Patel, P.R., Patel, N.K., Valia, R.Z. and Parmar, B.R. (2008). Effect of nitrogen and vermicompost on floral and yield parameters on marigold. National Symposium on Recent Advances in Floriculture, Navsari, pp. 71.

- Patel, R. B., Parmar, S., Chawla, S. L., Bhatt, D., & Patel, K. (2017). Effect of chemical and bio-fertilizers on growth and flowering of golden rod (*Solidago canadensis* L.) CV.“Local”. *IJCS*, **5**(5): 104-108.
- Piper, C.S. (1950). “Soil and Plant Analysis”. The University of Adelaide, Academic Press, Adelaide, Australia, 368 p.
- Pooja, G., Sunila, K., & Dikshit, S. N. (2012). Response of African marigold (*Tagetes erecta* L.) to integrated nutrient management. *Annals of Biology*, **28**(1), 66-67.
- Rao, C.C. and Reddy, K.M. (2006). Effect of integrated nutrient management on yield and quality of African marigold (*Tagetes erecta* L.). *Research on Crops*, **7**(1): 288-293.
- Rathi, S. S., Parmar, P. B. and Parmar, B. R. (2005). Influence of biofertilizers on growth and yield of African marigold (*Tagetes erecta* L.). *Gujarat Agric. Univ. Res. J.*, **30**(1- 2): 50-52.
- Rebecca., G., Starman, T. W., & Wang, Y. T. (2008). Nitrogen, phosphorus, and potassium requirements for optimizing growth and flowering of the nobile *Dendrobium* as a potted orchid. *HortScience*, **43**(2): 328-332.
- Richards, L.A. (1954). “Diagnosis and Improvement of Saline- Alkali Soils”, USDA Hand Book No. 60, Washington DC, USA.
- Roelants, A., (1973). Phosphorus fertilization of carnation cv. Scania red. *The effect of production and quality. Revue de l'Agriculture*, **26** (5): 1011-1026.
- Rolaniya, M. K., Khandelwal, S. K., Sunita koodi., Saroj R. Sepat., and Choudhary, A., (2017). Effect of NPK, Biofertilizers and Plant Spacings on Growth and Yield of African Marigold (*Tagetes erecta* Linn.). *Chem Sci Rev Lett*, **6**(21), 54-58.
- Sakr, R.A. Weaam. (2013). Chemical and biological fertilization of *Calendula officinalis* plant grown in sandy soil, *Journal of Horticultural Science & Ornamental Plants*, **9**(1): 17-27.
- Sardoei, A. S., Roien, A., Sadeghi, T., Shahadadi, F., & Mokhtari, T. S. (2014). Effect of vermicompost on the growth and flowering of African marigold (*Tagetes erecta*). *Am.-Euras. J. Agric. Environ. Sci*, **14**: 631-635.
- Seema, K., Shalini, P., Nammi, M., Hemlata, K., & Khobragade, Y. R. (2006). Effect of organic manure and biofertilizer on growth, flowering and yield of tuberose cv. Single. *Journal of Soils and Crops*, **16**(2): 414-416.

- Seetha, M.C., (1999). Effect of vermicompost and biofertilizers on growth and yield of gerbera (*Gerbera jamesonii* L.) cv., Local, M.Sc. (Agri.) thesis, University of Agricultural Sciences, Bangalore.
- Sharma, A., Sharma, K., Gaur, D. and Dhakad, H., (2017). Effect of integrated nutrient management on growth, flower yield and vase life of marigold (Var. Pusa Narangi gainda). *Journal of Pharmacognosy and Phytochemistry*, **6**(6): 319-323
- Sharma, D.P., Patel, M, and Gupta N. (2006). Influence of nitrogen, phosphorus and pinching on vegetative growth and floral attributes in African marigold (*Tagetes erecta* L.) *Journal of Ornamental Horticulture*, **9** (1): 25-28.
- Sharma, G., Sahu, N., & Shukla, N. (2017). Effect of bio-Organic and inorganic nutrient sources on growth and flower production of African marigold. *Horticulturae*, **3**(1): 11.
- Singanjude, A.R., Gajbhiye, R.P., Khobragade, Y.R and Moon, S.S. (2018) Yield and quality of African marigold as influenced by biofertilizers and nitrogen levels, *International Journal of Chemical Studies*, **6**(5): 23-26.
- Singh, A.K. (2007) Response of integrated nutrient management on growth and flowering attributes in Rose. *Journal of Ornamental Horticulture*, **10** (1): 58-60.
- Singh, C.V., Vidhya Shankar M., Kasana B.S and Bobede Ashish (2016). Effect of integrated nutrient management on flowering characters of African marigold (*Tagetes erecta*L). *International Journal of Agriculture Sciences*, **8**(4): 1000-1002.
- Singh, R., Kumar, M., Raj, S., & Kumar, S. (2013). Effect of integrated nutrient management (INM) on growth and flowering in gladiolus (*Gladiolus grandiflorus* L.) cv. White Prosperity. *Annals of Horticulture*, **6**(2), 242-251.
- Singh, R., Kumar, M., Raj, S., & Kumar, S. (2013). Effect of integrated nutrient management (INM) on growth and flowering in gladiolus (*Gladiolus grandiflorus* L.) cv. white prosperity. *Annals of Horticulture*, **6**(2), 242-251.
- Singh, U., & Kumar, V. (2016). Studies on Efficacy of integrated nutrient management on growth and yield of marigold (*Tagetes erecta* L.) cv. Pusa Narangi Gainda. *Advances in Life Sciences* , **5**(20).
- Subbiah, B.V. & Asija, C.K. (1956) A rapid method for estimation of available nitrogen in soil. *Gur. Sci.* 25: 258-260.
- Sunil, K., & Swati, S. (2013). Effect of organic manure, drying methods on flower yield and carotenoid contents in marigold (*Tagetes erecta* L.). *Asian Journal of Horticulture*, **8**(2): 385-390.

- Suthar, J. B. (2005). Influence of biofertilizers and chemical nitrogenous fertilizer on growth and flower yield of African marigold (*Tagetes erecta* L.) cv. Local. *M. Sc. (Agri.) Thesis*, AAU, Anand.
- Swathi, K., Indrajit, S., Soumen, M., and Sharma, S. (2017). Organic manures and bio-inoculants mediated influence on growth and flowering of African marigold (*Tagetes erecta* L.) cv. Pusa Narangi Gaiinda. *International Journal of Bio-Resource & Stress Management*, **8**(3), 429-432.
- Syamal, M.M., Dixit, S.K. and Kumar, S. (2006). Effect of biofertilizers on growth and yield of marigold. *J. Ornamental Hort.*, **9**(4): 304-305.
- Verma, A., and Thomas, M.R., (2009) Effect of organic sources of nitrogen and biofertilizer singly and in synergistic form on bud initiation in Carnation. National Conference on Floriculture for Livelihood and Profitability, 16-19 March 2009, IARI, New Delhi.
- Vishnu, A., Prasad, V. M., Deepthi, B., Srinivas, M. and Rajya, L. (2015). "Effect of integrated nutrient management on plant growth and flower yield of African marigold (*Tagetes erecta* L.) cv Pusa Basanti." *Environment and Ecology*, **34**(3): 841-844.
- Vyas, S.C., Vyas, S.S. and Modi, H.A. (1998). "Biofertilizers and Organic Farming". *AkrtaPrakashan*, Nadiad.
- Yadav, N. K. and Dixit, A. (1997). Effect of N and FYM on growth and yield of African marigold (*Tagetes erecta* L.). *Environ. Eco.*, **15**(4) : 849-851.
- Yadav, P.K., Singh S. and Dahiya S.S. (1999). Effect of N and FYM on chlorophyll and nutrient content in leaf of African marigold (*Tagetes erecta* L.) at flower bud initiation stage. *Environ. Eco.*, **17**(1): 188-190.
- Yadav, S. K., Pal, A. K., Anil K Singh., Yadav, D. and Sandee K M. (2018). Effect of different bio-fertilizers on growth and flowering of marigold. *Journal of Pharmacognosy and Phytochemistry*, **7**(1): 1548-1550.
- Yadav, S. K., Pal, A. K., Anil K. Singh., Yadav, D. and Sandeep K. M. (2017) Influence of different bio-fertilizers and its consortium on growth, flowering and seed yield of marigold. *Int. J. Pure App. Biosci*, **5** (6): 1660-1665.



**APPENDIX**

**Appendix- I.a: Analysis for variance of the plant height and plant spread.**

| Source of variation | D.F. | Mean sum of squares |         |         |              |         |         |
|---------------------|------|---------------------|---------|---------|--------------|---------|---------|
|                     |      | Plant height        |         |         | Plant spread |         |         |
|                     |      | 30 days             | 45 days | 60 days | 30 days      | 45 days | 60 days |
| Replication         | 2    | 4.11                | 0.43    | 17.84   | 0.20         | 3.92    | 4.49    |
| Treatment           | 8    | 4.97                | 19.40   | 22.44   | 16.36        | 8.98    | 18.21   |
| Error               | 16   | 1.42                | 5.70    | 5.58    | 5.49         | 3.30    | 6.59    |
| Total               | 26   |                     |         |         |              |         |         |

**Appendix- I.b: Analysis for variance of the stem diameter.**

| Source of variation | D.F. | Mean sum of squares |         |         |
|---------------------|------|---------------------|---------|---------|
|                     |      | Stem diameter       |         |         |
|                     |      | 30 days             | 45 days | 60 days |
| Replication         | 2    | 0.054               | 0.480   | 0.007   |
| Treatment           | 8    | 0.255               | 1.147   | 0.893   |
| Error               | 16   | 0.363               | 0.315   | 0.184   |
| Total               | 26   |                     |         |         |

**Appendix- I.c: Analysis for variance of primary branches per plant and secondary branches per plant.**

| Source of variation | D.F. | Mean sum of squares        |         |         |                              |         |
|---------------------|------|----------------------------|---------|---------|------------------------------|---------|
|                     |      | Number of primary branches |         |         | Number of secondary branches |         |
|                     |      | 30 days                    | 45 days | 60 days | 45 days                      | 60 days |
| Replication         | 2    | 0.412                      | 1.963   | 1.455   | 0.143                        | 5.898   |
| Treatment           | 8    | 1.945                      | 2.505   | 3.436   | 1.041                        | 11.25   |
| Error               | 16   | 0.395                      | 0.867   | 0.916   | 0.236                        | 4.314   |
| Total               | 26   |                            |         |         |                              |         |

**Appendix- II.a: Analysis for variance of the first flower bud appearance and Days to 50% flowering.**

| Source of variation | D.F. | Mean sum of squares         |                       |
|---------------------|------|-----------------------------|-----------------------|
|                     |      | First flower bud appearance | Days to 50% flowering |
| Replication         | 2    | 33.03                       | 5.81                  |
| Treatment           | 8    | 24.98                       | 9.95                  |
| Error               | 16   | 8.99                        | 2.06                  |
| Total               | 26   |                             |                       |

**Appendix- II.b: Analysis for variance of the flowering duration and individual flower weight.**

| Source of variation | D.F. | Mean sum of squares       |                                  |
|---------------------|------|---------------------------|----------------------------------|
|                     |      | Flowering duration (days) | Individual flower weight (grams) |
| Replication         | 2    | 3.11                      | 4.02                             |
| Treatment           | 8    | 12.58                     | 5.53                             |
| Error               | 16   | 4.81                      | 1.88                             |
| Total               | 26   |                           |                                  |

**Appendix- II.c: Analysis for variance of the flower yield per plant and flower yield per plot.**

| Source of variation | D.F. | Mean sum of squares    |                       |
|---------------------|------|------------------------|-----------------------|
|                     |      | Flower yield per plant | Flower yield per plot |
| Replication         | 2    | 146.7                  | 0.205                 |
| Treatment           | 8    | 13940.2                | 1.769                 |
| Error               | 16   | 5325.6                 | 0.270                 |
| Total               | 26   |                        |                       |

**Appendix- III.a: Analysis for variance of the flower diameter and peduncle length.**

| Source of variation | D.F. | Mean sum of squares |                 |
|---------------------|------|---------------------|-----------------|
|                     |      | Flower diameter     | Peduncle length |
| Replication         | 2    | 24.62               | 0.34            |
| Treatment           | 8    | 62.70               | 2.82            |
| Error               | 16   | 7.48                | 1.05            |
| Total               | 26   |                     |                 |

**Appendix- III.b: Analysis for variance of the shelf life.**

| Source of variation | D.F. | Mean sum of squares |
|---------------------|------|---------------------|
|                     |      | Shelf life          |
| Replication         | 2    | 0.716               |
| Treatment           | 8    | 0.725               |
| Error               | 16   | 0.257               |
| Total               | 26   |                     |

**Appendix- IV: Analysis for variance of the chlorophyll content of leaves and total carotenoids content in petals.**

| Source of variation | D.F. | Mean sum of squares |                              |
|---------------------|------|---------------------|------------------------------|
|                     |      | Chlorophyll content | Carotenoid content in petals |
| Replication         | 2    | 0.340               | 51.44                        |
| Treatment           | 8    | 2.960               | 12.43                        |
| Error               | 16   | 0.451               | 16.20                        |
| Total               | 26   |                     |                              |



## VITA

The author of this thesis Manohar G V was born on 13th March 1995 in Sidlagatta at Karnataka. He passed his second year pre-university examination conducted by department Pre-University education board Karnataka. from Byraveshwara rural PU college, Byrapalli, Srinivaspur.

In 2013 he joined UHSB, College of Horticulture, Kolar, Karnataka and successfully completed the degree of B.Sc. (Hort.) during the year 2016-17 with 7.69 OGPA out of 10.00 point scale. Then he joined M.Sc. (Hort.) course in the 1st semester, 2017-18 at College of Horticulture, Mandasaur to specialize in “Floriculture and Landscaping” and in partial fulfillment of the requirements for the award of the same, he was allotted with interesting problem “Effect of Integrated Nutrient Management on Growth and Flowering of French Marigold (*Tagetes patula*) cv. Pusa Arpita” for thesis work which has been completed by him and presented in this thesis.

He is now submitting the thesis after completing the course with 8.04 OGPA out of 10.00-point scale.