INTEGRATED NUTRIENT MANAGEMENT ON GROWTH, FLOWER YIELD AND POSTHARVEST QUALITY OF GERBERA (*Gerbera jamesonii* Bolus.) cv. GALILEO RED UNDER POLY HOUSE CONDITION

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CERTIFICATE

This is to certify that the thesis entitled, **"INTEGRATED NUTRIENT MANAGEMENT ON GROWTH, FLOWER YIELD AND POSTHARVEST QUALITY OF GERBERA (*Gerbera jamesonii* Bolus.) cv. GALILEO RED UNDER POLY HOUSE CONDITION"** submitted in partial fulfillment of the requirements for the degree of **DOCTOR OF PHILOSOPHY** in **HORTICULTURE** to the University of Agricultural Sciences, GKVK, Bangalore, is a record of *bona-fide* research work carried out by **Mrs. ELIZABETH GEORGE, I.D. No. PAK 6052,** during the period of her study in this University under my guidance and supervision and that no part of the thesis has been submitted for the award of any degree, diploma, associateship, fellowship or other similar titles.

BANGALORE
JULY, 2012

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JULY, 2012 **(ELIZABETH GEORGE)**

INTEGRATED NUTRIENT MANAGEMENT ON GROWTH, FLOWER YIELD AND POST HARVEST QUALITY OF GERBERA *(Gerbera jamesonii* Bolus.) cv. GALILEO RED UNDER POLY HOUSE CONDITION

ELIZABETH GEORGE

Thesis abstract

Studies were conducted to investigate the effect of integrated nutrient management on growth, flower yield and post harvest quality of gerbera (*Gerbera jamesonii* Bolus.) cv. Galileo Red under poly house condition during 2010-2012 at University of Agricultural Sciences, GKVK, Bangalore.

The results showed that application of 75 % recommended dose of nitrogen and phosphorus and 100 % potassium + *Azospirillum brasilense* + *Bacillus megaterium* + *Glomus fasciculatum* (VAM Fungi) + vermicompost + panchagavya + jeevamrutha + *Trichoderma harzianum* had significantly improved growth, flowering and yield attributes. The growth parameters like plant height (47.53cm), plant spread (49.66cm^2), number of leaves per plant (28.80), leaf area (158.40cm^2), number of suckers per plant (6.06) were found to be maximum at six months after planting and flower parameters like minimum number of days taken for 50 per cent flowering (83.67 days), maximum stalk length (59.53 cm), flower diameter (9.66cm), number of flowers per plant for first and second year (31.46 and 38.80) and flower yield per m^2 (220.20 and 271.60) were found to be highest. The maximum shelf life (15.33 days), highest net returns (Rs. 8,84,979) and cost: benefit ratio (1: 1.49) per 1000 m^2 were recorded in this treatment. The available nitrogen, phosphorus content in soil and leaf nitrogen, phosphorus and potassium content was also maximum in this treatment at both six and twelve months after planting. Soil general microbial population (bacteria, fungi and actinomycetes) and beneficial microbial population (*Azospirillum* sp., *Bacillus* sp., *Trichoderma* and VAM) were found to be maximum in this treatment at six months and one year after planting.

Even application of 50 per cent recommended dose of fertilizers along with biofertilisers, organic manures and biostimulants are better than depending on inorganic source of nutrients alone.

Signature of the student **Signature of the Major Advisor**

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Introduction

I. INTRODUCTION

Gerbera (*Gerbera jamesonii* Bolus.) commonly known as Transvaal daisy, Barberton daisy and African daisy is an ideal flower widely used as a cut flower besides for beds, pots, borders and rock gardens. It is one of the most popular commercial cut flowers in the world and according to the global ranking it occupies the sixth place among the cut flowers (Datta, 2006). The flowers are found in a wide range of colours and size with good keeping quality, lending them attractive to different floral arrangements.

Gerbera is native to South African and Asiatic regions and belongs to the family Compositae. The plant is a dwarf, herbaceous, perennial and grows in clump with solitary flower heads on long slender stalks, which grows well above the foliage. The leaves are radical, petiolated, lanceolate, deeply lobed, narrower at the base and wider at the top. Gerbera produces attractive flowers known as 'head' or capitulum. Flower heads are solitary; many flowered with conspicuous ray florets in one or two rows. The daisy like flowers are available in a wide range of colours including yellow, red, orange, cream, white, pink, brick red, scarlet, salmon peach, maroon and various other intermediate shades.

Flower longevity depends on the stage of harvest. The flowers are generally harvested when the outer ray florets are completely elongated or when the outer two rows of disc florets are perpendicular to the flower stem (Salunkhe *et al*., 1989). The flower stalks are long and leafless making them suitable for bouquets and flower arrangements. The genus Gerbera consists of forty species of semi hardy and perennial flowering plants (Bailey, 1963). Among them *Gerbera jamesonii* is the only species under cultivation.

The colour variations, diversity in size of flowers, long lasting behaviour and wide adaptability for cultivation, introduction of Dutch cultivars and suitability for protected cultivation made gerbera a flower of choice for cultivation in India. There is a great demand for gerbera particularly in European markets during winter months and almost throughout the year in India. Since India is situated geographically in an advantageous position comparatively closer to major flower consuming countries, it has a very good scope and potential in the flower trade The severe winter in several major flower producing European countries is also an advantageous factor to India, especially for cities like Bangalore, Pune, Nasik and other cities which enjoy moderate climate all through the year besides the availability of land and labour thereby offering great potential for producing gerbera on commercial scale.

It is difficult to get cut blooms of exportable quality in Gerbera when cultivated under open condition. Hence, in order to meet the international quality standards, high productivity, long lasting quality and to exploit the much desired potentiality of the Dutch cultivars, the crop has to be grown under protected structures. It has been shown that under greenhouse conditions, the crop can be successfully raised throughout the year besides protecting it from adverse climatic conditions and the incidence of pests and diseases, thereby ensuring higher returns.

In India, Gerbera is cultivated in Maharashtra, Karnataka, Tamil Nadu, Sikkim and West Bengal. In Karnataka, it is grown in Bangalore, Dharwad and Belgaum districts. The export of floricultural products from India has been on the increase in the recent years with the introduction of new floriculture products and ever increasing demand from the importing countries. Improved production technology is being used for getting best quality blooms in order to meet the export standards. In addition to the growing conditions, nutrients play a very important role in obtaining quality flowers. Chemical fertilisers play a highly significant role in intensive crop production. However, it has now been realised that continuous application of heavy doses of chemical fertilizers and plant protection chemicals has led to the deterioration of soil health in terms of its physical and chemical properties, reduction in organic content, soil humus, decline in soil microbial activities and increased pollution hazards of soil, water and air besides causing health hazards to poly house workers. Due to hike in the cost of fertilizers as well as the possibility for increased pollution under protected conditions, it has become imperative to arrive at an Integrated Nutrient Management practices so as to ensure eco friendly cultivation and the target yield at economized use of chemicals and organic sources of nutrients.

Integrated nutrient management combines inorganic, organic and biological sources of nutrients in a judicious and efficient way into ecologically sound and economically viable farming systems. Use of organic manures in one form or the other has advantages like slow release of nutrient and improvement of soil physical conditions. Organic resources such as farm yard manure, neem cake and vermicompost can be used for increasing the productivity of the soil. Biofertilisers or microbial inoculants are the formulations containing live or latent cells of efficient strains of microorganisms which help in augmenting the productivity through effective mobilisation of major plant nutrients like nitrogen, phosphorus and potash including other minor nutrients needed by the crop. Biostimulants like Panchagavya and Jeevamrutha have the potential to play the role of promoting growth and providing immunity in plant system. Physico-chemical properties of these organic products revealed that they contain macro nutrients, essential micro nutrients, many vitamins, essential amino acids, growth promoting factors like IAA, GA and beneficial microorganisms (Palekar, 2006; Natarajan, 2007). Studies on the use of biostimulants in gerbera to improve growth and flower yield are limited.

Keeping these aspects in view a study on the integrated nutrient management on growth, flower yield and post harvest quality of gerbera (*Gerbera jamesonii* Bolus) cv. Galileo Red under polyhouse condition was carried out with the following objectives.

1) To know the influence of organic manures, biofertilizers and biostimulants along with graded levels of inorganic fertilizers on growth and flower yield.

2) To study the influence of Integrated Nutrient Management on post harvest quality of flowers.

3) To study plant nutrient status influenced by different INM practices.

4) To work out the cost benefit ratio.

Review of Literature

II. REVIEW OF LITERATURE

Gerbera is one of the majestic floricultural crops grown for its cut flower. In addition to the cultivar selection and the growing conditions, the nutritional management plays a very important role for improvement of plant growth, productivity and quality of flowers. Application of balanced nutrients plays a prime role in its production. Gerbera requires balanced nutrients in the form of major and minor nutrients for optimum growth and production. The literature pertaining to INM and the use of organic and inorganic source of nutrients in gerbera and in other flower crops has been reviewed, pooled and presented in this chapter under the following headings.

2.1 Effect of inorganic nutrients on the growth, flowering and quality of gerbera

2.2 Effect of inorganic nutrients on the growth, flowering and quality of other flower crops

2.3 Effect of organic manures on the growth, flowering and yield of flower crops

2.4 Effect of biofertilisers on the growth, flowering and yield of flower crops

2.5 Effect of biostimulants on the growth, flowering and yield of flower crops

2.6 Effect of INM on the uptake of nutrients, growth, flowering and yield of flower crops

2.7 Effect of INM on the growth, flowering and yield of gerbera

2.8 Effect of INM on the post harvest longevity of flowers

2.9 Economics of INM in flower crops

2.1 Effect of inorganic nutrients on the growth, flowering and quality of gerbera

Among the major nutrients required for the normal plant growth and development, nitrogen has greater influence right from cell division to development of vegetative and reproductive organs. It is a constituent of nucleic acid, protein, protoplasm and chlorophyll. It is one of the most mobile of all the mineral nutrients absorbed by the plant. Studies indicate the greater influence of nitrogen on growth, flower production and quality blooms in many ornamental flowering plants.

Favourable effects of nitrogen on growth and flower production were emphasized previously by Arora and Saini, 1976. In determining the yields of flower crops, phosphorous is one of the major and crucial limiting factors. Deficiency of P may adversely affect the plant in maintaining the full supply of N and K and excess application of P may result in various nutritional problems including calcium and zinc deficiency.

The highest number of larger flowers per plant was produced by applying ammonium nitrate, superphosphate and potassium sulphate altogether at the rate of 4g/l to the gerberas grown in peat. Raising the salt concentration from 2 to 4 g/l improved the vegetative growth and increased accumulation of N, P_2O_5 and K_2O in leaves and roots (Gutmane and Grivina, 1975). Among the different NPK rates and combinations tested for gerbera, N, P_2O_5 and K_2O 2:4:1 g/25 cm pot gave more flowers and the ratio 1:2:0.5 g/25 cm pot produced longest flower stalks (Kamel *et al.,* 1975).

The highest number of flowers per plant was recorded in *Gerbera jamesonii* var. S*uperba* by applying N, P_2O_5 and K_2O at the rate of 2:4:1 g/plant (Kamel *et al.,* 1977). Skalska (1978) found out a fertilizer ratio of 1.5:0.8:2.5N, P_2O_5 and K_2O at the rate of 2 g/l of substrate for best plant growth of rooted cuttings of gerbera cv. Lada.

Blomme and Dambre (1980) conducted a trial using nitrogen, on one year crop of gerbera. They found that a basic application of 10 g N/m^2 and five top dressings of 5 g N/ m^2 each time were sufficient to produce a reasonable number of good quality flowers. The best flower yield of gerbera cv. Lada grown on 1:2 (loam : peat) substrate was obtained when 5 mg of N, 20-25 mg of P_2 O_5 and 30-40 mg K_2O were applied per 100 g substrate (Skalska, 1980).

The highest cut flower yield and best quality flowers of gerbera were produced by a basal dressing of 1-2 g NPK fertilizer containing 140-280 mg of N, 30-60 mg of P_2 O_5 and 175-350 mg of K_2O/l of peat (Kacperska, 1985). Skalska (1985) obtained the highest flower yield (244. 86 flowers/m^2) by maintaining the substrate concentration at 30 mg

N/100 g in gerbera cv. Lada grown under glass, in a 1:2 ratio of loam and peat media with a basal application of P_2O_5 and K_2O at 50 and 70 mg/100g respectively.

Significant improvement in vegetative growth and flower production in gerbera was obtained when nitrogen at 0.025 g/kg of soil was applied 15-17 days after planting, N: K at 0.1:0.15 g/kg at the stage of rapid vegetative growth, N: P: K at 0.1: 0.1:0.23 g/kg at bud formation and flowering (Mantrova *et al.,* 1982).

Blomme and Dambre (1984) obtained higher yield (34 flowers /m^2) in gerberas supplied with N and K_2O at 20 and 10g/ m^2, respectively in the form of slow release compounds.

Two years study conducted by Dufault *et al.* (1990) revealed that 220 kg each of N and K_2O/ha gave higher cut flower yield in gerbera. It was also observed that there was an increase in leaf tissue nutrient content with increase in nitrogen. Guha (1994) while studying the effect of different NH_4: NO_3 ratios in the production and quality of gerberas grown in rockwood, obtained the highest cumulative flower yield in the 1:2 ratio.

Ashwath *et al.* (1995) observed that split application of 100kg nitrogen/ha in first year was found to be best for maximum flower number with minimum culled per cent flowers. Foliar application of Multiplex 2ml/l once in a fortnight produced higher yield and better quality flowers in gerbera (Lakshmamma, 1998).

Being a cut flower crop grown under greenhouse, fertigation holds good. Sujatha (2002) observed that the application of 80 per cent recommended level of either water soluble fertilisers or straight fertilisers through fertigation was most effective for improved growth and flower production in gerbera.

Application of 20:20:15 g nitrogen, phosphorus and potassium/m^2/month was found effective in producing good quality and high number of flowers in gerbera under protected conditions (Gurav, *et al*., 2004). Mohariya *et al.*(2004) reported that flower stalk length, flower diameter, number of grade I flowers/plant and vase life of cut flower were significantly superior in the plants fertilised with 12.5g P_2O_5/m^2 and 15g K_2O $/m^2$ at fortnightly interval.

Nayak *et al.* (2005) observed that a mixture of NPK at 4:2:2 g/pot was found to be the best performer in respect of number of plantlets per pot(3.70), days to flower bud formation (137.20 days), number of flowers per plant(15.60) and diameter of the flower(8.92cm).

In gerbera maximum number of flowers /plant and per sq. m. was recorded with improved floral characters when applied with higher levels of N & P (10g N + 15 g P_2O_5 / m^2). Maximum flower diameter and vase life were obtained with N & P levels of 10 g N + 12. 5g P_2O_5 $/m^2$ and 5 g N + 15 g P_2O_5 $/m^2$ respectively (Pimple *et al*., 2006).

Globalisation and liberalisation policy in India especially for cut flowers encouraged the growers to take up cultivation of gerbera in poly houses for quality flower production. The nutrient removal is very high under protected conditions due to intensive cultivation of the crop and hence its nutrient requirements have to be carefully monitored through plant/leaf analysis for high productivity and quality. The diagnosis of nutrient imbalances through diagnosis and recommendation integrated system indices indicated that Potassium and Zinc were the most yield limiting nutrients in gerbera. The leaf nutrient standards can be used for efficient fertiliser programming and to correct the nutrients in question for obtaining good flower yield and quality flowers under protected conditions.

The optimum leaf nitrogen ranged from 2.54 to 2.87%, phosphorus from 0.13 to 0.16% and potassium from 3.37 to 4.37% (Anjaneylu, 2008). Hydroponic studies by Albino- Gardu *et al*. (2008) revealed that calcium dose of 12meq Ca^{2+} L^{-1} produced more number of flowers per plant, foliar area, dry weight of leaves and stems capitulum diameter and scape length in gerbera cv. Amaretto.

Barad *et al*. (2010) observed that for maximum growth, flower yield and quality of gerbera flowers cv. Sangria under net house conditions, the crop should be fertilised with 20:10:20g/m^2 N:P:K.

The best results of cut flower yield, flower quality and plant growth were obtained from gerberas nourished by the “Çolakoğlu-2” nutrient solution formulation which consists of 150 ppm N, 31 ppm P, 234 ppm K, 30 ppm Mg, 100 ppm Ca, 15 ppm S, 8 ppm Fe, 5 ppm Mn, 1.5 ppm B, 2 ppm Cu, 3 ppm Zn and 0.2 ppm Mo. The highest flower yield was 38.67 flowers per plant in this solution. The highest value of the number of daughter plants (3.53/plant) in gerbera was determined in the “Çolakoğlu-2” nutrient solution formulation (Sirin, 2011).

2.2 Effect of inorganic nutrients on growth, flowering and yield in other flower crops

Stunted growth of plants and reduction in number of leaves in China aster, zinnia and salvia due to deficiency of nitrogen and phosphorous was reported by Bose and Das (1966). According to Elengovan (1975) and Mantrova *et al.* (1976), judicious and balanced fertilizers are known to result in overall improvement in flower quality and total yields in many flower crops. Mengel and Kirkby (1969) observed that an interruption in plant nutrition even for a short period had a negative effect on the flower yield.

Arora and Saini (1976) reported that greater numbers of flowers were obtained with application of N, P_2O_5 and K_2O at 40, 10 and 30 g /m^2, respectively in the carnation var. Sunrise. Mukhopadhyay (1981) observed that N at 40 g/m^2 and P at 20 g/m^2 stimulated vegetative growth of plants and increased flower yield per plant in carnation. Biswas *et al*. (1982) studied the effect of different levels of N, P and K and their interactions on growth and flowering of carnations, by supplying through urea, SSP and MOP. The height of plant, number of branches and flowers per plant increased significantly with increasing levels of nitrogen. Similarly, interactions at higher levels of N, P and K significantly promoted flower number production.

In marigold, application of 225 kg N+ 120 kg P_2O_5 per hectare increased the plant height and number of leaves per plant (Nalawadi, 1982). Sayed Khallil (1982) observed that application of 100 kg N per hectare had significantly increased the number of flowers per plant, weight of flowers per plant, yield per plant and yield per hectare in gaillardia. In *Limonium tartaricum*, a supplementary top dressing of potassium as potash magnesia

(40 g K m^{-2}) in early April resulted in increased fresh and dry weight of inflorescence (Harm and Maync, 1985).

Yadav *et al.* (1985) showed that application of 200 kg P_2O_5 per hectare gave maximum vegetative growth in tuberose. The plants supplied with high phosphorous produced significantly greater number of flowers and weight of flowers than control. Ravindran and Reddy (1986) observed higher flower yield with higher N rates of 90 kg per hectare in marigold. When an NPK fertilizer mixture (1N: 0.5 P_2O_5 : 1.4 K_2O) was applied at 160g/m^2, 192 cut flowers of marketable quality (miniature carnations) were obtained per square meter under a population density of 43 per square meter (Fischer and Kurzmann, 1987).

Anuradha *et al.* (1988) noticed that number of flowers per plant, flower size and weight of flowers per plant increased with increasing levels of N and P in marigold. In chrysanthemum, Jayanthi and Gowda (1988) recorded the higher plant height with fertilizer dose of 40 g N + 40 g P_2O_5/m^2 and more plant spread, number of branches per plant and total dry matter production with fertilizer dose of 30 g N and 40 g P_2O_5/sq. m.

Kerlor *et al*. (1988) reported that in varieties ‘Sumantha’ and ‘Lena’, highest yield and best quality cut flowers were produced by alternate spraying with two lactofol products like Lactofel zinc (N: K: Mg: Fe at the ratio of 25:12.5:4:2 respectively) along with B, Cu, Mn, Zn, Mo, Co and physiologically active substances, and in Lactofol potassium (differing in micro element composition).

Mantur (1988) observed increased plant height, number of branches, leaf area and total dry matter production with increasing levels of N and P but effect of K showed reverse result in China aster. Mokashi (1988) reported the non increase in the plant height, number of branches and number of leaves with increased levels of N and P in gaillardia. The flower stems harvested from fertilised *Limonium* plants were significantly heavier in terms of fresh weight when compared to unfertilised plants (Paparozzi and Hatterman, 1988).

Arulmozhiyan and Pappiah (1989) obtained higher flower yield with the application of nitrogen at 120 kg and phosphorous at 90 kg/ha in marigold. Anuradha *et al.* (1990) found significant increase in the flower size and stalk length in marigold by increasing the dose of N and P.

A fertilizer dose of 150 kg N and 100 kg P_2O_5 per hectare in everlasting flower (Sharanabasappa, 1990) and fertilizer dose of 20 g N and 10 g P/m^2 in cosmos (Jana and Pal, 1991) increased the number of leaves. A significant increase in plant height, number of branches and plant spread in calendula was noticed with higher doses of nitrogen, phosphorous and potassium (Sigedar *et al.,* 1991).

Starck *et al.* (1991) studied the effect of nitrogen and potassium on yield and quality of carnation grown in peat and saw dust. The number of flowers produced ranged from 207 to 216 per square meter and significant differences between treatments were recorded. In most cases, plants grown in peat + sawdust mixtures had longer stems and bigger flowers than those grown in peat or sawdust alone. The higher nitrogen rate produced bigger flowers in plants grown in sawdust or 25 per cent peat + 75 per cent sawdust. Whereas higher K promoted stem elongation in plants grown in 50 per cent sawdust.

Venugopal (1991) noticed increased in plant height, number of branches, number of leaves, leaf area and dry matter production with increases in the nitrogen levels up to 200 kg per hectare in everlasting flower. Singhlodhi and Tiwari (1993) observed significantly increases in plant height and spread in chrysanthemum with the application of 45 g nitrogen along with 45 g phosphorous per m^2. Potting mixture, which contained 750mg N, 60 mg P and 150 mg K per litre, achieved maximum number of inflorescence in *Limonium perigrimum* cv. Ballerina Rose (Lewis *et al*., 1994).

An increase in flowering period and total flower yield per plant due to increased dose of NPK was reported by Singatakar *et al.* (1995) in gaillardia. Amrajeet Singh *et al.* (1996) in tuberose observed increased spike and rachis length with increased dose of nitrogen and phosphorous.

Hosni and Shoura (1996) reported the effects of N (10.3 g/plot) + P (0.3, 0.6, or 0.9 g/plot) on the stem diameter of carnation variety 'Lucena'. The stem diameter increased significantly with higher rate of potash.

Mukherjee (1996) reported that application of N, P, K, Ca and Mg in the proportion of 250g, 60g, 125g 40 g and 40g per square meter per annum, respectively, were found to be better in producing good quality carnation flowers. In China aster, the application of N at 180 kg and P at 120 kg/ha resulted in more plant height, leaf area and dry matter production (Maheswar, 1997).

In China aster, Debnath and Matti (1998) noticed higher number of flowers per plant with 10 g N + 20 g P + 20 g K/m^2 over control. John and Paul (1999) recorded the number of flower per plant, flower size and flower weight significantly improved with the application of nitrogen and phosphorous in chrysanthemum.

Krishna *et al.* (1999) observed that application of 120 per cent recommended dose of fertilizers through fertigation was most effective to improve vegetative growth and flower yield in carnation and stated that the nutrient requirement of carnation differs with the different growth stages.

Agarwal *et al.* (2002) reported that application of nitrogen @ 200 kg per hectare and potassium 200 kg hectare was significantly increased plant height and number of branches per plant in marigold. Mohanty *et al.* (2002) reported that application of nitrogen at 10 g per m^2 and phosphorous at 20 g per m^2 resulted in increased growth in marigold.

Indrajit and Nilimesh (2003) stated that the split application of N and P to soil twice a week resulted in the highest number of flowers (124.59), side shoots (12.44) and leaves (523.170) per plant; longest duration of flowering (147.35 days) and vase life (7.33 days in tap water); and greatest plant height (44.69 cm), flower stem length (36.30 cm) and flower weight (111.58 g per 100 flowers). N and P applied to foliage twice a week resulted in the largest flowers (5.72 cm), and longest (13.91 cm) and widest (0.92

cm) leaves, whereas N and P applied to soil once in a fortnight gave the earliest flowering (59.82 days after transplanting) and longest field life (6.48 days).

Application of 800 ppm of Zinc and 30 ppm of Manganese twice at 35 DAT and 20 days after first spray induced early flowering (97.80 and 108 days) with maximum duration of flowering (43.73 and 40.06 days), respectively in carnation (Jitendra *et al.*, 2003). Sarkar and Roychowdhury (2003) reported that split application of N and P (200 ppm each) to soil twice a week resulted in highest number of flowers (124.59), side shoots (12.44), leaves per plant (523.17), longest duration of flowering (147.35 days), vase life (7.33 days in tap water), tallest plants (44.69 cm), highest flower stem length (36.30 cm) and flower weight (11.18 g/100 flowers).

Sunita Devi *et al.* (2003) reported that with increasing level of nitrogen (30 g/m^2), height of plant (38.80 cm), number of leaves per plant (144.66), leaf area (1084.33 cm^2), diameter of stem (0.80 cm) and number of branches (9.63) per plant increased significantly in carnation cv. Cabaret.

Application of nitrogen at 1500 ppm resulted in maximum NPK content of leaves (2.241, 0.266 and 3.66%, respectively). A positive linear relationship was found between N content of leaves and days taken to bud formation, days taken to flowering, flower size, plant height, stem length, stem strength and flower yield/m^2 (Verma *et al.*, 2003).

Gurav *et al.* (2004) revealed that application of basal dose of NPK @ 200:200:100 Kg/ha by fertigation through straight fertilizers was the most superior which resulted in higher and quality production of carnation (168 flowers/m^2/yr) under greenhouse environment.

Gopinath and Chandrashekar (2009) observed that application of N, P_2O_5 and K_2O in the proportion of 200 g, 48 g, 160 g 40 g and 40g per square meter per annum, respectively, were found to be better in producing higher number of petals (62.25/ flower head), diameter of cut flowers (5.97 cm) and cumulative yield of first grade (265.36/m^2).

2.3 Effect of organic manures on the growth, flowering and yield of flower crops

2.3.1Effect of farm yard manure on the growth and yield of flower crops

Shifing of agricultural system to intensive cropping during the green revolution period had forced the use of inorganic fertilisers and synthetic pesticides leading totally to a chemical farming scenario. Increased use of inorganics resulted in elemental imbalance at soil and plant level, accumulation of harmful substances in plant and soil, residual toxicity and reduced inherent resistance of crops to external influence. One spoonful of healthy soil contains millions of beneficial microorganisms which play a key role in helping plants to utilise nutrients. Achieving balance between the nutrient requirement of crops and the nutrient reserves in the soil is essential to maintain higher yields and sustaining agricultural production. Conjunctive use of organics, inorganics and biofertilisers will help in improving crop production and sustaining soil fertility.

Farm yard manure (FYM) is the most commonly used organic manure in the Indian subcontinent. It is a composed mixture of cattle dung, bedding material in the stable, reminants of straw and plant stalks fed to the cattle. The application of organic manure (FYM) increases the soil microbial biomass. (Goyal *et al.*, 1993). Organic matter is known to encourage the proliferation of *Azotobacter* and *Azospirillum* in soils (Mishustin and Shilinikova, 1969). Hepper and Warner (1983) reported that vesicular arbuscular mycorrhizal fungi which grows saprophytically in soil and organic matter plays an important role in the process.

The cattle extract based FYM in India can potentially supply approximately 33 million tonnes of N, P and K per year (Gaur *et al.*, 1984). The FYM seems to act directly by increasing crop yield either by acceleration of respiratory process by cell permeability or by hormone growth action. It supplies N, P and K in available forms to the plants through biological decomposition. According to Gaur (1992) FYM contains 0.5 to 1.0 per cent N, 0.15 to 0.2 per cent P_2O_5 and 0.5 to 0.6 per cent K_2O. A brief review of literature on effect of FYM on few flower crops is given below.

Chrysanthemum flower yield increased from 10.79 to 16.85 tonnes per hectare, when the plots received N, P_2O_5 and K_2O at the rate of 20:20:20 g + 5 kg FYM per sq. m (Chezhiyan *et al.,* 1986). Kulkarni (1994) reported that highest peduncle length of 17.02 cm and maximum number of saleable flowers (38.40) were obtained in the treatment which received 1.5 tonnes per hectare of FYM + N, P_2O_5 and K_2O at the rate of 180:120:60 kg per hectare, in china aster.

Sreenivas *et al.* (1998) reported higher flower yield due to application of recommended NPK and 15 tonnes of FYM per hectare or phosphocompost at 8 tonnes per hectare. Yadav *et al.* (2000) observed reduction in flower size, number of flowers per plant and flower yield at higher dose of N (> 180ppm) in African marigold. In their earlier studies Yadav and Dixit (1997), the growth parameters plant height and plant spread and flower yield were increased consistently upto 120 ppm N with maximum yield at 180 ppm N. The application of FYM improved the flower characters.

In China aster, Haripriya and Sriramachandrasekharan (2002) reported that application of FYM + mine soil at 1:2 ratio resulted in the better growth and yield of marigold as compared to leaf mould and pressmud.

Prakash *et al.* (2002) stated that phosphorous and potassium content in the leaves increased with addition of 5 and 10 per cent FYM whereas, N content was increased in the leaves only with addition of 5 per cent FYM, addition of FYM to the soil also increased the yield parameters in their study.

Use of sand and FYM (1:1) produced maximum plant height, number of sprouts per plant, number of leaves per plant, diameter of shoot and number of flowers plant in wax Begonia (Anil *et al.,* 2009).

2.3.2 Effect of vermicompost on the growth and yield of flower crops

Vermicomposts are products derived from the accelerated biological degradation of organic wastes by earthworms and microorganisms. Earthworms consume and fragment the organic wastes into finer particles by passing them through a grinding gizzard resulting in organic matter rich in nutrients. Vermicompost incorporation at 20%, with or without chemical fertilizers, reduced the incidence of diseased plants, and the disease growth rate. The macro and micronutrient content (except K and Mn) were at optimum level in plants treated with 20% vermicompost with or without chemical fertilizer (Rodriguez Navarro *et al.,* 2000)**.**

The significant increase in plant height, leaf number, spike length and number of florets per spike in gladiolus in the plots treated with a combination of vermicompost @ 10 tonnes per hectare + 80 per cent recommended NPK (100:60:60 kg NPK/ha) was reported by Gangadharan and Gopinath (2000).

In marigold, the plants applied with vermicompost (15 tonnes per hectare) + 100 per cent recommended NPK produced maximum number of flowers per plant with greater flower diameter and flower yield than plants without vermicompost and fertilizer application (Mashaldi, 2000).

The golden rod plants supplied with vermicompost (10 tonnes per hectare) and 100 per cent recommended NPK (100:50:50 kg/ha) produced greater plant height, maximum number of leaves and highest flower yield (Kusuma, 2001).

Sindhu *et al*. (2009) reported highest bulk density (0.58 g/cm^3) and electric conductivity (0.85 dS/m) in media amended with soil + farmyard manure + vermicompost + samridhi + sawdust. Leaf magnesium content was maximum (0.55%) recorded in media amended with vermicompost.

Hidalgo and Harkess (2002) noticed that plants grown in 50% vermicompost had a greater growth index at height, foliar area, number of flowers per pot, dry weight and early flower development in chrysanthemum cv. ‘Mirmar’

Chauhan *et al.* (2005) in marigold cv. Pusa Narangi Gainda reported that the application of vermicompost @ 1000 g/m^2 recorded higher yield of flowers (1757.76 g/m^2) compared to application of vermicompost @ 500 gm/m^2 (1429.00 g/m^2).

Rajesh Bhalla *et al*. (2007) revealed maximum plant height (73.20 cm) in carnation cultivar Raggio – de- Sole when grown in media containing sand + soil + vermicompost at ratio 1:1:1 + inorganic fertilizers + biofertilizers.

2.4 Effect of biofertilisers on the growth, flowering and yield of flower crops

2.4.1 Effect of *Azospirillum*

Azospirillum is one among the commonly used biofertilizers known as plant growth promoting bacteria (PGPB). *Azospirillum* is a motile, gram negative, spiral shaped diazotropic bacterium, which lives in harmony with root tissues. The stimulatory effect exerted by *Azospirillum* has been attributed to several mechanisms including secretion of phytohormones, biological nitrogen fixation, and enhancement of mineral uptake by plants (Okon and Itzigsohn, 1995).

Balasubramanian (1989) observed increased growth in marigold inoculated with *Azospirillum.* This might be due to added nitrogen to crop through associative symbiosis and increased production of growth hormones like NAA, GA and cytokines. Preethi *et al*. (1990) reported increased growth and yield in *Azospirillum* inoculated Edward rose plants under optimum moisture conditions.

Ravichandran and Pappiah (1995) reported improved flower yield, flower diameter and weight in *Crossandra infundibuliformis*, when treated with *Azospirillum* + recommended dose of nitrogen. In a field trial with gundumalli (*Jasminium sambac*), Manonmani (1992) reported increased plant height, number of tertiary branches, shoot and leaf area, dry weight, root biomass, flower weight and yield with the inoculation of *Azospirillum* along with nitrogenous fertilizer application.

In Jathimalli Cv. CO-2, Vasanthi (1994) observed increased corolla length, bud width, petal breadth, flower diameter and advanced flowering in plants inoculated with Azospirillum.

Wange *et al.* (1995) revealed increased number of bulblets (14.3/plant) flower stalks (23348 dozen/ha) and more monetary returns (1:3.73) in tuberose Cv. single petaled with *Azospirillum* inoculation. Gadagi Ravi *et al*. (2003) reported that the combination of *Azospirillum* strain OAD-2 and 150 kgNha^{-1} showed the highest N uptake at 120DAT in *Gaillardia pulchella* var.Pucta. Prabhatkumar *et al.* (2003) reported, in China aster, that the increase in vegetative growth by use of biofertilizers might be related in stimulating nutrient uptake and biosynthesis of plant growth regulators, thereby improving the growth and development process of the plant.

2.4.2 Effect of phosphorus solubilising bacteria (PSB)

The role of phosphorus solubilising bacteria as a biofertilizers is unique in making the fixed soil-phosphorous available to plants. PSB produces plant growth regulating substances, which promote root growth (Greaves and Webley, 1969). Gaur (1992) observed that inoculation of PSB caused a further improvement in soil phosphorous, possibly due to the solubilization of fixed or the added phosphorous.

In a field trial with gundumalli (*Jasminum sumbac*), Manonmani (1992) reported increased plant height, number of tertiary branches, shoot and leaf area, dry weight, biomass, flower weight and yield with the inoculation of *Azospirillum* and phosphobacteria along with nitrogeneous fertilizers application. Application of *Azospirillum* and phosphobacteria alone or in combination with inorganic fertilizer leads to increase flowers per spike and yield in crossandra (Ravichandran and Pappiah, 1995).

Vandana and Subramanian (2000) attributed higher crop yield on PSB application due to vigorous solubilization of phosphate by phosphobacteria in lower levels of phosphorous. Sapna Sharma *et al.* (2010) stated that B-III and UF-2 strains of *Bacillus sp.* increased the growth of rooted cutting of carnation after two months of plantation, reduced the days of bud formation and days for flowering significantly and increased weight diameter and yield of flowers per plant. Strains were also found to reduce the *Fusarium* wilt significantly.

2.4.3 Effect of *Trichoderma*

Trichoderma harzianum is a saprophytic fungus which is used generally as a biological control agent against a wide range of economically important aerial and soilborne plant pathogens (Papavizas, 1985). *Trichoderma spp.* can also produce metabolites with activities analogous to plant hormones (Cutler *et al*., 1989).

The plant benefits by the presence of *Trichoderma spp.*, suggesting an interaction as avirulent symbionts (Howell *et al*. 2000; Harman, 2006). *Trichoderma* are known for their production of several lytic enzymes and antibiotics, among them *T. viride and T. harzianum* are commercialized. Strains of those species are widely used in biocontrol of soilborne plant-pathogenic fungi occurring in the most extreme to the most mundane of habitats. These fungi increase the rate of plant growth and development, by developing more robust roots. These deep roots cause crops, such as corn, and ornamental plants, to become more resistant to drought. *Trichoderma* also solubilizes phosphates and micronutrients.

Migheli *et al* (1993) reported that an isolate of *Trichoderma harzianum* has effectively reduced the incidence of *Phytophthora parasitica* in carnation.

Ousley *et al*. (1994) concluded that some *Trichoderma* strains have the potential to consistently increase plant growth (Lynch *et al*. 1991) and influence its phenology. Dual inoculation of peat based horticulture substrate with a mixture of four species of arbuscular mycorrhizal fungi and fungal biocontrol agent *Trichoderma harzianum* showed a significant positive effect on the growth and flowering of cyclamen plants (Dubsky *et al*, 2002).

Mycoparasitism and production of volatile compounds were the prominent mechanisms of biocontrol by Trichoderma sp. on Pencillium and Aspergillus causing storage rot of Gladiolus (Baiswar *et al*., 2006)

Kishore (2007) reported that among all the biocontrol agents evaluated against *F. oxysporum* f. sp. *gerberae*, *Trichoderma koningii* (65.70% inhibition) was found most effective than all other treatments followed by *T.harzianum* with 65.00 per cent inhibition. *Trichoderma* sp. increased tulip cut flower quality traits and induces maturity in immature bulbs (Mazhabi *et al*, 2011).

2.4.4 Effect of VAM on growth and yield

Vesicular-arbuscular mycorrhizal (VAM) fungi can form a symbiosis with a wide variety of plant hosts. The symbiosis stimulates growth and development of plants, increases absorption of plant immobile elements increases drought tolerance and reduces disease incidence. Moreover, colonization with VAM fungi increases uniformity and reduces mortality (Biermann and Linderman, 1983) and injury of geranium transplants.

Bagyaraj and Powell (1985) reported that VAM inoculation increased P uptake in marigold. Balasubramaniam (1989) recorded increased foliar P levels besides, enhanced contents of N, K, Mg and Zn in French marigold seedlings with VAM inoculation.

China aster cv. Shashank performed better when vermicompost applied along with VAM inoculation. Progressive improvement in growth and yield attributes of china aster were noticed with increased levels of vermicompost and VAM inoculation from zero to 10 ton/ha and 3 to 5 g/ plant respectively (Vijay Kumar and Abnit Singh, 2007).

2.5Effect of biostimulants on the growth and yield of flower crops

2.5.1Effect of Panchagavya

Use of fermented organics prepared from cowdung, cow urine, leguminous leaves or vermiwash which includes panchagavya, jeevamrut, beejamrut, sasyamrut, vermiwash, amritpani *etc.* are effective in promotion of growth and flowering in horticultural crops. Although, these manures may not provide enough nutrients in the area of application, but they help in the quick build up of soil fertility through enhanced activity of soil micro-flora and fauna. Liquid cattle manure should be applied to soils in such a manner that would improve soil fertility and crop production without causing salinity problems or increasing NO_3 levels.

Presence of naturally occurring, beneficial, effective micro organisms (EMO's), in panchagavya predominantely, lactic acid bacteria, yeast, actinomycetes, photosynthetic bacteria and certain fungi besides beneficial and proven fertilizers such as *Azotobacter*, *Azospirillum* and *Phosphobacterium* were detected which have the beneficial effect especially in improving soil quality, growth and yield of crops (Xu and Xu, 2000).

The positive influence of panchagavya foliar spray was pronounced on the test grain weight(9.7 to 16.6 %) and crude protein content (1.6 to 4.8%) and N uptake (11 to 35.2%) in sunflower, which may be due to the growth regulatory substances like IAA, GA, cytokinin and essential plant nutrients. In Jasmine, spraying two rounds of panchagavya, one before flower initiation and another during bud setting phase ensured continous flowering (Vivekanandan, 1999). Panchagavya @ 3 per cent spray 4 times for bhendi augmented the yield level in poultry manure (10.27 t/ha) treated plot which was comparable to inorganic supplementation (10.39 t/ha) with pesticide spray (Louduraj *et al.,* 2005).

Panchagavya applied @ 3 per cent spray at 0, 30, 50 days after sowing in rice (Ramanathan, 2006) recorded significantly higher grain yield (5430.00 kg/ha) over no panchagavya spray (4990.00 kg/ha) along with different organic manures.

Somasundaram and Singaram (2006) reported that panchagavya spray was found effective on many crops than the foliar spray of recommended nutrients and growth regulators. The superiority of the panchagavya in different crops was noticed with respect to the improvement in growth, yield components and yield of crops over no panchagavya spray from their studies conducted at Coimbatore.

Studies conducted at Indian Grassland and Fodder Research Institute (IGFRI), Jhansi with various Jaivik and Vedic Krishi inputs such as Angara, Amrithpani, Panchagavya and Gomutra *etc.,* indicated that all these products improved crop productivity, microbial population and activity in soils. Growth of mustard was found increased by the foliar application of gomutra and panchagavya. Lucerne fodder yield was also found significantly increased by application of gomutra and panchagavya as seed soaking treatment. Twice application of panchagavya increased the productivity by 49.63 per cent over control. Application of angara and amrithpani to soil and panchagavya as foliar spray was also found to increase sorghum grain and dry fodder yields (Veerabhadraih *et al.*, 2006).

Shwetha (2008) reported that significantly higher leaf area index (LAI), plant height, number of branches, dry matter accumulation, seed yield and yield parameters like number of pods /plant with the application of organic manures in combination with fermented organics *viz.*, Beejamrut, Jeevamrutha, Panchagavya over organics alone application.

Maximum plant height (90.67 cm) was observed when plants were treated with common basal dose + vermicompost (500g / m^2 twice a year) + 3% manchurian mushroom tea + 3% panchagavya, whereas plants treated with 50% required dose of fertilizers resulted in minimum plant height of 78.49 cm (Rajesh Bhalla *et al.*, 2006). Thamaraselvi *et al*. (2006) reported that 5 percent panchagavya spray significantly influenced the morphological characters of *Rosa bourboriana* and *Rosa centifolia* and also brought earlier flowering (45.6 days and 53.31 days respectively).

The treatment combination of panchagavya 4 % + 50 % recommended dose of fertilizers (RDF) favourably influenced the spathe length (7.50 cm) spathe breadth (7.00 cm), spadix length (4.5cm) and spike length (32.10 cm) of anthurium (Waheeduzzama Mohd., 2006).Tuberose cultivar pearl double recorded highest spike length, number of flower heads per spike and spike yield in treatment receiving RDF + panchayagavya (4%) and RDF + panchayagavya (4%) + manchurian mushroom tea. Similarly growth and yield attributes were found to better in the above mentioned treatment (Singh Bharti *et al*., 2007).

In carnation cv. Malaga application of 2 % panchagavya + 4% manchurian mushroom tea in addition to common basal dose of FYM 2 kg/m^2 / yr + DCC 200 g/m^2 + *Azospirillum* 2 g + *Phosphobacteria* 2 g + VAM 2 g / plant at 2 month intervals + *Trichoderma* 20 g /m^2/year resulted in good vegetative growth, flowering, yield and quality attributes (Punitha, 2007).

Kumar *et al*.(2008) reported that Peter Pears variety of gladiolus recorded highest plant height, number of leaves, vase life, florets per spike and corn weight when the plants are supplied with common base dose + panchayagavya (4%) + manchurian mushroom tea as compared to treatment consisting alone panchayagavya and manchurian mushroom tea at 2 and 4 per cent.

In recent days, organic biostimulants like Panchagavya have the potential to play the role of promoting growth and improving immunity in plant system (Anonymous, 2010). Renukaradya *et al*. (2011) reported that plants receiving 50 per cent RDF + vermicompost + 3 per cent manchurian tea + 3 per cent panchagavya recorded significantly higher number of branches per plant as compared to the other treatments.

2.5.2 Jeevamrut

According to Palekar (2006), Jeevamrut is a fermented liquid product prepared by mixing up cow dung (10.00 kg) with cow urine (10.00 litre), jaggery (2.00 kg), legume flour (2.00 kg) and handful of soil brought from the bunds of the lands where cultivation is to be taken up. Jeevamrut also contains enormous amount of microbial load which multiply and act as a soil tonic. It is said to enhance microbial activity in soil and ultimately ensuring the availability and uptake of nutrients by the crops.

Vasanthkumar (2006) reported that Jeevamrut is not a source of nutrients, but it is a fermented liquid product containing huge quantity of microbial load and which enhances soil bio-mass upon its application to soil even at very lesser rate as it act as a tonic to soil besides improving soil health.

2.6 Effect of integrated nutrient management on the uptake of nutrients, growth, yield and quality of flower crops

Integrated nutrient management practices involving judicious combination of organic manures, bio-fertilizers, bio-stimulants and chemical fertilizers can be feasible and viable for sustainable agriculture on a commercial and profitable scale. In addition, they are eco-friendly, easily available and cost-effective.

China aster showed positive response to application of *Azotobacter* or *Azospirillum* in combination with 75 kg N ha^{-1} (Kulkarni and Konde, 1990). Manonmani (1992) reported that in gundumallige (*Jasminum sambac*) increased plant height, number of tertiary branches, shoot and leaf area, plant dry weight, root biomass, flower weight and yield was due to inoculation of *Azospirillum* and Phosphobacteria along with nitrogenous fertiliser application.

Application of *Azospirillum* and phosphobacteria alone or in combination with inorganic fertilisers has led to increased flower yield per spike and yield in crossandra (Ravichandan and Pappiah, 1995). Nethra (1996) recorded more plant height, number of leaves, number of flowers per plant and flower yield per hectare due to application of vermicompost @ 10 tonnes per hectare and recommended dose of NPK in China aster. In chrysanthemum, Hemavathi (1997) recorded highest number of flowers and flower yield per plant by applying phosphorus solubilising bacteria + 75 percent recommended NPK (225:300:150kg ha^{-1}).

Shivalingappa (1998) studied the influence of biofertilsers on tuberose and observed that the treatment combination of NPK at 75: 35.5:50 kg per hectare with *Azotobacter*, *Azospirillum* and VAM was found significantly superior over the other treatments by recording maximum plant height, number of leaves, increased leaf area, increased number of tillers and number of spikes per plant.

Sreenivas *et al.* (1998) reported that the application of NPK and 15 tonnes of FYM per hectare or phosphocompost 8 tonnes/ha produced optimum flower yield in China aster. Velmurgan (1998) reported that increased dose of N and P with combined application of biofertilizers and GA_3 at 200 ppm recorded higher flower yield in African marigold.

Combined application of 75 per cent recommended nitrogen + *Azospirillum* and 75 percent recommended phosphorus + phosphobacteria gave highest flower yield in gundumallige (Bhavanisankar and Vangamudi, 1999a). Bhavanisanker and Vangamudi (1999 b) reported that combined application of 100 per cent nitrogen as urea and

Azospirillum showed maximum length of spike (3.53cm) and number of flower per spike (5.66) in Crossandra.

Application of nitrogen at 37.5 kg ha^{-1} + *Azospirillum* (2kg ha^{-1}) at sixth month after planting and foliar spray of ascorbic acid at 1000ppm resulted in highest number of flowering shoots, flower weight and flower diameter in Edward rose (Preethi *et al.*, 1990). Chandrikapure *et al.* (1999) reported that increased level of N with bioinoculants resulted early flowering in marigold. In tuberose Cv. Mexican single, combined application of NPK (120:140:120 kg/ha) with *Azospirillum* on a phosphobacteria resulted in higher spike length number of flowers per spike and flower yield compared to control (Swaminathan *et al.,* 1999).

Kathiresan (1999) observed increased plant height and number of leaves in gladiolus cv. White Prosperity when treated with *Azospirillum* and VAM along with recommended NPK (100:60:60kg ha^{-1}).

Gangadharan and Gopinath (2000) reported that application of vermicompost @ 10 tonnes per hectare and 80 per cent recommended dose of NPK resulted in producing better growth, flowering and quality of gladiolus cut flower. Rajdurai *et al.* (2000) indicated that application of NPK @ 45:45:37.5/kg along with combined inoculation of *Azospirillum* and VAM exhibited increased growth in respect of plant height (144.50 cm) number of leaves (156.20) and laterals per plant (28.30) in marigold.

Padmadevi *et al*. (2001) recorded highest vase life in Anthurium treated with *Azospirillum*, phosphobacteria, VAM along with inorganic nutrients and growth regulators. Narasimha Raju and Haripriya (2001) noticed maximum plant height, higher number of branches, dry matter and increased flower yield in Crossandra by the application of *Azospirillum* and phosphobacteria in combination with 100 per cent of NP (75:50:125kgha^{-1}).

Ajitkumar (2002) reported that the maximum plant height, number of branches, number of leaves, number of flower per plant and flower yield per hectare due to application of vermicompost @ 10 tonnes per hectare and recommended dose of NPK in marigold. Binisha *et al.* (2002) revealed that the treatment combination of NPK along with *Azospirillum* was more effective in improving vegetative and floral characters of dendrobium.

Benjamin Mathew and Singh (2003) reported that dipping seedlings in phosphorus solubilising bacteria, *Azotobacter* and *Azospirillum* slurry for 15 minutes recorded maximum vegetative growth in China aster.

Jawaharlal and Padmadevi (2003) reported that the application of biofertilizers along with inorganic nutrients and growth regulators had significantly effect on growth and flowering of anthurium.

Maximum nutrient uptake in Limonium cv. Blue diamond was attributed to application of 75 percent nitrogen and phosphorus + 100 percent potassium, vermicompost, *Azotobacter* and phosphorus solubilising bacteria (Gayathri *et al.*, 2004). Gopal Singh and Rathore (2004) reported that the highest number of spikes per hectare and flower yield per hectare in gladiolus with the application of NPK (120 + 60 + 40 kg/ha) + FYM 10 tonnes per hectare + $ZnSO_4$ 25 kg/ha + *Azotobacter*.

Munikrishnappa *et al*. (2004) in their experiment, the application of 50 per cent of recommended dose of fertilizer (RDF) along with vermicompost at 5 tonnes per hectare had improved the flower characters viz., spike length, rachis length, florets diameter, number of florets per spike and flower yield of tuberose. Shasidhara and Gopinath (2005) noticed higher yield of flowers with the application of 135:90:60 kg N, P_2O_5 and K_2O ha^{-1} + *Azotobacter* and VAM in Calendula.

Singh (2005) reported that in Rose, inoculation of *Azotobacter* along with recommended dose of nutrients has resulted in maximum number of flowers per m^2 during first and second flush. Chaithra (2006) reported that the use of *Azospirillum*, PSB, vermicompost along with 50 per cent recommended nitrogen, phosphorous and potassium helped in realizing better plant growth, higher quality flower yield in china aster (*C. chinensis* (L.) Nees) cv. Kamini under field condition.

Rajesh Bhalla *et al.* (2006) reported that treatment consisting of common basal dose + 3% Manchurian mushroom tea produced maximum stem length (85.42 cm), flower size (7.69 cm) and ‘A’ grade flowers (87.12%) in carnation cv. Sunrise.

Combined application of *Azotobacter* and phosphorus solubilising bacteria at 2.5 g per bulb in Tuberose resulted in maximum yield of flowers ha^{-1} and also fresh weight of bulb per plant (Seema kukde *et al*., 2006).

Shubha (2006) reported that in marigold (*Tagetes erecta*) cv. Orange Double characters such as days to flower bud initiation and 50 per cent flowering were found to be early in treatment of vermicompost + Poultry manure + *Azospirillum* + 75 per cent recommended dose of nitrogen.

Smitha *et al*. (2006) reported that FYM +*Azotobacter* +Phosphorus solubilising bacteria +100 percent nitrogen produced maximum yield of flowers, with improved quality of flowers and vase life (11.23 days) in China aster. Carnation cultivar Raggio-desole produced maximum plant height number of flowers, length of stalk, flower size earliness in flowering, highest vase life when it was grown on a culture having soil + sand + Vermicompost (1:1:1) (v/v + inorganic fertilizer + Bio fertilizer (*Azospirillum* and PSB) compared to treatments having FYM and municipal compost in the place of vermicompost (Rajesh Bhalla *et al*., 2007).

Tuberose cultivar pearl double recorded highest spike length, number of flower heads per spike and spike yield in treatment receiving RDF + panchagavya (4%) and RDF + panchagavya (4%) + manchurian mushroom tea. Similarly growth and yield attributes were found to better in the above mentioned treatment (Singh Bharti *et al*., 2007).

Kumar *et al*. (2008) reported that Peter Pears variety of gladiolus recorded highest plant height, number of leaves, vase life, florets per spike and corn weight when the plants are supplied with common base dose + panchagavya (4%) + manchurian mushroom tea as compared to treatment consisting alone panchagavya and manchurian mushroom tea at 2 and 4 per cent.

Dhiraj Kumar *et al.* (2009) revealed that combined application of *Azotobacter* and PSB with FYM and 50% recommended dose of nitrogen and phosphorus significantly improved growth, flowering behaviour and yield of cv. African Giant Double Orange.

Gangadhar Swamy (2010) observed that carnation cv. Dona recorded increased plant growth, flower quality and yield when plants are supplied with 50 per cent RDF + vermicompost + 3 per cent manchurian tea + 3 per cent panchagavya. Least number of flowers per plant and flowers per square meter was recorded in plants receiving common basal dose (8.00 and 160.00 respectively).

Sharma *et al.,* (2010) stated that carnation plants supplied with common basal dose along with biofertilizers (*Azospirillum*, PSB, VAM and *Trichoderma* @ 2g/plant) + 6% panchagavya and 6% manchurian mushroom tea showed highest plant height (71.03 cm), stem length (64.77 cm), flower size (4.99 cm) and number of flowers (6.60/plant).

In Anthurium cv. Verdun Red, growth parameters, *viz.*, leaf length (38.00 cm), leaf width (17.2 cm), petiole length (49.4 cm), petiole girth (2.11 cm), number of suckers (5) and all the economic traits *i.e.*, floral parameters *viz.*, early flowering (152.3 days) and number of spikes (9.4), spathe length (12.1 cm), spathe width (8.7 cm), spadix length (7.5 cm), stalk length (53.5 cm), girth of stalk (1.9 cm), longevity of spike on plant (21.0 days), days to loss of lustre (16 days), days to spathe blueing (18 days) and days to spadix necrosis (19 days) were maximum in Common basal dose+3% vermiwash. The plants received a common basal dose (CBD) with FYM 200 g/pot + decomposed coir compost 100 g/pot + vermicompost 25 g/pot + biofertilizers (VAM + *Azospirillum* + PSB) @2 g each/pot and *Trichoderma viridae* 20 g/pot at an interval of two months (Nagalakshmi *et al.,* 2010).

Parya *et al.,* (2010) observed that Plant height, number of leaf, suckers and number of flower stalk per plant in golden rod (*Soildago canadensis*) were maximum with reduced level of chemical fertilizer (75% of RDF) along with 3t/ha of vermicompost, which was at par with treatment receiving 75% of RDF in conjunction with 3 t/ha of FYM. It was also noted that in presence of organic manure even at lower level 1.5 t/ha along with 75% RDF showed statistically similar response to that of 100% RDF.

In African marigold cv. Pusa Narangi, application of 50% NPK + FYM + vermicompost recorded significantly higher plant height (75 cm), maximum number of branches (12.45), number of flower/plant (60), flower diameter (9.40 cm), flower weight (7.85 g) and flower yield per plant (471 g) compared to treatment T7 (100% NPK + FYM + control) (Bhat *et al*., 2010).

Verma *et al*.(2011)concluded that the use of *Azospirillum,* PSB , vermicompost equivalent 50% RD'N', 50 per cent FYM along with 50 per cent recommended nitrogen, phosphorus and potassium helped in realizing better plant growth, higher flower yield and better quality flowers of chrysanthemum (*Chrysanthemum morifolium* Ramat.) cv. Raja with higher benefit cost ratio under field condition.

2.7 Effect of integrated nutrient management on the growth, yield and quality of gerbera

Overuse of synthetic fertilisers and chemicals poses problems of environmental pollution with potential hazards to flora and fauna, also to human beings. Biofertilisers are inputs containing useful microorganisms. Biofertilisers are not alternatives for inorganic fertilisers. But they are useful in increasing yield, quality and productivity of crops when they are used in combination with organic manure and inorganic fertilisers in balanced proposition. Biofertilisers help in augmenting the productivity through effective mobilisation of major plant nutrients like Nitrogen, phosphorus and potassium including other minor nutrients needed by the crop.

A balanced application of both organic and inorganic fertilisers along with biofertilisers and biostimulants appears to be an ideal proposition to meet the nutritional requirement of the crop, as well as to produce optimum growth, yield and quality flowers under protected conditions.

Wange *et al.* (1993) observed that in micropropagated plantlets of Gerbera jamesonii cv. TerraMix inoculated with vesicular arbuscular mycorrhizal fungi established symbiosis within 4 to 8 weeks of culture in the greenhouse. Mortality of gerbera mycorrhizal plantlets was reduced at week 8 compared to the noninoculated control. Mycorrhizal substrates had long term benefits of increasing leaf and root dry weight and also mycorrhizal gerbera plants significantly faster than non-mycorrhizal plants.

Rodriguez-Navarro *et al.* (2000) reported that the macro and micronutrient content (except K and Mn) were at optimum levels in plants treated with 20 percent vermicompost with or without chemical fertiliser. In contrast, plants from treatments without vermicompost had lower content of macro and micronutrients, except K and Cu. In gerbera Narayanagowda (2003) reported maximum flower yield with more flower diameter and stalk length in the treatment combination of vermicompost 15 tonnes per hectare and 75 per cent recommended NPK.

Puttaswamy(2004) reported that vermicompost 100g/plant + phosphorus solubilising bacteria 25g/plant +Phytozeal 30ml/l and recommended dose of fertilisers (10: 15:20gNPK/m^2/month ,FYM-10t/ha) gave increased yield and longer vase life (11.4 days) in gerbera flowers grown under shade. Experiments conducted with integrated nutrient management in gerbera revealed that the plants supplied with 50% of recommended dose fertilizers (125: 120: 120 kg NPK / ha) + vermicompost (5 t/ha) + 3% panchagavya was superior in respect of all the economic floral parameters (Anonymous, 2006).

Barreto and Jagtap (2006) observed that cocopeat combined with vermicompost (1:1) produced flowers with the highest net returns (Rs.28.77) in gerbera. They also noted that bright coloured flowers (Dutch Vermillion [7]17) were produced in compost and vermicompost, whereas flowers in other treatments were comparatively pale (Capsicum red [7]15), which may be due to the higher nutrient content in these organic substrates.

Prasanna (2007) reported that in gerbera, maximum flower yield of high marketable quality can be obtained in 100 percent nitrogen, phosphorus and potassium with triple inoculation of *Azospirillum brasilense, Bacillus subtilis* and *Pseudomonas fluorescens*. The application of 70% RDF + *Azotobacter* + PSB resulted in the greatest flower stalk length (52.96 cm), flower stalk diameter (0.70 cm), flower diameter (9.20 cm) and number of flowers per plant (7.22) in *Gerbera jamesonii* (Thane *et al*., 2007).

Gerbera cv. Ruby Red produced under organic practices gave increased number of flowers (33/plant), while the conventionally grown plants yielded 18.7 flowers/plant. The shelf life of the gerbera flowers obtained with the organic treatment was 15 days, which was 4 days more than the conventional system. The mean flower diameter was 20.4% higher and the mean stalk length was 12.2 % higher than the conventionally produced flowers (Selvaraj, 2003).

Foliar spraying of panchagavya 3 per cent at 10 days interval from first month after planting comprising of 35 sprayings/year is recommended for gerbera. Soil drenching with dasagavya 3 per cent solution @ 1l/m^2 once in a month, foliar spraying of vermiwash @ 10 percent at 3,4,5,6,7 and 8 months after planting, drenching with Manchurian tea 5 percent filtrate at 30^{th}, 45^{th}, 60^{th} ,75^{th}, and 90^{th} day after planting is recommended for gerbera (Anonymous, 2008).

Nikbakht *et al*. (2008) reported that the use of humic acid along with fertilisers increased the number of harvested flowers and delayed the incidence of bent neck symptoms in gerbera.

2.8 Effect of INM on the postharvest longevity of flowers

The termination of post harvest life of cut flowers was characterized by wilting even when the flowers were constantly held in water. The flowers, which are kept in water gained weight initially but subsequently reduced weight at the end (Rogers, 1973). Reduction in vase life of marigold flowers with increase in N rates was reported by Anuradha *et al.* (1990). Biofertilizers can influence the longevity of flowers. This may be due to the increased phosphorous uptake by the plants and better development of water conducting tissues especially in Mycorrihizal plants than with nonmycorrhizal plants (Chang, 1990). Gerbera plants colonized by *Glomus mossae* produced flowers, which lasted three day longer than flowers of non mycorrhizal plants in the vase (Wen, 1991).

According to Srinivas (1994) china aster flowers harvested from plots receiving FYM and 100 per cent recommended NPK exhibited maximum vase life (8.5 days) compared to untreated control. China aster plants supplied with vermicompost (10 tonnes per hectare) produced flowers with the longest vase life (11.6 days) as noticed by Nethra (1996).

Hemavathi (1997) observed that chrysanthemum plants inoculated with VAM + 50 per cent recommended NPK reduced flowers with longest vase life compared to plants receiving recommended NPK. Kathiresan (1999) observed that the longest vase life of flowers (9.67 days) in gladiolus plants inoculated with VAM+ *Azospirillum* + 125:75:60 kg NPK ha^{-1}.

In gerbera, maximum vase life (12 days) was observed in flowers harvested from plants treated with *Azospirillum*, VAM and 50 per cent recommended nitrogen, phosphorous and recommended potassium (Seetha, 1999).

In marigold, maximum flower longevity was recorded in treatment with vermicompost (15 tonnes per hectare) and 100 per cent recommended NPK treatment over the control (Mashaldi, 2000). Gayathri *et al*. (2004) observed maximum vase life of 4 days in *Limonium* cv. Blue diamond when inoculated with *Azotobacter* +phosphorus solubilising bacteria + 75 percent NP+100 percent K+ vermicompost) which can be attributed to better development of water conducting tissues facilitated by biofertilisers.

Smitha *et al*. (2006) reported that FYM+*Azotobacter*+phosphorus solubilising bacteria +100 percent N produced maximum yield of quality flowers and found increased vase life (11.23 days) of China aster.

Waheeduzzama *et al*., (2006) reported that treatment combination of vermicompost 100 g/plant + 50 % RDF recorded better vase life in *Anthurium andreanum* cv. Meringue. Application of 50% of Recommended dose of fertilizers (RDF) (NPK 30:10:10 @ 0.2% twice a week + FYM spray @ 1:10 ratio once a week) + 3%vermiwash + 3% panchagavya in Dendrobium variety Sonia 17 was found to be superior in respect of all the vegetative parameters as well as flowering parameters including vase life (Anonymous, 2006).

Prasanna (2007) reports a longest vase life (13.62 days) in gerbera plants grown with triple inoculation of *Azospirillum brasilense, Bacillus subtilis, and Pseudomonas fluorescens* with 100 per cent NPK. Gangadhar Swamy (2010) reported significantly longer vase life (10.00 days), higher water uptake (32.16 ml), lowest physiological loss in weight (21.66%) in carnation plants receiving 50 per cent RDF + vermicompost + 3 per cent manchurian tea + 3 per cent panchagavya.

2.9Economics of integrated nutrient management in flower crops

The INM approaches not only improve the quality of the produce but also help in improving the soil fertility including the biosphere by reducing the cost of production in agriculture. Yield analysis and financial returns of gerberas grown over a period of two years in a heated greenhouse showed 60, 48 and 96 kg of N, P_2 O_5 and K_2O/1000 m^2 were efficient rates (Volpi and Farina, 1987).

Phosphocompost PC-4, which was prepared with 5.0 per cent P_2O_5 as mechanical reinforced phosphocompost + 10 per cent pyrites showed highest cost-benefit ratio of 1 : 2.64 which suggested that, utilization of phosphocompost is profitable and can be recommended in the cultivation of china aster (Srinivas, 1994).

In tuberose cv. single, Wang *et al.* (1995) reported that inoculation with *Azotobacter* or *Azospirillum* alone gave a cost benefit ratio (1:3.5) equivalent to the application of nitrogen at 150 kg/ha. Vermicompost at the rate of 5 tonnes + N, P_2O_5 and K_2O at the rate of 90:60:50 kg/ha recorded the highest benefit cost ratio of 3.10:1 (Nethra, 1996). Hemavathi (1997) observed increased cost benefit ratio when plants were inoculated with *Azospirillum* + 75 per cent recommended NPK (1:2.7) compared to NPK alone (1:1.9).

In crossandra cv. Dindigul local, the application of 100 per cent NPK (75:50:125 kg/ha) + *Azospirillum* + phosphobacteria each at 2 kg/ha gave the highest flower yield

(41.72 g/plant) with the maximum returns per rupee invested (1:3.5) as reported by Narismha Raju and Haripriya (2001).

Gayathri *et al*. (2004) observed that Limonium cv. Blue Diamond, application of 50 percent N and P +100 percent K + vermicompost +*Azotobacter*+phosphorus solubilising bacteria gave highest net return of Rs. 26,984 per 100m2 for a period of eight months with a cost benefit ratio of (1:2.11).

Shashidhara and Gopinath (2005) reported that in calendula reducing the application of recommended dose of N and P by 25per cent and substituting the same with *Azotobacter* and VAM resulted in the highest cost benefit ratio of 1.82. The application of *Azospirillum*, PSB, vermicompost and 50 per cent recommended NPK in china aster cv. Kamini has resulted in maximum net returns with a cost benefit ratio of 1:4.1 per ha as reported by Chaithra (2006).

Godse *et al*. (2006) reported that in gladiolus, application of vermicompost + *Azotobacter* + phosphorus solubilising bacteria + 80 per cent recommended dose of fertilisers resulted in highest cost benefit ratio (3.70:1) when compared to recommended dose of fertilisers alone (2.81:1).

Gerbera plants provided with 100 per cent NPK +*Azospirillum brasilense* + *Bacillus subtilis* +*Pseudomonas fluorescens* produced maximum marketable flowers with maximum benefit cost ratio of 2.34:1(Prasanna, 2007).

Gangadhar Swamy (2010) revealed that in carnation highest net returns for a period of one year was maximum (Rs.57, 905) in the treatment receiving 50 per cent RDF +vermicompost + 3 per cent manchurian tea + 3 per cent panchagavya.

In Chrysanthemum, treatment combination of *Azospirillum*, PSB, vermicompost equivalent 50 per cent recommended dose of 'N', 50 per cent recommended NPK and 50 per cent FYM has realized maximum net returns Rs.3,28504 per hectare with a benefit cost ratio of 1:6.04 (Verma *et al*., 2011).

Material and Methods

III. MATERIAL AND METHODS

Studies on the “Integrated nutrient management on the growth, flower yield and post harvest quality of Gerbera (*Gerbera jamesonii* Bolus.) cultivar Galileo Red under poly house condition” was carried out at the Floriculture unit, Department of Horticulture, University of Agricultural Sciences (UAS), Gandhi Krishi Vigyan Kendra (GKVK), Bangalore during 2010- 2012. The details of the materials used and methods followed in the study are presented below.

3.1 Geographical location and climate

The experimental station is located at 12°58′ North latitude and 77° 35′ East longitudes and at an altitude of 930 meters above mean sea level. The climate is moderate and favourable for cut flower production round the year under poly house. The data of the weather parameters recorded during the experimental period are presented in Appendix-I. The experiment was laid out in red sandy loam soil having a pH of 6.5-7.0.

3.2 Details of experimental set - up

3.2.1 Poly house- structural details

The experiment was laid out in low cost, naturally ventilated poly house (north-south oriented) of 20m length, 10 m breadth and 4m height (200m^2). A UV stabilised low density polyethylene film of 800 gauge was used as the cladding material for the arch shaped poly house. All the sides of the poly house were covered with anti- insect rambonet of 60 mesh for natural ventilation and protection against insect pests. Besides rambonet, rollable flaps were also provided outside the poly house to regulate temperature and relative humidity inside the greenhouse. Shade net (50 %) was provided inside the poly house at 3m height to reduce the light intensity and regulate temperature.

3.2.2 Experimental details

a) Design : CRD

b) No. of replications : Three

c) Number of plants : 7per m^2

d) Spacing : 45 cm x 30 cm

e) No. of beds : Eight

f) Crop : Gerbera

g) Variety : Galileo Red

3.2.3 Treatment details

The details of 12 treatments are as follows:

T_1: 100 per cent recommended dose of Nitrogen, Phosphorus and Potassium

T_2: **T_1** + Vermicompost

T_3: 75 per cent of recommended dose of Nitrogen, Phosphorus, 100 per cent Potassium+ Vermicompost + *Azospirillum brasilense* + *Bacillus megaterium* + VAM fungi (*Glomus faciculatum*)

T_4: **T_3** + *Trichoderma harzianum*

T_5: **T_3** + Jeevamrutha

T_6: **T_3** + Panchagavya

T_7: **T_3** + Panchagavya + Jeevamrutha + *Trichoderma harzianum*

T_8: 50 per cent of recommended dose of Nitrogen, Phosphorus, 100 per cent Potassium + Vermicompost + *Azospirillum brasilense* + *Bacillus megaterium* +VAM fungi (*Glomus fasciculatum*)

T_9: **T_8** + *Trichoderma harzianum*

T_{10}: **T_8** + Jeevamrutha

T_{11}: **T_8** + Panchagavya

T_{12}: **T_8** + Panchagavya + Jeevamrutha + *Trichoderma harzianum*

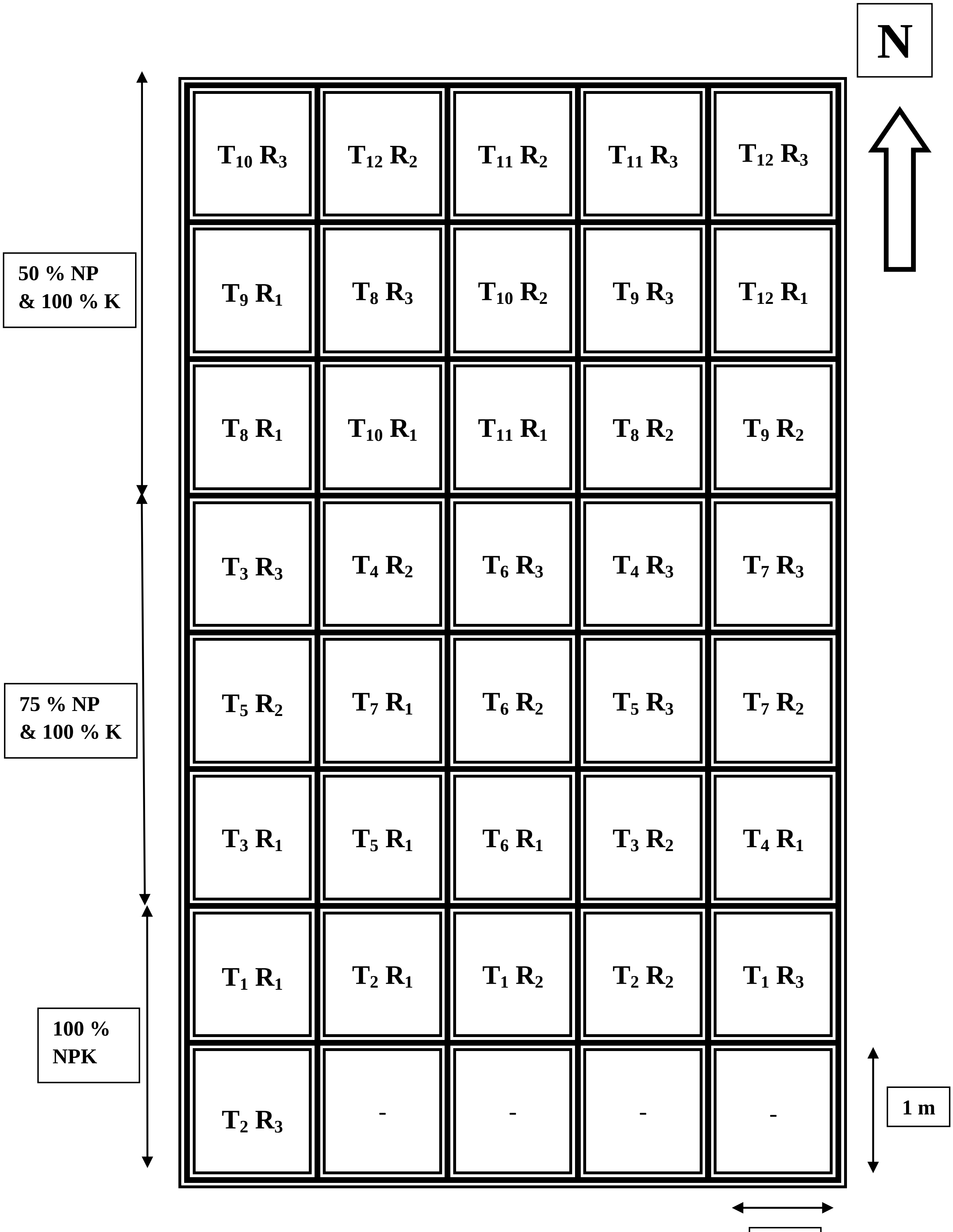


Fig.1: Experimental layout

Note:

Recommended dose of nutrients:

20:10:15g NPK/m^2/month up to flowering and 25: 12: 25g NPK/m^2/month after flowering. Fertilisers were applied at 15 days interval.

Fertilizers applied in grams per square meter at 15 days interval through fertigation

Level of application	Fertilisers	Quantity (g/m^2)
100 % NPK	WSF (19:19:19) Urea MOP	31.57 14.13 10.83
75% NP & 100% K	WSF (19:19:19) Urea MOP	23.68 10.43 13.33
50% NP & 100 % K	WSF (19:19:19) Urea MOP	15.78 7.06 15.26

WSF: Water Soluble Fertiliser

MOP: Muriate of Potash

3.2.4 Application of nutrients

I. Common basal application:

Application of FYM @ 5kg/m^2/year applied to the soil at the time of planting and foliar application of micronutrients @ 2.5ml/l at monthly intervals were taken up irrespective of treatments.

II. Vermicompost application

Vermicompost @ 2.5kg/m^2/ year was applied to the soil at the time of planting as per the treatment specifications.

III. Biofertiliser application

Azospirillum brasilense, Bacillus megaterium and *Glomus fasciculatum* (VAM fungi) each @ 20 g/m^2 as well as *Trichoderma harzianum* @ 10g/m^2 were applied at the time of planting and later once in six months through soil application as per treatment specifications. The biofertilisers were procured from the Indian Institute of Horticultural Research, Hesaraghatta, Bangalore.

IV. Biostimulants application:

Foliar application of panchagavya @ 3 per cent and soil application of jeevamrutha @ 10ml/m^2 were done once in a month as per treatment specifications. Panchagavya and Jeevamrutha were prepared as per the standard procedures. The steps for the preparation of panchagavya and jeevamrutha are given below.

3.2.5 Preparation of Panchagavya

The following materials (in fresh state) were taken as per the required quantity and uniformly mixed in a plastic drum.

Sl.No	Ingredient	Quantity
	Main items	
1.	Fresh cow dung	5 kg
2.	Cow urine	3 litres
3.	Cow milk	2 litres
4.	Cow curd	1 litre
5.	Cow ghee	100g
	Other items	
1.	Sugarcane juice	3 litres
2.	Tender coconut water	3 litres
3.	Banana fruit	12 numbers

The mixture was kept for three months in a plastic drum covered with muslin cloth under shade and thoroughly stirred daily. After three months the mixture was filtered and diluted to 3 per cent and then used at monthly interval as foliar spray as per

Plate 1: General view of poly house

Plate 2: Land preparation

the treatment specifications. The physico chemical properties of Panchagavya are given in Appendix-II (Anonymous, 2010).

3.2.6 Preparation of Jeevamrutha

Jeevamrutha was prepared by mixing the following ingredients in a plastic drum at the quantity given below.

Sl. No.	Ingredient	Quantity
1.	Fresh cow dung	5 kg
2.	Cow urine	7.5 litres
3.	Jaggery	3 kg
4.	Pulse flour	1 kg
5.	Water	100 litres

The mixture was kept for 4 days in a bucket covered with muslin cloth in the shade and stirred daily. Then the mixture was applied to the soil @ 10 ml/ m^2 at monthly intervals as per the treatment specifications.

3.3 Experimental procedure

3.3.1 Land preparation and fumigation

Planting area inside the poly house was irrigated a few days earlier to facilitate easy preparation. The land was thoroughly prepared by digging, harrowing and levelling. Weeds, stubbles *etc.*, were completely removed and soil was brought to a fine tilth. Raised beds of 1m width, 30 cm height and 20 m length were prepared with a walking space of 45 cm between the beds. Well decomposed farm yard manure, sand and coconut coir pith in 2:1:1 proportion was applied and mixed thoroughly with the soil. Beds were fumigated with two per cent formalin solution @ 5 l/m^2 and covered with polythene sheet for 4 days. Later the beds were thoroughly irrigated three times to remove the residues. Drip irrigation system with main and sub main (63mm) and laterals (16mm) with control taps for each row was laid out for the entire area. Each plot had two rows of drip laterals with an emitter of 4 litre per hour capacity spread at 30cm.

Plate 3: Gerbera cv. Galileo Red

Plate 4: Planting material

Plate 5: Ingredients used in preparation of Panchagavya and Jeevamrutha

Plate 6: Prepared products of Panchagavya and Jeevamrutha

Plate 7: General view of experimental plot at different stages of crop growth

Plate 8: General view of experimental plot after flowering

3.3.2 Selection of Gerbera cultivar for experiment

Tissue culture plants of Gerbera cv. Galileo Red which produces red colour flowers with black centre, an attractive and popular cultivar in and around Bangalore, was procured from Florance Flora to take up planting under poly house.

3.3.3 Planting

Uniformly growning rooted tissue cultured plants having 4-5 leaves were selected and planted at a spacing of 45X30cm on 21st June 2010. There were 7 plants per square meter and a total of 8 beds of 20 m length with two rows of plants in each bed were maintained. There were totally 36 plots of 3.6 m^2 size.

3.3.4 Fertiliser application

Fertiliser treatments were imposed 3-4 weeks after planting when the plants were well established. The water soluble complex fertiliser 19:19:19 and straight fertilisers *ie*., urea and MOP were used as per the treatment levels through fertigation. The entire quantity of fertilizers was applied through fertigation in split doses once in 15 days throughout the year.

3.3.5 Irrigation

The entire plot was irrigated with a water can with rose head immediately after planting. Subsequently the irrigation was provided through drip irrigation system which was operated on an average four times a week for 2 hours each time to keep the soil moisture to the field capacity.

3.3.6 Intercultivation

Hand weeding was followed as and when weeds were noticed. Light earthing up operations were carried out at monthly intervals.

3.3.7 Plant protection measures

Appropriate plant protection measures were undertaken, whenever insect pests and disease incidence were noticed. The incidence of thrips and whiteflies was controlled by spraying appropriate insecticides alternately at regular intervals and also through insect traps.

3.3.8 Harvesting

Flowers were harvested when the outer rows of ray florets were completely elongated and one or two rows of disc florets were fully developed. The flowers were harvested by sideward pull of the flower stalk at the base. The heel of the base was removed by giving a slant cut using a sharp knife and kept immediately in chlorinated water.

3.4 Observations recorded

3.4.1 Vegetative parameters

Observations on the following vegetative parameters were taken from five randomly selected and tagged plants from each replication and mean values were worked out.

3.4.1.1 Plant height (cm)

Plant height was measured from the base of the plant at ground level to the tip of the plant at 45 days interval from the date of planting and expressed in centimetres.

3.4.1.2 Plant spread (cm^2)

Spread of the plant was measured at 45 days interval from the date of planting in north south and east west directions at right angles to each other and their mean was calculated and expressed in cm^2.

3.4.1.3 Number of leaves

Total number of leaves produced per plant was counted at 45 days interval from the date of planting.

3.4.1.4 Leaf area (cm^2)

Leaf area was calculated using the formula length x breadth x standard factor from randomly selected leaves of each labelled plants from each plot and expressed in square centimeter.

The factor was computed by finding out the leaf area of 10 bulk leaves by length x breadth method and by graphical method.

$$\text{Factor} = \frac{\text{Leaf area measured by graph method}}{\text{Functional leaf area (l x b)}} = 0.80$$

3.4.1.5 Number of suckers per plant

The number of suckers produced from labelled plants was counted and the mean values were recorded.

3.4.2 Flower characters

To study the various characters related to flowering and floral parameters, five randomly selected plants in each replication were used to record observations.

3.4.2.1 Days taken for flower bud initiation

The number of days taken for the initiation of first flower bud in a plant after planting was recorded treatment wise.

3.4.2.2 Days taken for complete flower opening

The number of days taken for the complete opening of flower from the emergence of flower bud stage after planting was recorded treatment wise.

3.4.2.3 Days taken to 50 per cent flowering

The number of days required for 50 per cent of plants to produce flowers in each treatment was recorded.

3.4.2.4 Diameter of flower (cm)

The diameter of the completely opened flower was measured using normal measuring scale and expressed in centimetres.

3.4.2.5 Length of ray florets (cm)

The length of ray florets was measured using scale and expressed in centimetres.

3.4.2.6 Length of flower stalk (cm)

Stalk length of the flowers was measured from the point just below the flower head up to the point of origin of stalk and the average stalk length of flowers was worked out and expressed in centimetre.

3.4.2.7 Diameter of flower stalk (cm)

The diameter of flower stalk was measured at middle point by using vernier callipers and expressed in centimetres.

3.4.3 Yield parameters

3.4.3.1 Number of flowers produced per plant per year

Five plants were selected randomly from each replicated plot and total number of flowers produced per plant per year was recorded treatment wise by counting number of flowers harvested during one year period.

3.4.3.2 Number of flowers produced per square meter per year

Total number of flowers produced per square meter area was recorded at every harvest and total number of flowers produced during one year period was worked out.

3.4.3.3 Number of flower per 1000m^2

The number of flowers per 1000m^2 for two years was computed by converting the number of flowers per square meter into number of flowers per 1000m^2.

3.4.3.4 Percentage of marketable flowers

The flowers available with all desirable traits suitable for market were counted at every harvest and computed for total marketable yield per plant and expressed in percentage.

3.4.4 Shelf life studies

Post harvest life of cut flowers was studied by harvesting the flowers during early morning hours from each treatment. Harvested flower stalk ends were immersed immediately in a bucket containing water. In the laboratory, after cutting basal stalk of the flowers to uniform length they were placed in glass containers containing standard preservative solution of 25ppm silver nitrate + 200ppm 8-HQS + 2 per cent sucrose under room conditions.

3.4.4.1 Uptake of water (g)

The difference between the consecutive weight of bottle plus solution was taken as the water uptake in grams during given period of time.

3.4.4.2 Transpirational loss of water (g)

The difference between the consecutive weights of bottle with sucrose solution including flowers represents the water loss by transpiration, which was expressed as gram per unit time.

3.4.4.3 Shelf life (days)

The shelf life of cut flowers was expressed in terms of number of days taken from the date of harvest till the flowers become unfit for continuing in vase which was characterised by the wilting of the petals.

3.4.5 Soil analysis

Soil samples were collected from 0-30cm depth before planting and at six months interval. The samples were then pooled, labelled, oven dried and analyzed for available nitrogen, phosphorus and potassium. The data on the physical and chemical properties of soil before planting is given in Appendix –III.

3.4.5.1 Available Nitrogen (kg/ha)

The available nitrogen (kg/ha) in the soil sample was determined by alkali-potassium permanganate method (Jackson, 1973).

3.4.5.2 Available Phosphorus (kg/ha)

The available phosphorus content in the soil was extracted with the help of Bray's No 1 extract (Jackson, 1973).

3.4.5.3 Available Potassium (kg/ha)

The available potassium content in the soil was extracted by 1 N neutral ammonium acetate and determined by flame photometric method as described by Jackson (1973).

3.4.6 Microbial parameters

General microflora *viz*., bacteria, fungi and actinomycetes and beneficial microbial population in the experimental soils were estimated at the beginning of the experiment and at six months interval by serial dilution plate count technique by plating on an appropriate media like Soil Extract agar, Martin Rose Bengal Agar and Kuster's Agar for soil bacteria, fungi and actinomycetes respectively. Similarly *Azospirillum* population was estimated on Doberiener's media, *Bacillus megaterium* on Pikovaskaya's media, *Trichoderma harzianum* on *Trichoderma* specific media. The media compositions are given in Appendix-IV. The general and beneficial microbial population in the soil before planting is given in Appendix-V.

3.4.7 Leaf analysis

Leaf samples were collected separately treatment wise from the experimental plots at six months intervals. Recently and fully matured leaves were selected for chemical analysis. The leaf samples collected were put in butter paper bags, treatment wise and dried in a hot air oven at 40-50^0 C. At the end of the second or third day, the butter paper bags containing the dried leaf samples were taken out and the dried leaves were crushed in a mechanical grinder to obtain powdered leaf samples which were subjected to chemical analysis later.

3.4.7.1 Total Nitrogen (%)

The total nitrogen was determined by micro Kjeldhal method as outlined by Tandon (1993). Plant samples were digested with concentrated sulphuric acid in the presence of digestion mixture (K_2SO_4: $CuSO_4$: Selenium). The digested material was distilled and liberated ammonia was trapped in boric acid and titrated against standard acid.

3.4.7.2 Phosphorus (%)

The Phosphorus content in leaf tissue was determined by Vanadomolybdate method (Tandon, 1993).

3.4.7.3 Potash (%)

The potassium content in the leaf tissue was determined by flame photometer method as mentioned by Tandon (1993).

3.5 Cost Economics

The cost of planting materials, manures, chemical fertilisers, plant protection chemicals, biostimulants, labour charges and cost involved on all cultural practices including depreciated costs of green house structure and irrigation system were worked out based on the prevailing prices and wages during the cropping season and cost of cultivation per 1000 m^2 was computed for two years.

3.6 Statistical analysis

The data on various biometric observations, quality parameters and nutrient contents collected during the period of study were subjected to statistical analysis as per the procedure outlined by Sunder raj *et al.* (1972). The results are presented and discussed at 5 per cent probability level.

Experimental Results

IV. EXPERIMENTAL RESULTS

The details of the results of research work entitled "Integrated nutrient management on the growth, flower yield and postharvest quality of Gerbera (*Gerbera jamesonii* Bolus.) Cv. Galileo Red under poly house condition" conducted at the Department of Horticulture, University of Agricultural Sciences, Gandhi Krishi Vigyana Kendra, Bangalore during the period from 2010-12 under naturally ventilated low cost poly house are presented in this chapter.

4.1 Vegetative parameters

4.1.1 Plant height at 45, 90, 135, 180, 225 and 270 days after planting

The data pertaining to plant height as influenced by INM treatments at 45, 90, 135, 180, 225 and 270 days after planting is presented in Table 1.

The plant height differed significantly at different stages of growth *i.e.*, 45, 90,135,180, 225 and 270 days after planting. At 45 and 90 days after planting, it was found that plants treated with 75 per cent of recommended dose of nitrogen, phosphorus, 100 per cent potassium+ vermicompost + *Azospirillum brasilense* + *Bacillus megaterium* + *Glomus fasciculatum* (VAM fungi) + Panchagavya + Jeevamrutha + *Trichoderma harzianum* (T_7) recorded the maximum plant height (27.80cm and 32.87cm respectively) followed by plants treated with 75 per cent of recommended dose of nitrogen, phosphorus, 100 per cent potassium+ vermicompost + *Azospirillum brasilense* + *Bacillus megaterium* + *Glomus fasciculatum* (VAM fungi) + Jeevamrutha (T_5) (26.36cm, 30.03cm respectively) and the lowest plant height was in plants which received 50 per cent of recommended dose of nitrogen, phosphorus, 100 per cent potassium+ vermicompost + *Azospirillum brasilense* + *Bacillus megaterium* + *Glomus fasciculatum* (T_8) (23.76cm and 28.10cm respectively). At 135 days after planting plants treated with 75 per cent of recommended dose of nitrogen, phosphorus, 100 per cent potassium+ vermicompost + *Azospirillum brasilense* + *Bacillus megaterium* + *Glomus fasciculatum* (VAM fungi) + panchagavya + jeevamrutha+ *Trichoderma harzianum* (T_7) recorded maximum plant height (36.33cm) followed by 75 per cent of recommended dose of nitrogen, phosphorus,

Table 1: Influence of integrated nutrient management treatments on plant height of gerbera cv. Galileo Red under poly house condition

Treatment	Plant height (cm)					
	Days after planting					
	45	90	135	180	225	270
T_1: 100% recommended dose of NPK	25.26	28.86	30.80	34.90	37.60	40.13
T_2: T_1 + Vermicompost	25.70	29.13	31.36	35.20	38.06	40.73
T_3: 75% recommended dose of N,P +100% K+ vermicompost + *Azospirillum brasilense* +*Bacillus megaterium* + *Glomus fasciculatum*	25.50	29.33	33.53	37.13	40.80	44.20
T_4: T_3+ *Trichoderma harzianum*	25.63	29.50	34.03	37.31	41.80	44.66
T_5: T_3 + Jeevamrutha	26.36	30.03	34.53	38.56	43.66	45.43
T_6: T_3 + Panchagavya	26.23	29.93	34.23	38.06	42.86	45.06
T_7: T_3+ Panchagavya+ Jeevamrutha+ *Trichoderma harzianum*	27.80	32.87	36.33	40.03	44.86	47.53
T_8: 50% recommended dose of N,P +100% K+ vermicompost + *Azospirillum brasilense* +*Bacillus megaterium* + *Glomus fasciculatum*	23.76	28.10	31.46	35.03	38.50	41.03
T_9: T_8+ *Trichoderma harzianum*	23.86	28.13	31.76	35.26	38.80	41.60
T_{10}: T_8 + Jeevamrutha	24.40	28.63	32.16	36.13	39.86	42.53
T_{11}: T_8 + Panchagavya	24.13	28.53	32.00	35.86	39.33	42.36
T_{12}: T_8 + Panchagavya+ Jeevamrutha+ *Trichoderma harzianum*	24.86	29.03	33.66	37.26	41.46	44.46
F-test	*	*	*	*	*	*
S.Em±	0.28	0.28	0.30	0.42	0.56	0.38
CD at 5%	0.84	0.84	0.90	1.26	1.68	1.14

* Significant at 5%

Note:

Recommended Dose of Fertilisers: 20: 10: 15 g NPK/ m^2/month up to flowering
25: 12: 25g NPK/m^2/month after flowering
Vermicompost: 2.5kg/m^2/year
Azospirillum brasilense, *Bacillus megaterium* and *Glomus fasciculatum* (VAM fungi) each @ 20 g/m^2,
Trichoderma harzianum @ 10g/m^2 once in six months
Foliar application of Panchagavya 3% and Jeevamrutha@ 10ml/m^2 applied to the soil once in a month.

100 per cent potassium+ vermicompost + *Azospirillum brasilense* + *Bacillus megaterium* + *Glomus fasciculatum* (VAM fungi) + jeevamrutha (T_5) (34.53cm) whereas least plant height (30.80cm) was observed in plants which received the treatment receiving recommended dose of fertilizers (T_1).

At 180, 225 and 270 days after planting the maximum plant height (40.03cm, 44.86cm and 47.53cm respectively) was recorded in plants supplied with 75 per cent of recommended dose of nitrogen, phosphorus, 100 per cent potassium+ vermicompost + *Azospirillum brasilense* + *Bacillus megaterium* + *Glomus fasciculatum* (VAM fungi) + panchagavya + jeevamrutha+ *Trichoderma harzianum* (T_7), followed by treatment with 75 per cent of recommended dose of nitrogen, phosphorus, 100 per cent potassium+ vermicompost + *Azospirillum brasilense* + *Bacillus megaterium* + *Glomus fasciculatum* (VAM fungi) + jeevamrutha (T_5) (38.56cm, 43.66cm and 45.43 cm, respectively at 180, 225 and 270 days after planting) which was on par with T_6 (75 per cent of recommended dose of nitrogen, phosphorus, 100 per cent potassium+ vermicompost + *Azospirillum brasilense* + *Bacillus megaterium* + *Glomus fasciculatum* (VAM fungi) + panchagavya) (38.06cm, 42.86cm and 45.06 cm, at 180, 225 and 270 days after planting respectively). The minimum plant height (34.90cm, 37.60cm and 40.13 cm at 180, 225 and 270 days after planting respectively) was observed in plants supplied with recommended dose of fertilizers alone (T_1).

4.1.2 Plant Spread

The plant spread of gerbera at different stages of plant growth (45, 90, 135, 180, 225 and 270 days after planting) as influenced by integrated nutrient management treatments is presented in Table 2.

Not much difference in spread of plants was noticed up to 45 days after planting. However at 45, 90, 135, 180, 225 and 270 days after planting, the spread of the plants differed significantly. Maximum spread was recorded in T_7 plants (75 per cent recommended dose of nitrogen, phosphorus +100 per cent potassium+ vermicompost + *Azospirillum brasilense* + *Bacillus megaterium* + *Glomus fasciculatum* (VAM fungi) + panchagavya + jeevamrutha+ *Trichoderma harzianum)* at 45 ,90, 135, 180, 225 and 270

Table 2: Influence of integrated nutrient management treatments on plant spread in gerbera cv. Galileo Red under poly house condition

Treatment	Plant spread(cm^2)					
	Days after planting					
	45	90	135	180	225	270
T_1: 100% recommended dose of NPK	22.06	27.83	31.46	36.13	39.60	42.30
T_2: T_1 + Vermicompost	22.53	28.46	31.86	36.70	40.00	42.53
T_3: 75% recommended dose of N,P +100% K+ vermicompost + *Azospirillum brasilense* +*Bacillus megaterium* + *Glomus fasciculatum*	22.86	28.40	33.80	38.53	42.20	44.86
T_4: T_3+ *Trichoderma harzianum*	23.01	28.83	34.86	39.06	42.73	45.16
T_5: T_3 + Jeevamrutha	23.53	29.36	35.46	40.03	43.73	46.46
T_6: T_3 + Panchagavya	23.13	29.06	35.26	39.30	43.13	45.86
T_7: T_3+ Panchagavya+ Jeevamrutha+ *Trichoderma harzianum*	24.56	30.56	36.53	42.26	46.73	49.66
T_8: 50% recommended dose of N,P +100% K+ vermicompost+ *Azospirillum brasilense*+*Bacillus megaterium* + *Glomus fasciculatum*	21.00	26.03	31.93	36.93	39.90	42.63
T_9 : T_8+ *Trichoderma harzianum*	21.06	26.16	32.00	37.13	40.13	42.86
T_{10} : T_8 + Jeevamrutha	21.46	26.86	32.66	37.86	41.13	43.86
T_{11} : T_8 + Panchagavya	21.26	26.56	32.56	37.73	40.93	43.06
T_{12} : T_8 + Panchagavya+ Jeevamrutha+ *Trichoderma harzianum*	21.80	27.23	33.86	38.86	42.46	45.13
F-test	*	*	*	*	*	*
S.Em±	0.20	0.25	0.29	0.40	0.25	0.38
CD at 5%	0.59	0.75	0.87	1.20	0.75	1.14

* Significant at 5%

Note:

Recommended Dose of Fertilisers: 20:10:15g NPK/m^2 up to flowering

25: 12: 25g NPK/m^2/month after flowering

Vermicompost: 2.5kg/m^2/year

Azospirillum brasilense, *Bacillus megaterium* and *Glomus fasciculatum* (VAM fungi) each @ 20 g/m^2

Trichoderma harzianum @ 10g/m^2 once in six months

Foliar application of Panchagavya 3% and Jeevamrutha@ 10ml/m^2 applied to the soil once in a month.

days after planting (24.56cm, 30.56cm, 36.53cm, 42.26cm, 46.73cm, 49.66cm, respectively). The next best plant spread was registered in plants treated with 75 per cent of recommended dose of nitrogen, phosphorus, 100 per cent potassium+ vermicompost + *Azospirillum brasilense* + *Bacillus megaterium* + *Glomus fasciculatum* (VAM fungi) + jeevamrutha (T_5) (23.53cm, 29.36cm, 35.46cm, 40.03cm, 43.73cm, 46.46cm at 45, 90, 135, 180, 225 and 270 days after planting respectively). At 45 and 90 days after planting the lowest plant spread (21.00cm and 26.03cm respectively) was recorded in plants supplemented with 50 per cent recommended dose of nitrogen, phosphorus +100 per cent potassium+ vermicompost + *Azospirillum brasilense* + *Bacillus megaterium* + *Glomus fasciculatum* (VAM fungi) (T_8), whereas minimum plant spread were recorded in plants with 100 per cent recommended dose of nitrogen, phosphorus and potassium (T_1) at 135, 180 and 225 days after planting (31.46cm, 36.13cm, 39.60cm, 42.30cm respectively).

4.1.3 Number of leaves produced at different stages of plant growth

The number of leaves produced in gerbera as influenced by different INM treatments is presented in Table 3. Significantly differing number of leaves was produced per plant in different treatments at 45, 90, 135, 180, 225 and 270 days after planting. The maximum number of leaves was observed in treatment plants (T_7**)** which received 75 per cent recommended dose of nitrogen, phosphorus +100 per cent potassium+ vermicompost + *Azospirillum brasilense* + *Bacillus megaterium* + *Glomus fasciculatum* (VAM fungi) + pachagavya + jeevamrutha+ *Trichoderma harzianum* (8.76, 12.16, 15.83, 19.66, 24.63 and 28.8 at 45, 90, 135, 180, 225 and 270 days after planting respectively) followed by T_5 (75 per cent of recommended dose of nitrogen, phosphorus, 100 per cent potassium+ vermicompost + *Azospirillum brasilense* + *Bacillus megaterium* + *Glomus fasciculatum* (VAM fungi) **+** jeevamrutha (8.26, 11.66, 15.13, 17.93, 23.93, 26.53, respectively at 45, 90, 135, 180, 225, 270 days after planting). At 45 and 90 days after planting, the lowest number of leaves (7.24, 9.76 and 7.28, 9.66) were observed in $T_8$and T_9 receiving 50 per cent recommended dose of nitrogen, phosphorus +100 per cent potassium+ vermicompost + *Azospirillum brasilense* + *Bacillus megaterium* + *Glomus fasciculatum* (VAM fungi) and 50 per cent recommended dose of nitrogen, phosphorus +100 per cent potassium+ vermicompost + *Azospirillum brasilense* + *Bacillus*

Table 3: Influence of integrated nutrient management treatments on number of leaves in gerbera cv. Galileo Red under poly house condition

Treatment	Number of leaves/plant					
	Days after planting					
	45	**90**	**135**	**180**	**225**	**270**
T_1: 100% recommended dose of NPK	7.51	10.20	14.06	15.30	20.23	23.20
T_2: T_1 + Vermicompost	7.64	10.76	14.33	15.76	20.60	23.60
T_3: 75% recommended dose of N,P +100% K+ vermicompost + *Azospirillum brasilense*+*Bacillus megaterium* + *Glomus fasciculatum*	7.69	11.03	14.53	16.90	22.36	25.26
T_4: T_3+ *Trichoderma harzianum*	7.96	11.17	14.83	17.10	23.16	25.73
T_5: T_3 + Jeevamrutha	8.26	11.66	15.13	17.93	23.93	26.53
T_6: T_3 + Panchagavya	8.16	11.57	15.03	17.66	23.50	26.03
T_7: T_3+ Panchagavya+ Jeevamrutha+ *Trichoderma harzianum*	8.76	12.16	15.83	19.66	24.63	28.80
T_8: 50% recommended dose of N,P +100% K+ vermicompost + *Azospirillum brasilense* +*Bacillus megaterium* + *Glomus fasciculatum*	7.24	9.76	12.13	15.80	21.46	23.83
T_9: T_8+ *Trichoderma harzianum*	7.28	9.66	12.70	15.83	21.86	23.86
T_{10}: T_8 + Jeevamrutha	7.40	9.93	13.46	16.13	22.03	24.40
T_{11}: T_8 + Panchagavya	7.33	9.83	13.13	16.06	21.90	24.10
T_{12}: T_8 + Panchagavya+ Jeevamrutha+ *Trichoderma harzianum*	7.46	10.16	13.93	16.90	22.90	25.66
F-test	*	*	*	*	*	*
S.Em±	0.152	0.226	0.222	0.296	0.317	0.362
CD at 5%	0.442	0.659	0.650	0.866	0.926	1.05

* Significant at 5%

Note:

Recommended Dose of Fertilisers: 20: 10: 15 g NPK/ m^2/month up to flowering;
25: 12: 25g NPK/m^2/month after flowering

Vermicompost: 2.5kg/m^2/year

Azospirillum brasilense, *Bacillus megaterium* and *Glomus fasciculatum* (VAM fungi)each @ 20 g/m^2, *Trichoderma harzianum* @ 10g/m^2 once in six months

Foliar application of Panchagavya 3% and Jeevamrutha@ 10ml/m^2 applied to the soil once in a month.

megaterium + *Glomus fasciculatum* (VAM fungi) + *Trichoderma harzianum* respectively.

At 135, 180, 225 and 270 days after planting the lowest number of leaves (14.06, 15.30, 20.23 and 23.20, respectively) were recorded in plants supplied only with recommended dose of fertilisers (T_1).

4.1.4 Leaf area (cm^2)

Leaf area at different stages of plant growth (45, 90, 135, 180, 225 and 270 days after planting) in various INM treatments is presented in Table 4. At 45 and 90 days after planting, the maximum leaf area of 69.93cm^2 and 95.13cm^2 was observed in treatment supplied with 75 per cent recommended dose of nitrogen, phosphorus +100 per cent potassium+ vermicompost + *Azospirillum brasilense* +*Bacillus megaterium* + *Glomus fasciculatum* (VAM fungi) + pachagavya + jeevamrutha + *Trichoderma harzianum* (T_7) which was on par with the treatment receiving 75 per cent recommended dose of nitrogen, phosphorus +100 per cent potassium+ vermicompost + *Azospirillum brasilense* +*Bacillus megaterium* + *Glomus fasciculatum* (VAM fungi) + jeevamrutha (T_5) (69.23cm^2 and 92.23cm^2 respectively). Whereas, the lowest leaf area (67.16cm^2 and 84.16 cm^2) was recorded in treatment receiving 50 per cent recommended dose of nitrogen, phosphorus +100 per cent potassium+ vermicompost + *Azospirillum brasilense* + *Bacillus megaterium* + *Glomus fasciculatum* (VAM fungi) (T_8). (Table4).

At 135, 180, 225 and 270 days after planting, maximum leaf area (121.60cm^2, 136.10 cm^2, 148.13 cm^2 and 158.4 cm^2, respectively) was observed in treatment receiving 75 per cent recommended dose of nitrogen, phosphorus +100 per cent potassium+ vermicompost + *Azospirillum brasilense* +*Bacillus megaterium* + *Glomus fasciculatum* (VAM fungi) + pachagavya + jeevamrutha + *Trichoderma harzianum* (T_7) . The next best leaf area (117.23cm^2, 131.53 cm^2, 146.06cm^2, and 155.13 cm^2, respectively) was in T_5 plants (75 per cent recommended dose of nitrogen, phosphorus +100 per cent potassium+ vermicompost + *Azospirillum brasilense* + *Bacillus megaterium* + *Glomus fasciculatum* (VAM fungi) + jeevamrutha) followed by T_6 (75 per cent of recommended dose of nitrogen, phosphorus, 100 per cent potassium+ vermicompost + *Azospirillum brasilense*

Table 4: Influence of integrated nutrient management treatments on leaf area in gerbera cv. Galileo Red under poly house condition

Treatment	Leaf area (cm^2)					
	Days after planting					
	45	90	135	180	225	270
T_1: 100% recommended dose of NPK	68.10	87.03	106.30	122.83	139.06	144.13
T_2: T_1 + Vermicompost	68.30	87.83	108.36	123.56	140.00	144.66
T_3: 75% recommended dose of N,P + 100% K + vermicompost+ *Azospirillum brasilense* + *Bacillus megaterium* + *Glomus fasciculatum*	68.50	89.83	114.06	128.46	144.26	151.80
T_4: T_3+ *Trichoderma harzianum*	68.93	90.83	115.13	129.23	144.83	153.50
T_5: T_3 + Jeevamrutha	69.23	92.33	117.23	131.53	146.06	155.13
T_6: T_3 + Panchagavya	69.10	91.33	116.76	130.86	145.80	154.26
T_7: T_3+ Panchagavya+ Jeevamrutha+ *Trichoderma harzianum*	69.93	95.13	121.60	136.10	148.13	158.40
T_8: 50% recommended dose of N,P +100% K + vermicompost + *Azospirillum brasilense* + *Bacillus megaterium* + *Glomus fasciculatum*	67.16	84.16	110.46	125.63	141.33	148.53
T_9: T_8+ *Trichoderma harzianum*	67.33	84.66	111.43	126.33	141.43	148.73
T_{10}: T_8 + Jeevamrutha	67.66	85.83	112.40	127.06	142.13	150.86
T_{11}: T_8 + Panchagavya	67.50	85.13	112.06	126.66	141.80	150.20
T_{12}: T_8 + Panchagavya+ Jeevamrutha+ *Trichoderma harzianum*	67.80	86.80	114.66	129.00	144.53	152.46
F-test	*	*	*	*	*	*
S.Em±	0.40	0.44	0.5	0.42	0.45	0.35
CD at 5%	1.20	1.32	1.50	1.26	1.35	1.05

* Significant at 5%

Note:

Recommended Dose of Fertilisers: 20: 10: 15 g NPK/ m^2/month up to flowering;
25: 12: 25g NPK/m^2/month after flowering
Vermicompost: 2.5kg/m^2/year
Azospirillum brasilense, *Bacillus megaterium* and *Glomus fasciculatum* (VAM fungi) each @ 20 g/m^2, *Trichoderma harzianum* @ 10g/m^2 once in six months
Foliar application of Panchagavya 3% and Jeevamrutha @ 10ml/m^2 applied to the soil once in a month.

+ *Bacillus megaterium* + *Glomus fasciculatum* (VAM fungi) + panchagavya) (116.76cm^2, 130.86 cm^2, 145.80cm^2 and 154.26cm^2, respectively) and the minimum leaf area was noticed in T_1 plants with 100 per cent recommended dose of nitrogen, phosphorus and potassium (106.30cm^2, 122.83 cm^2, 139.06cm^2 and 144.13 cm^2, respectively).

4.1.5 Number of suckers produced per plant

The data on number of suckers produced per plant at the end of two years of study is presented in Table 5. The maximum number (6.06) of suckers per plant was recorded in treatment T_7 plants receiving 75 per cent recommended dose of nitrogen, phosphorus +100 per cent potassium+ vermicompost + *Azospirillum brasilense* + *Bacillus megaterium* + *Glomus fasciculatum* (VAM fungi) + pachagavya + jeevamrutha+ *Trichoderma harzianum.* This was followed by T_5 and T_6 (5.60 and 5.46 suckers respectively). Minimum numbers (4.26) of suckers were recorded in plants supplied with recommended dose of fertilisers alone (T_1)

4.2 Flower characters

4.2.1 Number of days taken for flower bud initiation

The data on the number of days taken for flower bud initiation from the date of planting is presented in Table 6. Significant differences were noticed among the treatments. The least number of days was taken for flower bud initiation in the treatment T_7 plants with 75 per cent recommended dose of nitrogen, phosphorus +100 per cent potassium+ vermicompost + *Azospirillum brasilense* + *Bacillus megaterium* + *Glomus fasciculatum* (VAM fungi) + panchagavya + jeevamrutha + *Trichoderma harzianum* (24.27 days after planting). This was followed by T_5 (75 per cent recommended dose of nitrogen, phosphorus +100 per cent potassium+ vermicompost + *Azospirillum brasilense* + *Bacillus megaterium* + *Glomus fasciculatum* (VAM fungi) + jeevamrutha) (25.47 days) and T_6 (75 per cent recommended dose of nitrogen, phosphorus +100 per cent potassium+ vermicompost + *Azospirillum brasilense* + *Bacillus megaterium* + *Glomus fasciculatum* (VAM fungi) + panchagavya) (25.80 days). The maximum number of days

Table 5: Influence of integrated nutrient management treatments on the number of suckers (at end of two years) per plant in gerbera cv. Galileo Red under poly house condition

Treatment	No. of suckers/plant
T_1: 100% recommended dose of NPK	4.26
T_2: T_1 + Vermicompost	4.33
T_3: 75% recommended dose of N,P +100% K+ vermicompost + *Azospirillum brasilense*+*Bacillus megaterium* + *Glomus fasciculatum*	4.93
T_4 : T_3+ *Trichoderma harzianum*	5.06
T_5 : T_3 + Jeevamrutha	5.60
T_6 : T_3 + Panchagavya	5.46
T_7 : T_3+ Panchagavya+ Jeevamrutha+ *Trichoderma harzianum*	6.06
T_8 : 50% recommended dose of N,P +100% K+ vermicompost + *Azospirillum brasilense* +*Bacillus megaterium* + *Glomus fasciculatum*	4.40
T_9 : T_8+ *Trichoderma harzianum*	4.53
T_{10} : T_8 + Jeevamrutha	4.86
T_{11} : T_8 + Panchagavya	4.73
T_{12} : T_8 + Panchagavya+ Jeevamrutha+ *Trichoderma harzianum*	5.00
F-test	*
S. Em±	0.18
CD at 5%	0.54

* Significant at 5%
Note: Recommended Dose of Fertilisers: 20:10:15g NPK/m^2 up to flowering
25: 12: 25g NPK/m^2/month after flowering
Vermicompost: 2.5kg/m^2/year
Azospirillum brasilense, *Bacillus megaterium* and *Glomus fasciculatum* (VAM fungi) each @ 20 gram/m^2,
Trichoderma harzianum @ 10gram/m^2 once of six months
Foliar application of Panchagavya 3% and Jeevamrutha@ 10ml/m^2 applied to the soil once in a month

Plate 9: View of T_7 plot

Plate 10: View of T_7 and T_1 plot

taken for initiation of flower bud (28.87 days after planting) was recorded in treatment (T_1) receiving 100 per cent recommended dose of fertilisers.

4.2.2 Number of days taken for complete opening of flowers

The number of days taken for complete opening of flowers from bud emergence stage, differed significantly among treatments (Table 6). Plants provided with 75 per cent recommended dose of nitrogen, phosphorus +100 per cent potassium+ vermicompost + *Azospirillum brasilense* + *Bacillus megaterium* + *Glomus fasciculatum* (VAM fungi) + panchagavya + jeevamrutha+ *Trichoderma harzianum* (T_7) took minimum number of days (12.13 days) for complete opening of flowers. This was followed by T_5 T_6 and T_4 plants which were statistically on par with each other (12.53, 12.87 and 12.93 days, respectively). The maximum number (15.60 days) of days taken for complete opening of flowers was recorded in plants which were supplied only with 100 per cent recommended dose of nitrogen, phosphorus and potassium (T_1).

4.2.3 Days taken for 50 per cent flowering

The data on days taken for 50 per cent plants under each treatment for flowering is presented in Table 6 and was found to be significantly varied among treatments. The least number of days taken for 50 per cent of plants to start flowering (83.67 days after planting) was recorded in T_7 plants (75 per cent recommended dose of nitrogen, phosphorus +100 per cent potassium+ vermicompost + *Azospirillum brasilense* + *Bacillus megaterium* + *Glomus fasciculatum* (VAM fungi) + panchagavya + jeevamrutha + *Trichoderma harzianum*) which was followed by the treatment receiving 75 per cent recommended dose of nitrogen, phosphorus +100 per cent potassium+ vermicompost + *Azospirillum brasilense* + *Bacillus megaterium* + *Glomus fasciculatum* (VAM fungi) + jeevamrutha (T_5) (85.40 days after planting). Treatment receiving 100 per cent recommended dose of nitrogen, phosphorus and potassium and 100 per cent recommended dose of nitrogen, phosphorus and potassium + vermicompost (T_1 and T_2) took maximum number of days for 50 per cent plants to start flowering (89.93 and 89.33 days, respectively).

Table 6: Influence of integrated nutrient management treatments on the flowering of gerbera cv. Galileo Red under poly house condition

Treatment	Days to flower bud initiation (after planting)	Days to complete opening of flowers	Days to 50 per cent flowering (after planting)
T_1: 100% recommended dose of NPK	28.87	15.60	89.93
T_2: T_1 + Vermicompost	28.1	14.67	89.33
T_3: 75% recommended dose of N,P +100% K+ vermicompost+*Azospirillum brasilense* +*Bacillus megaterium* + *Glomus fasciculatum*	26.87	13.10	86.80
T_4: T_3+ *Trichoderma harzianumss*	26.13	12.93	86.00
T_5: T_3 + Jeevamrutha	25.47	12.53	85.40
T_6: T_3 + Panchagavya	25.80	12.87	85.73
T_7: T_3+ Panchagavya+ Jeevamrutha+ *Trichoderma*	24.27	12.13	83.67
T_8: 50% recommended dose of N,P +100% K+ vermicompost+ *Azospirillum brasilense* +*Bacillus megaterium* + *Glomus fasciculatum*	27.80	14.53	88.13
T_9: T_8+ *Trichoderma harzianum*	27.73	14.47	87.87
T_{10}: T_8 + Jeevamrutha	27.13	13.87	87.13
T_{11}: T_8 + Panchagavya	27.53	14.00	87.53
T_{12}: T_8 + Panchagavya+ Jeevamrutha+ *Trichoderma harzianum*	26.47	13.40	86.53
F-test	*	*	*
SEm±	0.23	0.19	0.21
CD(0.05)	0.69	0.57	0.63

* Significant at 5%   NS- Non-Significant

Note:

Recommended Dose of Fertilisers: 20:10:15g NPK/m^2 up to flowering
25: 12: 25g NPK/m^2/month after flowering
Vermicompost: 2.5kg/m^2/year
Azospirillum brasilense, *Bacillus megaterium* and *Glomus fasciculatum* (VAM fungi) each @ 20 g/m^2
Trichoderma harzianum @ 10g/m^2 once in six months
Foliar application of Panchagavya 3% and Jeevamrutha@ 10ml/m^2 applied to the soil once in a month.

4.2.4 Diameter of flowers at initial and later stages of plant growth

The diameter of flowers recorded at initial (six months after planting) and later stages (twelve months after planting) of plant growth are given in Table 7. Among the different treatments T_7 provided with 75 per cent recommended dose of nitrogen, phosphorus +100 per cent potassium+ vermicompost + *Azospirillum brasilense* + *Bacillus megaterium* + *Glomus fasciculatum* (VAM fungi) + panchagavya + jeevamrutha+ *Trichoderma harzianum* showed maximum flower diameter at both stages of plant growth (9.06cm and 9.66cm at initial and later stages, respectively), which was followed by T_5 (75 per cent recommended dose of nitrogen, phosphorus +100 per cent potassium+ vermicompost + *Azospirillum brasilense* + *Bacillus megaterium* + *Glomus fasciculatum* (VAM fungi) + jeevamrutha) (8.80cm and 9.51cm at initial and later stages, respectively). The lowest diameter of flowers was recorded in plants receiving 100 per cent recommended dose of nitrogen, phosphorus and potassium (T_1) (7.60cm and 9.18cm at initial and later stages respectively).

4.2.5 Length of the ray florets at initial and later stages of plant growth

The data on length of ray florets influenced by different INM treatments is presented in Table 7. The observation on ray florets length showed significant difference among treatments at both the initial and later stages of plant growth. The maximum length (3.82cm and 3.93cm at initial and later stages, respectively) was observed in plants receiving 75 per cent recommended dose of nitrogen, phosphorus +100 per cent potassium+ vermicompost + *Azospirillum brasilense* + *Bacillus megaterium* + *Glomus fasciculatum* (VAM fungi) + panchagavya + jeevamrutha+ *Trichoderma harzianum* (T_7) which was followed by T_5 which received 75 per cent recommended dose of nitrogen, phosphorus +100 per cent potassium+ vermicompost + *Azospirillum brasilense* + *Bacillus megaterium* + *Glomus fasciculatum* (VAM fungi) + jeevamrutha (3.71cm and 3.86cm, respectively) and T_6 receiving 75 per cent recommended dose of nitrogen, phosphorus +100 per cent potassium+ vermicompost + *Azospirillum brasilense* + *Bacillus megaterium* + *Glomus fasciculatum* (VAM fungi)+ panchagavya (3.70cm and 3.80cm at initial and later stages of plant growth, respectively). The minimum ray floret length (3.26cm and 3.43cm at initial and later stages, respectively) was noticed in

Table 7: Influence of integrated nutrient management treatments on flower diameter and length of ray floret of gerbera cv. Galileo red under poly house condition

Treatment	Flower diameter (cm)		Length of ray floret (cm)	
	6 MAP	12 MAP	6 MAP	12 MAP
T_1: 100% recommended dose of NPK	7.60	9.18	3.26	3.43
T_2: T_1 + Vermicompost	7.86	9.26	3.32	3.50
T_3: 75% recommended dose of N,P +100% K+ vermicompost + *Azospirillum brasilense* +*Bacillus megaterium* + *Glomus fasciculatum*	8.40	9.41	3.65	3.70
T_4: T_3+ *Trichoderma harzianum*	8.53	9.46	3.68	3.73
T_5: T_3 + Jeevamrutha	8.80	9.51	3.71	3.86
T_6: T_3 + Panchagavya	8.63	9.46	3.70	3.80
T_7: T_3+ Panchagavya+ Jeevamrutha+ *Trichoderma harzianum*	9.06	9.66	3.82	3.93
T_8: 50% recommended dose of N,P +100% K+ vermicompost + *Azospirillum brasilense* +*Bacillus megaterium* + *Glomus fasciculatum*	8.03	9.29	3.37	3.53
T_9: T_8+ *Trichoderma harzianum*	8.13	9.31	3.38	3.56
T_{10}: T_8 + Jeevamrutha	8.33	9.36	3.47	3.63
T_{11}: T_8 + Panchagavya	8.20	9.34	3.41	3.60
T_{12}: T_8 + Panchagavya+ Jeevamrutha+ *Trichoderma harzianum*	8.50	9.44	3.66	3.73
F-test	*	*	*	*
SEm±	0.12	0.08	0.03	0.05
CD at 5%	0.36	0.24	0.09	0.15

* Significant at 5%   MAP: Months After Planting
Recommended Dose of Fertilisers: 20:10:15g NPK/m^2 up to flowering
25: 12: 25g NPK/m^2/month after flowering
Vermicompost: 2.5kg/m^2/year
Azospirillum brasilense, *Bacillus megaterium* and *Glomus fasciculatum* (VAM fungi) each @ 20 g/m^2,
Trichoderma harzianum @ 10g/m^2 once in six months
Foliar application of Panchagavya 3% and Jeevamrutha@ 10ml/m^2 applied to the soil once in a month.

treatment receiving 100 per cent recommended dose of nitrogen, phosphorus and potassium (T_1).

4.2.6 Flower stalk length at initial and later stages of plant growth

The observations on flower stalk length at initial and later stages of plant growth, showed significant differences among the treatments (Table 8). The longest stalk length (54.60cm and 59.53cm at initial and later stages, respectively) was observed in plants receiving 75 per cent recommended dose of nitrogen, phosphorus + 100 per cent potassium+ vermicompost + *Azospirillum brasilense* + *Bacillus megaterium* + *Glomus fasciculatum* (VAM fungi) + panchagavya + jeevamrutha + *Trichoderma harzianum* (T_7), followed by treatment receiving 75 per cent recommended dose of nitrogen, phosphorus +100 per cent potassium+ vermicompost + *Azospirillum brasilense* + *Bacillus megaterium* + *Glomus fasciculatum* (VAM fungi) + jeevamrutha (T_5) (53.70cm and 58.53cm at initial and later stages of plant growth, respectively). Stalk length was lowest (50.66cm and 54.73cm at initial and later stages, respectively) in plants receiving 100 per cent recommended dose of nitrogen, phosphorus and potassium alone (T_1).

4.2.7 Flower stalk diameter at initial and later stages of plant growth

The data on flower stalk diameter at initial and later stages of plant growth influenced by INM treatments is presented in Table 8. The observation on stalk diameter showed significant difference among treatments at both the initial stages (six months after planting) and later stages (twelve months after planting). The maximum stalk diameter (0.548cm and 0.568cm at initial and later stages, respectively) was observed in treatment receiving 75 per cent recommended dose of nitrogen, phosphorus +100 per cent potassium+ vermicompost + *Azospirillum brasilense* + *Bacillus megaterium* + *Glomus fasciculatum* (VAM fungi) + panchagavya + jeevamrutha+ *Trichoderma harzianum* (T_7). The next best flower stalk diameter was recorded in T_5 plants which received 75 per cent recommended dose of nitrogen, phosphorus +100 per cent potassium+ vermicompost + *Azospirillum brasilense* + *Bacillus megaterium* + *Glomus fasciculatum* (VAM fungi) + jeevamrutha (0.545cm and 0.564cm at initial and later stages of plant growth, respectively) which was on par with T_6 receiving 75 per cent recommended dose of

Table 8: Influence of integrated nutrient management treatments on flower stalk length and flower stalk diameter of gerbera cv. Galileo Red under poly house condition

Treatment	Flower stalk length (cm)		Diameter of flower stalk (cm)	
	6 MAP	12 MAP	6 MAP	12 MAP
T_1: 100% recommended dose of NPK	50.66	54.73	0.523	0.541
T_2: T_1 + Vermicompost	50.93	55.30	0.528	0.547
T_3: 75% recommended dose of N,P +100% K+ vermicompost +*Azospirillum brasilense* +*Bacillus megaterium* + *Glomus fasciculatum*	52.46	57.16	0.541	0.559
T_4: T_3+ *Trichoderma harzianum*	52.73	57.43	0.543	0.562
T_5: T_3 + Jeevamrutha	53.70	58.53	0.545	0.564
T_6: T_3 + Panchagavya	53.46	58.16	0.544	0.563
T_7: T_3+ Panchagavya+ Jeevamrutha+ *Trichoderma harzianum*	54.6	59.53	0.548	0.568
T_8: 50% recommended dose of N,P +100% K+ vermicompost + *Azospirillum brasilense* +*Bacillus megaterium* + *Glomus fasciculatum*	51.06	55.46	0.532	0.551
T_9: T_8+ *Trichoderma harzianum*	51.30	55.60	0.532	0.551
T_{10}: T_8 + Jeevamrutha	51.53	56.26	0.537	0.554
T_{11}: T_8 + Panchagavya	51.46	56.23	0.535	0.553
T_{12}: T_8 + Panchagavya+ Jeevamrutha+ *Trichoderma harzianum*	52.60	57.20	0.542	0.56
F-test	*	*	*	*
S.Em±	0.27	0.63	0.003	0.004
CD at 5%	0.81	1.89	0.091	0.012

* Significant at 5%   MAP: Months After Planting

Note: Recommended Dose of Fertilisers: 20:10: 15 g NPK/ m^2/month up to flowering;
25: 12: 25g NPK/m^2/month after flowering
Vermicompost: 2.5kg/m^2/year
Azospirillum brasilense, *Bacillus megaterium* and *Glomus fasciculatum* (VAM fungi) each @ 20 g/m^2,
Trichoderma harzianum @ 10g/m^2 once in six months
Foliar application of Panchagavya 3% and Jeevamrutha @ 10ml/m^2 applied to the soil once in a month.

Plate 11: Flower diameter observed in different treatments

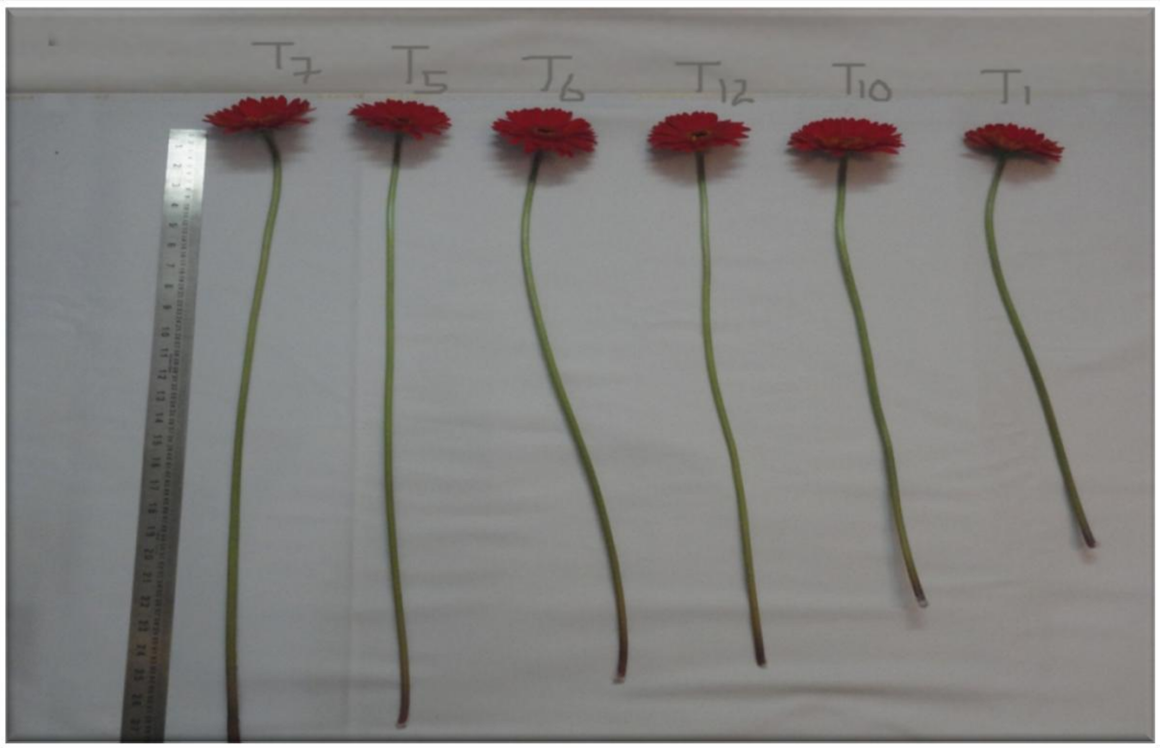


Plate 12: Flower stalk length observed in different treatments

nitrogen, phosphorus +100 per cent potassium+ vermicompost + *Azospirillum brasilense* + *Bacillus megaterium* + *Glomus fasciculatum* (VAM fungi) + panchagavya (0.544cm and 0.563cm at initial and later stages of plant growth, respectively). The minimum stalk diameter (0.523cm and 0.541cm at initial and later stages, respectively) was noticed in treatment receiving 100 per cent recommended dose of nitrogen, phosphorus and potassium (T_1).

4.3 Yield parameters

The data pertaining to yield attributes viz., number of flowers produced per plant per year, number of flowers produced per meter square per year, number of flowers produced per 1000m^2 for two years and per cent of marketable flowers harvested for a period of two years as influenced by integrated nutrient management treatments are presented in Table 9 and Figure 1.

4.3.1 Number of flowers produced per plant per year

The number of flowers produced per plant per year significantly differed among the INM treatments and the data are presented in Table 9. Plants provided with 75 per cent recommended dose of nitrogen, phosphorus +100 per cent potassium+ vermicompost + *Azospirillum brasilense* + *Bacillus megaterium* + *Glomus fasciculatum* (VAM fungi) + panchagavya + jeevamrutha+ *Trichoderma harzianum* (T_7) produced maximum number of flowers per plant (31.47 and 38.80 flowers per plant for first and second year, respectively) during the first and second year which was followed by treatment with 75 per cent recommended dose of nitrogen, phosphorus +100 per cent potassium+ vermicompost + *Azospirillum brasilense* + *Bacillus megaterium* + *Glomus fasciculatum* (VAM fungi) + jeevamrutha (T_5) (30.27 and 37.13 flowers during the first and second year, respectively) and the minimum (26.33 and 31.53 during first and second year, respectively) was recorded in T_1 plants which were provided only with 100% recommended dose of fertilisers.

4.3.2 Number of flowers produced per meter square per year

The number of flowers produced per meter square per year (Table 9) differed significantly among the INM treatments, with the maximum number of flowers per metre square (220.26 and 271.66 for the first and second year, respectively) in treatment receiving 75 per cent recommended dose of nitrogen, phosphorus +100 per cent potassium+ vermicompost + *Azospirillum brasilense* + *Bacillus megaterium* + *Glomus fasciculatum* (VAM fungi) + panchagavya + jeevamrutha+ *Trichoderma harzianum* (T_7) followed by T_5 (75 per cent recommended dose of nitrogen, phosphorus +100 per cent potassium+ vermicompost + *Azospirillum brasilense* + *Bacillus megaterium* + *Glomus fasciculatum* (VAM fungi) + jeevamrutha) (211.73 and 259.93 flowers/m^2 for the first and second year, respectively). Minimum number of flowers per metre square (184.13and 220.73 flowers for the first and second year, respectively) for the first and second year of crop growth was recorded in treatment receiving 100 per cent recommended dose of nitrogen, phosphorus and potassium (T_1).

4.3.3 Number of flowers per 1000 m^2 for two years

The estimated flower yield per 1000m^2 for two years was calculated and presented in the Figure 2.

Significant differences in flower yield per hectare were observed among different treatments. The yield per 1000m^2 ranged from 404860 to 491920. Maximum flower yield per 1000m^2 per two years was recorded in the treatment T_7 (75 per cent recommended dose of nitrogen, phosphorus +100 per cent potassium+ vermicompost + *Azospirillum brasilense* + *Bacillus megaterium* + *Glomus fasciculatum* (VAM fungi) + panchagavya + jeevamrutha+ *Trichoderma harzianum)* which was significantly higher than all other treatments. The next best was treatment T_5 (75 per cent recommended dose of nitrogen, phosphorus +100 per cent potassium+ vermicompost + *Azospirillum brasilense* + *Bacillus megaterium* + *Glomus fasciculatum* (VAM fungi) + jeevamrutha) (471660) and T_6 (468060) (75 per cent recommended dose of nitrogen, phosphorus +100 per cent potassium+ vermicompost + *Azospirillum brasilense* + *Bacillus megaterium* + *Glomus*

Table 9: Influence of integrated nutrient management treatments on flower yield of gerbera cv. Galileo Red

Treatment	Flower yield			
	Per plant/year		Per m^2/year	
	1 year	II year	I year	II year
T_1: 100% recommended dose of NPK	26.33	31.53	184.13	220.73
T_2: T_1 + Vermicompost	26.86	33.13	188.06	231.93
T_3: 75% recommended dose of N,P +100% K+ vermicompost +*Azospirillum brasilense* +*Bacillus megaterium* + *G. fasciculatum*	29.26	35.73	204.53	250.13
T_4: T_3+ *Trichoderma harzianum*	29.80	36.20	208.60	253.46
T_5: T_3 + Jeevamrutha	30.26	37.13	211.73	259.93
T_6: T_3 + Panchagavya	30.06	36.80	210.33	257.73
T_7: T_3+ Panchagavya+ Jeevamrutha+ *Trichoderma harzianum*	31.46	38.86	220.26	271.66
T_8: 50% recommended dose of N,P +100% K+ vermicompost + *Azospirillum brasilense* +*Bacillus megaterium* + *G. fasciculatum*	27.06	33.20	189.20	232.06
T_9: T_8+ *Trichoderma harzianum*	27.26	33.46	190.86	234.06
T_{10}: T_8 + Jeevamrutha	27.33	33.86	191.60	237.06
T_{11}: T_8 0+ Panchagavya	27.33	33.73	191.06	236.13
T_{12}: T_8 + Panchagavya+ Jeevamrutha+ *Trichoderma harzianum*	28.26	34.60	197.20	242.20
F-test	*	*	*	*
S. Em±	0.43	0.39	1.13	1.88
CD at 5%	1.29	1.17	3.39	5.64

* Significant at 5%   **Note**: Recommended Dose of Fertilisers: 20:10:15g NPK/m^2 up to flowering
25: 12: 25g NPK/m^2/month after flowering Vermicompost: 2.5kg/m^2/year
Azospirillum brasilense, Bacillus megaterium and *Glomus fasciculatum* (VAM fungi) each @ 20 gram/m^2,
Trichoderma harzianum @ 10gram/m^2 once in six month.
Foliar application of Panchagavya 3% and Jeevamrutha@ 10ml/m^2 applied to the soil once in a month.

Legend

T_1: 100 per cent recommended dose of Nitrogen, Phosphorus and Potassium

T_2: **T_1** + Vermicompost

T_3: 75 per cent of recommended dose of Nitrogen, Phosphorus, 100 per cent Potassium+ Vermicompost + *Azospirillum brasilense* + *Bacillus megaterium* + VAM fungi (*Glomus faciculatum*)

T_4: **T_3** + *Trichoderma harzianum*

T_5: **T_3** + Jeevamrutha

T_6: **T_3** + Panchagavya

T_7: **T_3** + Panchagavya + Jeevamrutha + *Trichoderma harzianum*

T_8: 50 per cent of recommended dose of Nitrogen, Phosphorus, 100 per cent Potassium + Vermicompost + *Azospirillum brasilense* + *Bacillus megaterium* +VAM fungi (*Glomus fasciculatum*)

T_9: **T_8** + *Trichoderma harzianum*

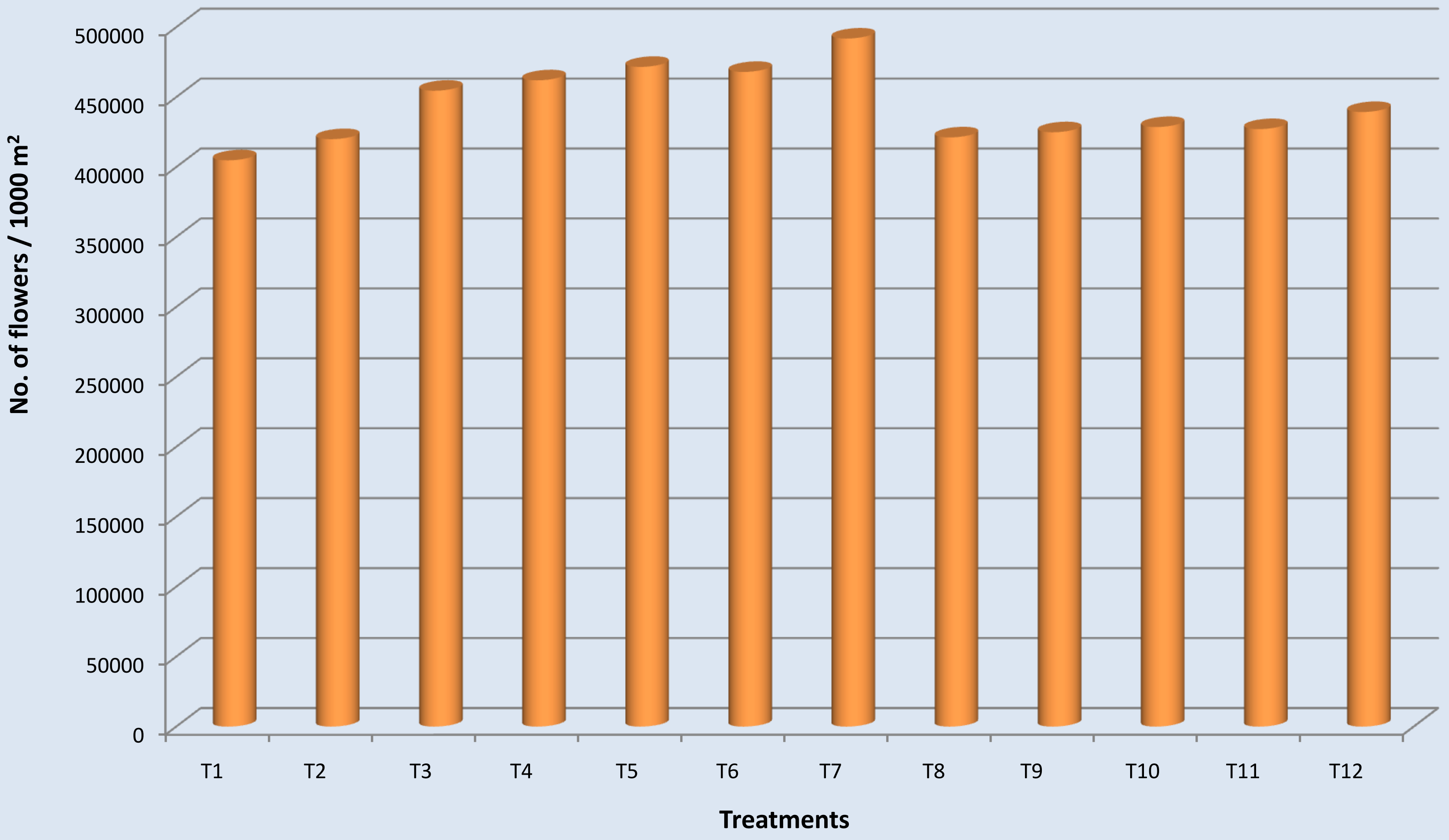
T_{10}: **T_8** + Jeevamrutha

T_{11}: **T_8** + Panchagavya

T_{12}: **T_8** + Panchagavya + Jeevamrutha + *Trichoderma harzianum*

Note :
Recommended Dose of Fertilisers: 20:10:15g NPK/m^2 up to flowering
25: 12: 25g NPK/m^2/month after flowering
Vermicompost: 2.5kg/m^2/year
Azospirillum brasilense, Bacillus megaterium and *Glomus fasciculatum* (VAM fungi) each @ 20 g/m^2
Trichoderma harzianum @ 10g/m^2 once in six months
Foliar application of Panchagavya 3% and Jeevamrutha@ 10ml/m^2 applied to the soil once in a month.

Fig. 2: Influence of integrated nutrient management treatments on the number of flowers per 1000m^2 for two years in gerbera cv. Galileo Red under poly house condition



fasciculatum (VAM fungi)) whereas, minimum (404860) flower yield per 1000m^2 for two years was noticed in treatment T_1 (100 % recommended dose of fertilizers).

4.3.2 Percentage marketable flowers

The data on percentage marketable flowers as influenced by different INM treatments (Table 9 and Figure 3), showed significant differences with respect to the percentage of marketable flowers. Highest per cent of marketable flowers (92.33%) was observed in treatment receiving 75 per cent recommended dose of nitrogen, phosphorus +100 per cent potassium+ vermicompost + *Azospirillum brasilense* + *Bacillus megaterium* + *Glomus fasciculatum* (VAM fungi) + panchagavya + jeevamrutha+ *Trichoderma harzianum* (T_7), followed by treatment receiving 75 per cent recommended dose of nitrogen, phosphorus +100 per cent potassium+ vermicompost + *Azospirillum brasilense* + *Bacillus megaterium* + *Glomus fasciculatum* (VAM fungi) + jeevamrutha (T_5) (90.00%) . The lowest percentage of marketable flowers (86.66%) was observed in treatment with 100 per cent recommended dose of nitrogen, phosphorus and potassium (T_1).

4.4 Shelf life studies

4.4.1 Uptake of water

The uptake of water varied significantly due to the influence of different INM treatments and the data are presented in Table 10.

Largest amount of cumulative uptake of water by the gerbera cut flowers was recorded in T_7 (75 per cent recommended dose of nitrogen, phosphorus +100 per cent potassium+ vermicompost + *Azospirillum brasilense* + *Bacillus megaterium* + *Glomus fasciculatum* (VAM fungi) + panchagavya + jeevamrutha+ *Trichoderma harzianum)* (93.66g) which was followed by treatment with 75 per cent recommended dose of nitrogen, phosphorus +100 per cent potassium+ vermicompost + *Azospirillum brasilense* + *Bacillus megaterium* + *Glomus fasciculatum* (VAM fungi) (T_5) (91.13g) whereas, treatment T_1 (100 per cent recommended dose of nitrogen, phosphorus and potassium) showed the lowest water uptake (86.26g).

Legend

T_1: 100 per cent recommended dose of Nitrogen, Phosphorus and Potassium

T_2: **T_1** + Vermicompost

T_3: 75 per cent of recommended dose of Nitrogen, Phosphorus, 100 per cent Potassium+ Vermicompost + *Azospirillum brasilense* + *Bacillus megaterium* + VAM fungi (*Glomus faciculatum*)

T_4: **T_3** + *Trichoderma harzianum*

T_5: **T_3** + Jeevamrutha

T_6: **T_3** + Panchagavya

T_7: **T_3** + Panchagavya + Jeevamrutha + *Trichoderma harzianum*

T_8: 50 per cent of recommended dose of Nitrogen, Phosphorus, 100 per cent Potassium + Vermicompost + *Azospirillum brasilense* + *Bacillus megaterium* +VAM fungi (*Glomus fasciculatum*)

T_9: **T_8** + *Trichoderma harzianum*

T_{10}: **T_8** + Jeevamrutha

T_{11}: **T_8** + Panchagavya

T_{12}: **T_8** + Panchagavya + Jeevamrutha + *Trichoderma harzianum*

Note :
Recommended Dose of Fertilisers: 20:10:15g NPK/m^2 up to flowering
25: 12: 25g NPK/m^2/month after flowering
Vermicompost: 2.5kg/m^2/year
Azospirillum brasilense, Bacillus megaterium and *Glomus fasciculatum* (VAM fungi) each @ 20 g/m^2
Trichoderma harzianum @ 10g/m^2 once in six months
Foliar application of Panchagavya 3% and Jeevamrutha@ 10ml/m^2 applied to the soil once in a month.

Fig. 3: Influence of integrated nutrient management on the percentage of marketable flowers of gebera cv. Galileo Red

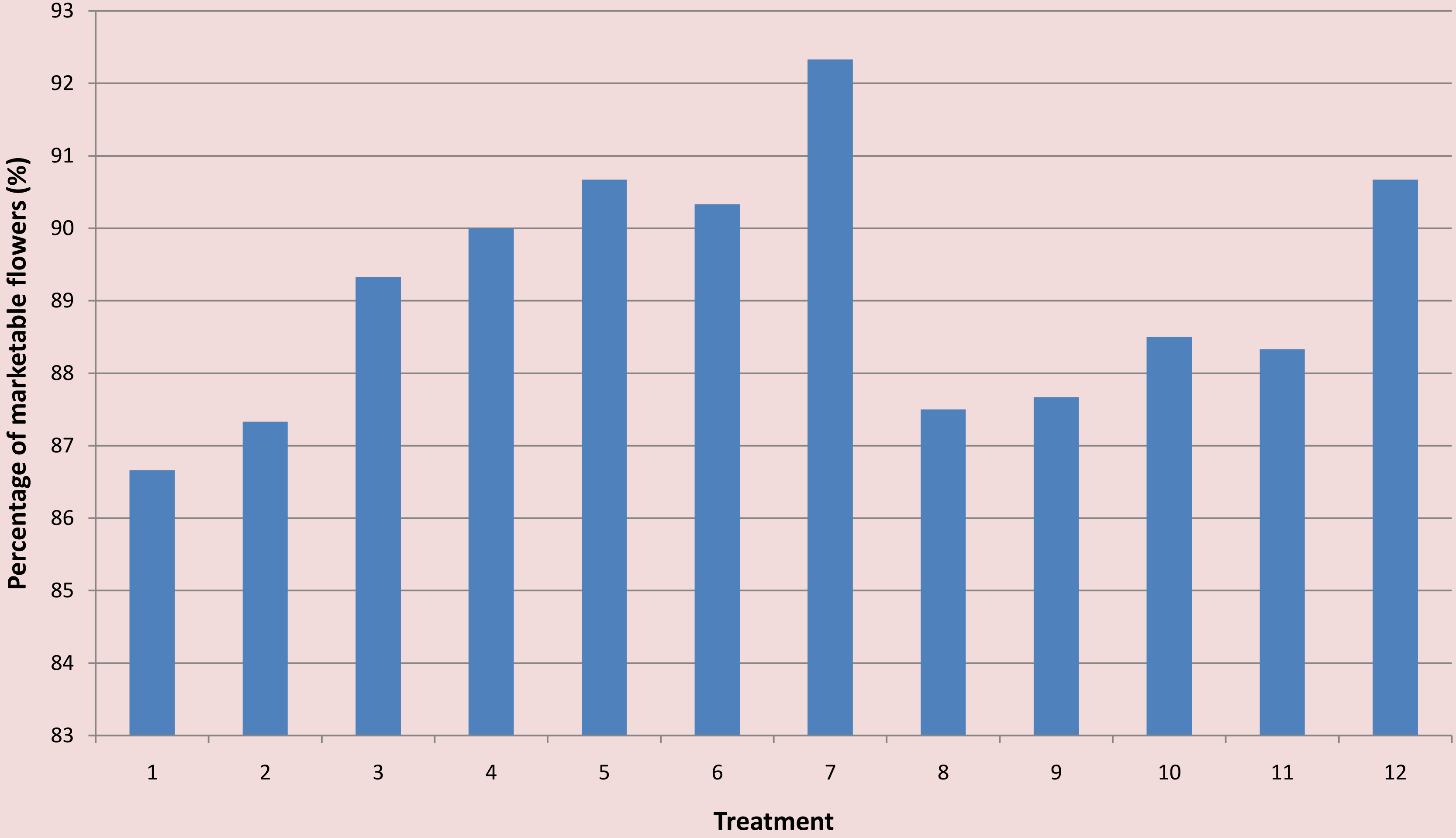


Table 10: Influence of integrated nutrient management treatments on water uptake, water loss and shelf life in gerbera cv. Galileo Red

Treatment	Cumulative water uptake (g)	Cumulative water loss (g)	Shelf life (days)
T_1: 100% recommended dose of NPK	86.26	89.46	12.67
T_2: T_1 + Vermicompost	86.86	88.86	13.00
T_3: 75% recommended dose of N,P +100% K+ vermicompost+ *Azospirillum brasilense*+*Bacillus megaterium* + *Glomus fasciculatum*	89.80	90.60	14.00
T_4: T_3+ *Trichoderma harzianum*	90.13	91.40	14.33
T_5: T_3 + Jeevamrutha	91.13	92.06	15.00
T_6: T_3 + Panchagavya	90.60	91.53	14.67
T_7: T_3+ Panchagavya+ Jeevamrutha+ *Trichoderma harzianum*	93.66	94.86	15.33
T_8: 50% recommended dose of N,P +100% K+ vermicompost + *Azospirillum brasilense*+*Bacillus megaterium* + *Glomus fasciculatum*	87.66	89.13	13.16
T_9: T_8+ *Trichoderma harzianum*	87.86	89.06	13.20
T_{10}: T_8 + Jeevamrutha	88.40	89.40	13.67
T_{11}: T_8 + Panchagavya	88.06	89.20	13.33
T_{12}: T_8 + Panchagavya+ Jeevamrutha+ *Trichoderma harzianum*	89.93	90.86	14.20
F-test	*	*	*
S. Em±	0.20	0.18	0.25
CD at 5%	0.61	0.54	0.75

* Significant at 5%

Note:

Recommended Dose of Fertilisers: 20:10:15g NPK/m^2 up to flowering

25: 12: 25g NPK/m^2/month after flowering

Vermicompost: 2.5kg/m^2/year

Azospirillum brasilense, *Bacillus megaterium* and *Glomus fasciculatum* (VAM fungi) each @ 20 gram/m^2,

Trichoderma harzianum @ 10gram/m^2 once in six months

Foliar application of Panchagavya 3% and Jeevamrutha@ 10ml/m^2 applied to the soil once in a month.

Plate 13: General view of Vase life studies

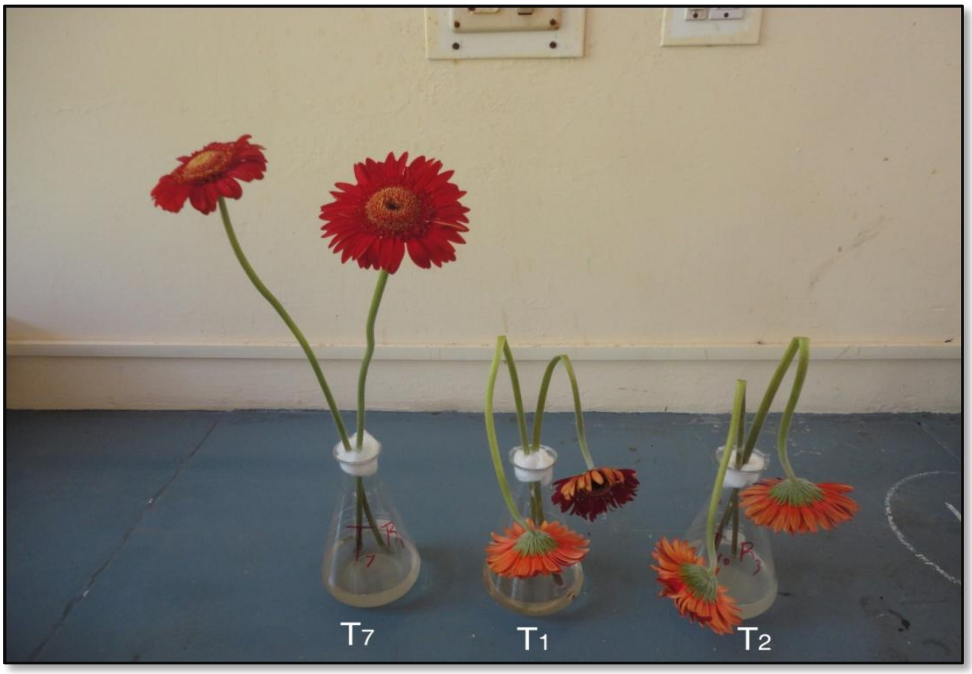


Plate 14: Vase life of T_7 flowers after 14 days compared to T_1 and T_2

4.4.2 Water loss

The cumulative loss of water differed significantly among the INM treatments and the data is presented in Table 10. The maximum water loss was noticed in treatment with 75 per cent recommended dose of nitrogen, phosphorus +100 per cent potassium + vermicompost + *Azospirillum brasilense* + *Bacillus megaterium* + *Glomus fasciculatum* (VAM fungi) + panchagavya + jeevamrutha + *Trichoderma harzianum* (T_7) (94.86g), followed by treatment T_5 (92.06g) (75 per cent recommended dose of nitrogen, phosphorus +100 per cent potassium+ vermicompost + *Azospirillum brasilense* + *Bacillus megaterium* + *Glomus fasciculatum* (VAM fungi) + jeevamrutha), while the minimum water loss was recorded in T_2 (88.66g) .

4.4.3 Shelf life

The data (Table 10) on shelf life of cut flowers has showed significant difference among treatments. The maximum shelf life of 15.33 days was recorded in flowers obtained from treatment receiving 75 per cent recommended dose of nitrogen, phosphorus +100 per cent potassium+ vermicompost + *Azospirillum brasilense* + *Bacillus megaterium* + *Glomus fasciculatum* (VAM fungi) + panchagavya + jeevamrutha+ *Trichoderma harzianum* (T_7), followed by treatment T_5 (75 per cent recommended dose of nitrogen, phosphorus +100 per cent potassium+ vermicompost + *Azospirillum brasilense* + *Bacillus megaterium* + *Glomus fasciculatum* (VAM fungi) + jeevamrutha) (15.00 days), while the minimum shelf life was recorded in the flowers of treatment T_1 in which the plants were provided only with recommended dose of NPK (12.67days).

4.5 Soil analysis

4.5.1 Available Nitrogen

The available nitrogen content in soil differed significantly among the treatments at 6 and 12 months after planting (Table 11). The highest nitrogen (277.86kgha^{-1}and 298.53kg ha^{-1}at six and twelve months after planting, respectively) was recorded in the soils of treatment T_7 (75 per cent recommended dose of nitrogen, phosphorus +100 per cent potassium+ vermicompost + *Azospirillum brasilense* + *Bacillus megaterium* + *Glomus fasciculatum* (VAM fungi) + panchagavya + jeevamrutha + *Trichoderma harzianum)* that significantly differed with soils of treatment T_1 supplemented only with recommended dose of nitrogen, phosphorus and potassium at six and twelve months after planting (253.46 kg ha^{-1} and 258.13 kg ha^{-1}, respectively).

4.5.2 Available Phosphorus

The soil samples collected from experimental plot with treatment T_7 (75 per cent recommended dose of nitrogen, phosphorus +100 per cent potassium+ vermicompost + *Azospirillum brasilense* + *Bacillus megaterium* + *Glomus fasciculatum* (VAM fungi) + panchagvya + jeevamrutha+ *Trichoderma harzianum*) (32.46 kg ha^{-1}) showed significantly the highest available phosphorus followed by T_5 (75 per cent recommended dose of nitrogen, phosphorus +100 per cent potassium+ vermicompost + *Azospirillum brasilense* + *Bacillus megaterium* + *Glomus fasciculatum* (VAM fungi) + jeevamrutha) and T_6 (75 per cent recommended dose of nitrogen, phosphorus +100 per cent potassium+ vermicompost + *Azospirillum brasilense* + *Bacillus megaterium* + *Glomus fasciculatum* (VAM fungi) + panchagavya) (30.46 kg ha^{-1} and 30.03 kg ha^{-1}, respectively) at 6 months after planting. The lowest available phosphorus (23.23 kg ha^{-1} and 27.06 kg ha^{-1} at six and twelve months after planting, respectively) was recorded in soils treated only with 100 percent recommended dose of nitrogen, phosphorus and potassium (T_1). A similar trend was noted at 12 months after planting where the highest available phosphorus was noticed in T_7 (75 per cent recommended dose of nitrogen, phosphorus +100 per cent potassium+ vermicompost + *Azospirillum brasilense* + *Bacillus megaterium* + *Glomus fasciculatum* (VAM fungi) + panchagvya + jeevamrutha+ *Trichoderma harzianum*) (36.56kg ha^{-1}) followed by T_5 (34.63 kg ha^{-1}) (75 per cent recommended dose of nitrogen, phosphorus +100 per cent potassium+ vermicompost + *Azospirillum brasilense* + *Bacillus megaterium* + *Glomus fasciculatum* (VAM fungi) +jeevamrutha) (Table 11) .

Table 11: Influence of integrated nutrient management treatments on the available nitrogen, phosphorus and potassium content in soil at six and twelve months after planting

Treatment	Nitrogen (kg ha^{-1})		Phosphorus (kg ha^{-1})		Potassium (kg ha^{-1})	
	6 MAP	12 MAP	6 MAP	12 MAP	6 MAP	12 MAP
T_1: 100% recommended dose of NPK	253.46	258.13	23.23	27.06	297.20	305.46
T_2: T_1 + Vermicompost	254.40	260.16	24.43	27.46	295.13	303.26
T_3: 75% recommended dose of N,P + 100% K+ vermicompost+ *Azospirillum brasilense*+*Bacillus megaterium* + *G. fasciculatum*	267.16	287.00	28.96	33.10	285.46	286.06
T_4: T_3+ *Trichoderma harzianum*	268.16	287.53	29.76	33.76	278.40	284.13
T_5: T_3 + Jeevamrutha	272.46	291.80	30.46	34.63	272.53	276.20
T_6: T_3 + Panchagavya	270.23	288.73	30.03	34.23	277.46	280.46
T_7: T_3+ Panchagavya+ Jeevamrutha+ *Trichoderma harzianum*	277.86	298.53	32.46	36.56	268.66	272.33
T_8: 50% recommended dose of N,P + 100% K+ vermicompost+ *Azospirillum brasilense*+*Bacillus megaterium* + *G. fasciculatum*	259.03	283.16	26.26	30.66	291.80	298.86
T_9 : T_8+ *Trichoderma harzianum*	260.16	283.43	26.53	31.16	290.46	297.40
T_{10} : T_8 + Jeevamrutha	262.53	285.06	27.56	32.16	287.66	293.26
T_{11} : T_8 + Panchagavya	260.86	284.16	27.16	31.80	288.80	296.20
T_{12}: T_8 + Panchagavya+ Jeevamrutha + *Trichoderma harzianum*	267.86	287.23	29.33	33.16	282.20	287.13
F-test	*	*	*	*	*	*
S. Em±	0.33	0.34	0.32	0.28	0.44	0.74
CD at 5%	0.99	1.02	0.96	0.84	1.32	2.22

* Significant at 5% MAP- Months after planting

Note: Recommended Dose of Fertilisers: 20:10:15g NPK/m^2 up to flowering
25: 12: 25g NPK/m^2/month after flowering.
Vermicompost: 2.5kg/m^2/year
Azospirillum brasilense, *Bacillus megaterium* and *Glomus fasciculatum* (VAM fungi) each @ 20 gram/m^2,
Trichoderma harzianum @ 10gram/m^2 once in six months
Foliar application of Panchagavya 3% and Jeevamrutha@ 10ml/m^2 applied to the soil once in a month.

4.5.3 Available Potassium

The highest available potassium was recorded in T_1 followed by T_2 at six months after planting (297.20 kg ha^{-1} and 295.13 kg ha^{-1}, respectively). The lowest (268.66 kg ha^{-1}) available potassium was recorded in T_7 (75 per cent recommended dose of nitrogen, phosphorus +100 per cent potassium+ vermicompost + *Azospirillum brasilense* + *Bacillus megaterium* + *Glomus fasciculatum* (VAM fungi) + panchagavya + jeevamrutha + *Trichoderma harzianum*). A similar trend was noted at 12 months after planting where the highest available phosphorus was noticed in T_1 and T_2 (305.46 kg ha^{-1} and 303.26 kg ha^{-1}, respectively) and the least available phosphorus was in T_7 (272.33 kg ha^{-1}) (Table 11).

4.6 Microbial count

4.6.1 General microflora

The data pertaining to microbial populations' *viz.*, bacteria, fungi and actinomycetes in soil at six months interval as influenced by integrated nutrient management are presented in Table 12. Treatments differed significantly with respect to bacteria, fungi and actinomycetes population.

The highest bacterial population was found in the rhizosphere soils of treatment T_7 which was, 75 per cent recommended dose of nitrogen, phosphorus +100 per cent potassium+ vermicompost +*Azospirillum brasilense* +*Bacillus megaterium* + *Glomus fasciculatum* (VAM fungi) + panchagavya + jeevamrutha+ *Trichoderma harzianum* (58.33 x 10 ^{6}cfu g^{-1}soil and 94.67 x 10 ^{6}cfu g^{-1}soil respectively at six and twelve months after planting, respectively) followed by T_5 (55.67 x 10 ^{6}cfu g^{-1} soil and 91.33 x 10 ^{6}cfu g^{-1} soil, respectively) 75 per cent recommended dose of nitrogen, phosphorus +100 per cent potassium+ vermicompost +*Azospirillum brasilense* + *Bacillus megaterium* + *Glomus fasciculatum* (VAM fungi) + jeevamrutha at six and twelve months after planting. The lowest bacterial population was recorded in rhizosphere soils of uninoculated plot T_1 treatment only with 100 per cent recommended dose of nitrogen, phosphorus and potassium (34.33 x 10 ^{6}cfu g^{-1} soil and 36.33 x 10 ^{6}cfu g^{-1}soil, respectively).

Table 12: Influence of integrated nutrient management treatments on soil general microbial population at six and twelve months after planting in gerbera cv. Galileo Red

Treatment	Bacteria (No. 10^6 X Cfug^{-1} soil)		Fungi (No. 10^3 X Cfug-^{1} soil)		Actinomycetes (No. 10^4 X Cfug^{-1} soil)	
	6 MAP	**12 MAP**	**6 MAP**	**12 MAP**	**6 MAP**	**12MAP**
T_1: 100% recommended dose of NPK	34.33	36.33	13.00	14.33	9.00	11.00
T_2: T_1 + Vermicompost	37.33	51.33	14.67	16.33	9.93	12.33
T_3: 75% recommended dose of N,P + 100% K + vermicompost+ *Azospirillum brasilense* +*Bacillus megaterium* + *Glomus fasciculatum*	47.00	77.67	18.67	24.00	13.33	15.67
T_4: T_3 + *Trichoderma harzianum*	51.67	82.00	21.67	26.33	14.00	16.67
T_5: T_3 + Jeevamrutha	55.67	91.33	19.67	24.67	15.00	18.33
T_6: T_3 + Panchagavya	54.67	86.67	18.67	24.33	14.67	17.67
T_7: T_3 + Panchagavya+ Jeevamrutha+ *Trichoderma harzianum*	58.33	94.67	22.67	28.33	15.67	18.67
T_8: 50% recommended dose of N,P + 100% K + vermicompost+ *Azospirillum brasilense* +*Bacillus megaterium* + *Glomus fasciculatum*	41.67	56.67	18.00	22.67	11.00	13.00
T_9: T_8+ *Trichoderma harzianum*	42.00	61.33	20.67	26.00	11.67	13.67
T_{10}: T_8 + Jeevamrutha	46.33	70.00	18.33	23.33	12.33	15.00
T_{11}: T_8 + Panchagavya	45.33	65.67	17.67	23.00	12.03	14.33
T_{12}: T_8 + Panchagavya+ Jeevamrutha+ *Trichoderma harzianum*	49.33	79.67	21.00	28.00	13.33	16.00
F-test	*	*	*	*	*	*
S. Em ±	0.30	0.28	0.33	0.27	0.24	0.27
CD at 5%	0.88	0.86	0.99	0.81	0.72	0.80

* Significant at 5% MAP- Months after planting

Note: Recommended Dose of Fertilisers: 20:10:15g NPK/m^2 up to flowering

25: 12: 25g NPK/m^2/month after flowering

Vermicompost: 2.5kg/m^2/year

Azospirillum brasilense, *Bacillus megaterium* and *Glomus fasciculatum* (VAM fungi) each @ 20 gram/m^2, *Trichoderma harzianum* @ 10gram/m^2 once in six months

Foliar application of Panchagavya 3% and Jeevamrutha@ 10ml/m^2 applied to the soil once in a month.

The fungal population was highest in the soils of treatment T_7 which had 75 per cent recommended dose of nitrogen, phosphorus +100 per cent potassium+ vermicompost +*Azospirillum brasilense* +*Bacillus megaterium* + *Glomus fasciculatum* (VAM fungi) + panchagavya + jeevamrutha+ *Trichoderma harzianum* (22.67 x 10^3 cfu g^{-1}soil and 28.33 x 10 ^{3}cfu g^{-1}soil, respectively) at six and twelve months after planting. This was followed by T_4 (21.67 x 10 ^{3}cfu g^{-1}soil and 26.33 x 10 ^{3}cfu g^{-1}soil, respectively at six and twelve months after planting) (75 per cent recommended dose of nitrogen, phosphorus +100 per cent potassium+ vermicompost +*Azospirillum brasilense* +*Bacillus megaterium* + *Glomus fasciculatum* (VAM fungi) + *Trichoderma harzianum*). The lowest fungal population was recorded in the rhizosphere soils of uninoculated plot (T_1) which were supplemented only with recommended dose of NPK (13.00 x 10 ^{3}cfu g^{-1} soil and 14.33 x 10 ^{3}cfu g^{-1} soil, respectively at six and twelve months after planting).

The actinomycetes population in soil was maximum in the treatment (T_7) which had 75 per cent recommended dose of nitrogen, phosphorus +100 per cent potassium+ vermicompost + *Azospirillum brasilense* + *Bacillus megaterium* + *Glomus fasciculatum* (VAM fungi) + panchagavya + jeevamrutha+ *Trichoderma harzianum* (15.67 x 10 ^{4}cfu g^{-1} soil and 18.67 x 10 ^{4}cfu g^{-1} soil, respectively at six and twelve months after planting). The lowest actinomycetes population was found in the rhizosphere soils of T_1 that had only the recommended dose of NPK (9.00 x 10 ^{4}cfu g^{-1}soil and 11.00 x 10 ^{4}cfu g^{-1} soil, respectively at six and twelve months after planting).

4.6.2 Beneficial microflora

The data pertaining to population of build up of beneficial microorganisms in soil at six and twelve months interval as influenced by integrated nutrient management treatments are presented in Table 13.

Soils of different treatments differed significantly with respect to N-fixing and P-solubilising microorganisms. The highest *Azospirillum* population was found in the rhizosphere soils of the treatment (T_7) which had 75 per cent recommended dose of nitrogen, phosphorus +100 per cent potassium+ vermicompost + *Azospirillum brasilense* + *Bacillus megaterium* + *Glomus fasciculatum* (VAM fungi) + panchagavya +

Table 13: Influence of integrated nutrient management treatments on the soil beneficial microbial population at six and twelve months after planting in gerbera cv. Galileo Red

Treatment	*Azospirillum sp.* (No. 10^6 X Cfug^{-1} soil)		*Bacillus sp.* (No. 10^6 X Cfug-^{1} soil)		*Trichoderma sp.* (No. 10^3 X Cfug^{-1} soil)		VAM (spores per 50g soil)	
	6 MAP	12 MAP	6 MAP	12 MAP	6 MAP	12 MAP	6MAP	12MAP
T_1: 100% recommended dose of NPK	8.00	11.00	5.67	8.33	4.67	7.67	35.33	42.67
T_2: T_1 + Vermicompost	9.03	11.67	6.67	9.67	5.33	8.33	38.67	46.33
T_3: 75% recommended dose of N,P + 100% K+ vermicompost + *Azospirillum brasilense +Bacillus megaterium + Glomus fasciculatum*	13.67	15.67	10.67	13.00	7.67	10.00	66.33	80.67
T_4: T_3+ *Trichoderma harzianum*	14.67	16.00	11.33	13.67	12.00	14.67	67.33	81.67
T_5: T_3 + Jeevamrutha	15.67	17.33	12.00	14.33	8.67	11.33	69.33	83.33
T_6: T_3 + Panchagavya	15.00	16.67	11.67	14.00	8.33	10.67	68.67	82.33
T_7: T_3+ Panchagavya+ Jeevamrutha+ *Trichoderma harzianum*	16.33	19.33	12.67	15.33	12.33	15.33	70.00	85.33
T_8: 50% recommended dose of N,P + 100% K+ vermicompost + *Azospirillum brasilense +Bacillus megaterium + Glomus fasciculatum*	12.03	14.00	8.67	11.33	5.67	9.00	63.33	75.67
T_9: T_8+ *Trichoderma harzianum*	12.33	14.67	9.33	11.67	11.00	13.33	64.33	76.33
T_{10}: T_8 + Jeevamrutha	13.33	15.33	10.00	12.33	6.67	9.67	65.33	78.33
T_{11}: T_8 + Panchagavya	12.67	15.00	9.67	12.10	6.33	9.33	65.00	77.67
T_{12}: T_8 + Panchagavya+ Jeevamrutha+ *Trichoderma*	14.00	15.73	10.67	13.33	11.67	14.00	67.33	81.00
F-test	*	*	*	*	*	*	*	*
S. E m±	0.42	0.27	0.29	0.23	0.30	0.33	0.51	0.32
CD at 5%	1.26	0.81	0.88	0.69	0.90	0.97	1.53	0.93

* Significant at 5% MAP- Months after planting

Note: Recommended Dose of Fertilisers: 20:10:15g NPK/m^2 up to flowering

25: 12: 25g NPK/m^2/month after flowering Vermicompost: 2.5kg/m^2/year

Azospirillum brasilense, Bacillus megaterium and *Glomus fasciculatum* (VAM fungi) each @ 20 gram/m^2,

Trichoderma harzianum @ 10gram/m^2 once in six months

Foliar application of Panchagavya 3% and Jeevamrutha@ 10ml/m^2 applied to the soil once in a month.

jeevamrutha+ *Trichoderma harzianum* (16.33 x 10 ^{6}cfu g^{-1} soil and 19.33 x 10 ^{6}cfu g^{-1} soil, respectively at six and twelve months after planting). The lowest *Azospirillum* population at six and twelve months after planting was recorded in the treatment T_1 that had 100 per cent recommended dose of NPK alone (8.00 x 10 ^{6}cfu g^{-1} soil and 11.00 x 10 ^{6}cfu g^{-1} soil at six and twelve months after planting, respectively).

Bacillus megaterium population was maximum in the treatment combination of 75 per cent recommended dose of nitrogen, phosphorus +100 per cent potassium+ vermicompost + *Azospirillum brasilense* + *Bacillus megaterium* + *Glomus fasciculatum* (VAM fungi) + panchagavya + jeevamrutha+ *Trichoderma harzianum* (T_7) at six and twelve months after planting (12.67 x 10 ^{6}cfu g^{-1} soil and 15.33 x 10 ^{6}cfu g^{-1} soil, respectively). Treatment having only the recommended dose of NPK (T_1) recorded the lowest *Bacillus* population at six and twelve months after planting (5.67 x 10 ^{6}cfu g^{-1} soil and 8.33 x 10 ^{6}cfu g^{-1} soil, respectively).

Trichoderma population was maximum in the treatment (T_7) which had 75 per cent recommended dose of nitrogen, phosphorus +100 per cent potassium+ Vermicompost + *Azospirillum brasilense* + *Bacillus megaterium* + *Glomus fasciculatum* (VAM fungi)+ panchagavya + jeevamrutha+ *Trichoderma harzianum* at both six and twelve months after planting (12.33 x 10 ^{3}cfu g^{-1} soil and 15.33 x 10 ^{3}cfu g^{-1} soil, respectively) followed by treatment with 75 per cent recommended dose of nitrogen, phosphorus +100 per cent potassium+ vermicompost + *Azospirillum brasilense* + *Bacillus megaterium* + *Glomus fasciculatum* (VAM fungi) + *Trichoderma harzianum* (T_4) (12.00 x 10 ^{3}cfu g^{-1} soil and 14.67 x 10 ^{3}cfu g^{-1} soil at six and twelve months after planting, respectively). The treatment (T_1) having only the 100% recommended dose of NPK recorded the lowest *Trichoderma* sp. population at six and twelve months after planting (4.67 x 10 ^{3}cfu g^{-1} soil and 7.67 x 10 ^{3}cfu g^{-1} soil, respectively).

VAM spores were found maximum in treatment of *Azospirillum brasilense* + *Bacillus megaterium* + *Glomus fasciculatum* (VAM fungi) + panchagavya + jeevamrutha+ *Trichoderma harzianum* with 75 per cent recommended dose of nitrogen, phosphorus +100 per cent potassium and vermicompost at both six and twelve months

Table 14: Influence of integrated nutrient management treatments on the nitrogen, phosphorus and potassium content of gerbera leaves at six and twelve months after planting

Treatment	Nitrogen (%)	Nitrogen (%)	Phosphorus (%)	Phosphorus (%)	Potassium (%)	Potassium (%)
	6 MAP	12 MAP	6 MAP	12 MAP	6 MAP	12 MAP
T_1: 100% recommended dose of NPK	2.54	2.716	0.246	0.296	4.24	4.293
T_2: T_1 + Vermicompost	2.64	2.743	0.253	0.310	4.273	4.313
T_3: 75% recommended dose of N,P +100% K+ vermicompost+ *Azospirillum brasilense* + *Bacillus megaterium* + *Glomus fasciculatum*	2.596	2.803	0.280	0.396	4.280	4.373
T_4: T_3+ *Trichoderma harzianum*	2.576	2.816	0.293	0.406	4.290	4.393
T_5: T_3 + Jeevamrutha	2.696	2.863	0.320	0.430	4.306	4.396
T_6: T_3 + Panchagavya	2.643	2.836	0.300	0.410	4.293	4.38
T_7: T_3+ Panchagavya+ Jeevamrutha+ *Trichoderma harzianum*	2.766	2.963	0.360	0.450	4.313	4.40
T_8: 50% recommended dose of N,P + 100% K+ vermicompost+ *Azospirillum brasilense* + *Bacillus megaterium* + *Glomus fasciculatum*	2.430	2.750	0.250	0.356	4.287	4.386
T_9: T_8+ *Trichoderma harzianum*	2.493	2.753	0.253	0.366	4.286	4.393
T_{10}: T_8 + Jeevamrutha	2.556	2.77	0.266	0.376	4.306	4.39
T_{11}: T_8 + Panchagavya	2.546	2.76	0.263	0.383	4.286	4.38
T_{12}: T_8 + Panchagavya+ Jeevamrutha + *Trichoderma harzianum*	2.583	2.813	0.286	0.403	4.31	4.40
F-test	*	*	*	*	*	*
S. Em±	0.04	0.04	0.007	0.008	0.020	0.021
CD at 5%	0.12	0.12	0.021	0.024	0.059	0.062

* Significant at 5% MAP- Months after planting

Note: Recommended Dose of Fertilisers: 20:10:15g NPK/m^2 up to flowering

25: 12: 25g NPK/m^2/month after flowering

Vermicompost: 2.5kg/m^2/year

Azospirillum brasilense, Bacillus megaterium and *Glomus fasciculatum* (VAM fungi) each @ 20 gram/m^2,

Trichoderma harzianum @ 10gram/m^2 once in six months

Foliar application of Panchagavya 3% and Jeevamrutha@ 10ml/m^2 applied to the soil once in a month after planting (70.00 and 85.33spores/50g soil, respectively). This was followed by treatment with 75 per cent recommended dose of nitrogen, phosphorus +100 per cent potassium+ vermicompost + *Azospirillum brasilense* + *Bacillus megaterium* + *Glomus fasciculatum* (VAM fungi) + jeevamrutha (T_5) (69.33 spores/50g soil and 83.33 spores/50g soil at six and twelve months after planting, respectively). Minimum spores of VAM were recorded in uninoculated plants supplied with 100 per cent recommended dose of NPK (T_1) (35.33spores/50g soil and 42.67 spores/50g soil, respectively at six and twelve months after planting).

4.7 Leaf analysis

The data on leaf nutrient content presented in Table 14, indicates a significant variation in leaf nitrogen, phosphorus and potassium content in different INM treatments both at six and twelve months after planting. The highest nitrogen, phosphorus and potassium content in leaf (2.76%N, 0.36%P, 4.31%K at six months, 2.96%N, 0.45%P, 4.40%K at 12 months, respectively) was recorded in treatment T_7 plants receiving 75 per cent recommended dose of nitrogen, phosphorus +100 per cent potassium+ vermicompost + *Azospirillum brasilense* + *Bacillus megaterium* + *Glomus fasciculatum* (VAM fungi) + panchagavya + jeevamrutha+ *Trichoderma harzianum* followed by treatment T_5 (2.69% N, 0.32 % P, 4.31% K at six months, 2.86%N, 0.43%P, 4.39% K at twelve months, respectively) receiving 75 per cent recommended dose of nitrogen, phosphorus +100 per cent potassium+ vermicompost + *Azospirillum brasilense* + *Bacillus megaterium* + *Glomus fasciculatum* (VAM fungi) + jeevamrutha. Lowest leaf nitrogen, phosphorus and potassium (2.54% and 2.716% N, 0.24% and0.29% P_2O_5, and 4.24 and 4.29% K_2O at six and twelve months after planting, respectively) was found in uninoculated plants receiving recommended dose of fertilisers alone (T_1).

4.8 Cost economics

The cost of cultivation of gerbera cv. Galileo Red for two years was worked out per 1000 m^2 and is presented in Table 15. The details of total cost of cultivation are furnished in Appendix - VI.

Table 15: Economics of growing gerbera cv. Galileo Red with different integrated nutrient management treatments

Treatment	Fixed cost (Rs)	Cost of cultivation (Rs)	Total cost of cultivation (Rs)	Total yield/ 1000 m^2	Gross returns (Rs)	Net returns (Rs)	Benefit cost ratio (Rs)
T_1: 100% Recommended dose of N, P and K	464133	129054	593187	404860	1214580	621393	1:1.04
T_2: T_1 + Vermicompost	464133	141554	605687	419990	1259970	654283	1:1.08
T_3: 75 % recommended dose of Nitrogen, Phosphorus and 100 % Potassium + *Azosprillum brasilense* + *Bacillus megaterium* + *Glomus fasciculatum* + Vermicompost	464133	118320	582453	454660	1363980	781527	1:1.34
T_4: T_3 + *Trichoderma harzianum*	464133	119920	584053	462060	1386180	802127	1:1.37
T_5: T_3 + Jeevamrutha	464133	120520	584653	471660	1414980	830327	1:1.42
$T_{6:}$ T_3 + Panchagavya	464133	122880	587013	468060	1404180	817167	1:1.39
T_7: T_3 + Panchagavya + Jeevamrutha + *Trichoderma harzianum*	464133	126680	590813	491930	1475790	884977	1:1.49
T_8: 50 % recommended dose of Nitrogen, Phosphorus and 100 % Potassium + *Azosprillum brasilense* + *Bacillus megaterium* + *Glomus fasciculatum* + Vermicompost	464133	87418	551551	421260	1263780	712229	1:1.28
T_9: T_8 + *Trichoderma harzianum*	464133	89018	553151	424920	1274760	721609	1:1.30
T_{10}: T_8 + Jeevamrutha	464133	89618	553751	428660	1285980	732229	1:1.32
T_{11}: T_8 + Panchagavya	464133	91978	556111	427190	1281570	725459	1:1.30
T_{12}: T_8 + Panchagavya + Jeevamrutha + *Trichoderma harzianum*	464133	95778	559911	439400	1318200	758289	1:1.35

An average price of each stalk – Rs.3/- *Calculation of total cost of cultivation is furnished in Appendix- VI

Legend

T_1: 100 per cent recommended dose of Nitrogen, Phosphorus and Potassium

T_2: **T_1** + Vermicompost

T_3: 75 per cent of recommended dose of Nitrogen, Phosphorus, 100 per cent Potassium+ Vermicompost + *Azospirillum brasilense* + *Bacillus megaterium* + VAM fungi (*Glomus faciculatum*)

T_4: **T_3** + *Trichoderma harzianum*

T_5: **T_3** + Jeevamrutha

T_6: **T_3** + Panchagavya

T_7: **T_3** + Panchagavya + Jeevamrutha + *Trichoderma harzianum*

T_8: 50 per cent of recommended dose of Nitrogen, Phosphorus, 100 per cent Potassium + Vermicompost + *Azospirillum brasilense* + *Bacillus megaterium* +VAM fungi (*Glomus fasciculatum*)

T_9: **T_8** + *Trichoderma harzianum*

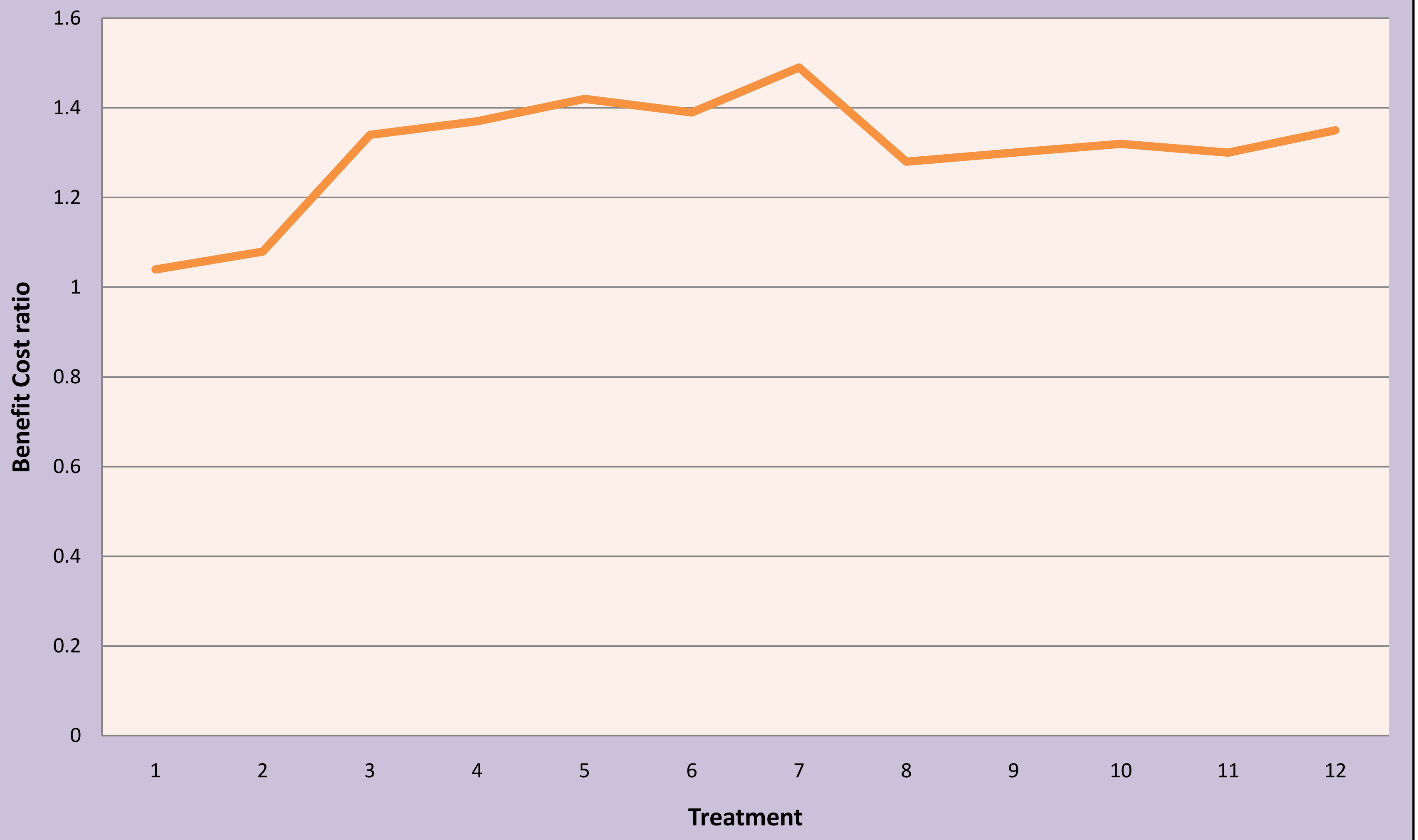
T_{10}: **T_8** + Jeevamrutha

T_{11}: **T_8** + Panchagavya

T_{12}: **T_8** + Panchagavya + Jeevamrutha + *Trichoderma harzianum*

Note :
Recommended Dose of Fertilisers: 20:10:15g NPK/m^2 up to flowering
25: 12: 25g NPK/m^2/month after flowering
Vermicompost: 2.5kg/m^2/year
Azospirillum brasilense, Bacillus megaterium and *Glomus fasciculatum* (VAM fungi) each @ 20 g/m^2
Trichoderma harzianum @ 10g/m^2 once in six months
Foliar application of Panchagavya 3% and Jeevamrutha@ 10ml/m^2 applied to the soil once in a month.

Fig. 4: Influence of integrated nutrient management on the benefit cost ratio of gerbera cv. Galileo Red



The maximum revenue (Rs 14,75,790 per 1000 m^2 for two years) and net profit (Rs. 8,84,977 per 1000 m^2 for two years) with higher cost benefit ratio (1:1.49) (Figure 4) were recorded in the treatment T_7 (75 per cent recommended dose of nitrogen, phosphorus +100 per cent potassium+ vermicompost + *Azospirillum brasilense* + *Bacillus megaterium* + *Glomus fasciculatum* (VAM fungi) + panchagavya + jeevamrutha+ *Trichoderma harzianum)*. The minimum total revenue, net income and cost benefit ratio (Rs2,14,580, Rs 6,21,393 per 1000m^2 for two years and 1:1.04, respectively) was observed in T_1 (100 per cent RDF).

Discussion

V. DISCUSSION

In the wake of increased cost of chemical fertilisers coupled with ecological imbalances caused by their continuous use, the trend of growing horticultural crops using organic manure is in vogue. However, the change over from chemical to organic crop production takes time and the producers have to sustain yield loss till the soil productivity is built to a desirable level. Further, there is a shortage of organic manures which are required in bulk quantity. Hence, crop nutrient management should aim at effective and judicious use of major sources of plant nutrients like organic manures, inorganic fertilizers and bio-fertilizers in an integrated manner to get maximum economic yield and reduce dependency on chemical fertilizers in crop production to certain extent.

Keeping these in view, an experiment was carried out under protected structure to study the "Integrated nutrient management on growth, flower yield and post harvest quality of gerbera (*Gerbera jamesonii* Bolus.) cv. Galileo Red under poly house condition". The results of the experiment are discussed below.

5.1 Effect of Integrated nutrient management on the growth parameters of gerbera

Growth, development and ultimate yield of any crop are regulated through a series of biological events involving biochemical, physiological and morphological changes which takes place during its development in accordance with the supply of light, water, temperature and nutrients (Donald, 1962). In the present study, there was a significant variation with respect to plant height, plant spread, leaf area and number of leaves due to the adoption of integrated nutrient management practices.

5.1.1 Plant height

Plant height was significantly influenced by integrated nutrient management practices at all the stages of crop growth. The maximum plant height was recorded at 270DAP, in the plants treated with 75 per cent recommended dose of nitrogen, phosphorus +100 per cent potassium+ vermicompost + *Azospirillum brasilense* + *Bacillus megaterium* + *Glomus fasciculatum* (VAM fungi) + panchagavya + jeevamrutha+ *Trichoderma harzianum* (T_7) (47.53cm), followed by the treatment T_5 (75

% RD NP and 100 % K + *Azospirillum brasilense* + *Bacillus megaterium* + *Glomus fasciculatum* (VAM fungi)+ vermicompost + Jeevamrutha) (45.43cm) and treatment T_6 (75 % Recommended dose of N, P and 100 % K + *Azospirillum brasilense* + *Bacillus megaterium* + *Glomus fasciculatum* (VAM fungi) + vermicompost + panchagavya) (45.06 cm) and minimum mean plant height (40.13 cm) was in the treatment receiving 100% recommended dose of fertilizer.

This clearly indicates the importance of adding organic manures to the soil in conjunction with inorganic fertilizer, which increases the availability of nutrients considerably resulting in positive effect on growth parameters. Increase in height may be due to the higher availability of nitrogen, which will be converted into amino acids, which in turn leads to increased rate of meristamatic activity resulting in better plant height. This is in confirmation with earlier reports of Arora and Jhon (1978), Mukhopadhyay (1981) and Biswas *et al.* (1982) in carnation. Apart from the role of nitrogen, vermicompost might have helped to increase the plant height, as vermicompost is a rich source of readily available macronutrients and chelated form of micronutrients such as Fe and Zn. In addition, application of panchagavya and jeevamrutha might have influenced the increase in plant height, due to the presence of growth regulatory substances such as GA and cytokinin (Anonymous, 2010). As panchagavya was sprayed on the foliage, the absorption of nutrients was on higher side, thus encouraging quick growth and increased plant height. Similar reports of positive effect of panchagvya on plant height were reported by Renukaradya (2005) in carnation and Rajesh Bhalla *et al*. (2006) in gladiolus.

Azospirillum inoculation showed improved plant growth due to growth substances produced and released continuously in the minor rhizosphere and it increased the ability of absorption of nutrients by the crop resulting in maximum plant height which was significantly superior in T_7. Similar results of higher plant height due to combined application of *Azospirillum*, PSB and inorganic fertilizers have been reported earlier in crossandra (Narashima Raju and Haripriya, 2001) and in gundumalli (Manonmani, 1992). Fixation of nitrogen by *Azospirillum*, greater phosphorus uptake by VAM combined with availability of nutrients from NPK could have led to increased plant height as reported by Seetha (1999) in gerbera.

5.1.2 Plant spread

In present study, plant spread was significantly influenced by the use of different sources of organic manures, biofertilizers and biostimulants along with graded levels of fertilizer at 45, 90, 120, 180, 225 and 270 DAP. Maximum plant spread was recorded in the treatment T_7 (75 % RD NP and 100 % K + *Azospirillum brasilense* + *Bacillus megaterium* + *Glomus fasciculatum* (VAM fungi) + vermicompost + panchagavya + jeevamrutha + *Trichoderma harzianum*) (49.66cm^2) at 270 DAP, which was followed by the treatment T_5 (46.46cm^2) (75 % RD NP and 100 % K + *Azospirillum brasilense* + *Bacillus megaterium* + *Glomus fasciculatum* (VAM fungi) + vermicompost + jeevamrutha) and treatment T_6 (75 % RD NP and 100 % K + *Azospirillum brasilense* + *Bacillus megaterium* + *Glomus fasciculatum* (VAM fungi) + vermicompost + panchagavya) (45.86cm^2).

Increased plant spread may be attributed to the effective functioning of biofertilisers which produce bioactive substances with probiotic effects. The combination of organic manures, fertilisers, biofertilisers and biostimulants might have helped in better availability and uptake of nutrients by the plants. *Azospirillum* and PSB produced bioactive substances having similar effect as that of growth hormones leading to better vegetative growth. Jeevamrutha and panchagavya which was applied both to the soil and foliage as foliar application, act as a better sources of nutrients, as they contains nitrogen in available form, which must have increased the number of leaves (Somasundaram *et al*., 2004). This could be attributed to the sufficient quantity of nutrient flow into the plants treated with biofertilisers and biostimulants as reported earlier by Renukaradya (2005) in carnation.

5.1.3 Number of leaves

Number of leaves per plant decides the efficiency of photosynthetic activity, which helps in improved plant growth and yield. In the present study, number of leaves produced per plant increased throughout the cropping period. Fertigation with 75 per cent recommended dose of nitrogen, phosphorus +100 per cent potassium+ vermicompost + *Azospirillum brasilense* + *Bacillus megaterium* + *Glomus fasciculatum* (VAM fungi) + panchagavya + jeevamrutha+ *Trichoderma harzianum* (T_7) (28.80) recorded maximum number of leaves at all stages and was highest at 270 DAP. This was followed by treatment T_5 (75 % RD NP and 100 % K + *Azospirillum brasilense* + *Bacillus megaterium* + VAM + vermicompost + jeevamrutha) (26.53) and treatment T_6 (75 % RD NP and 100 % K + *Azospirillum brasilense* + *Bacillus megaterium* + *Glomus fasciculatum* (VAM fungi) + vermicompost + panchagavya) (26.03).

This indicates that there would have been better supply of both macro and micro nutrients, which could have contributed to increased leaf number. Increased number of leaves could be attributed to efficiency of biofertilisers in terms of nitrogen fixation, phosphorus solubilisation and its mobilisation and production of growth promoting substances. The research results of the study are in conformity with the findings of Kale *et al*. (1987) in Salvia, Nethra (1996) in China aster and Prasanna (2007) in gerbera who observed more number of leaves due to biofertiliser application. This increase in the number of leaves might be also due to the integrated nutrient approach coupled with increased plant height and number of laterals. This indicates that vermicompost and biostimulants might have been a better source of nutrients and which were applied to the soil and foliage as foliar application accordingly, as they contain nitrogen in available form, which might have increased the number of leaves (Somasundaram *et al*., 2004). Predominance of microorganisms like *Lactobacillus,* yeast, *Azospirillum, Azotobacter*, Phosphobacterium and *Pseudomonas* in jeevamrutha and panchagavya produces various organic acids and growth hormones which result in faster growth.

5.1.4 Leaf area

Leaves are the main photosynthetic apparatus in plants, synthesizing various metabolites required for plant growth and development. The leaf area of the plant plays an important role in the photosynthetic activity as it harnesses more of radiant energy from the sunlight. Leaf area also increased throughout the cropping period. Highest leaf area was recorded in plants supplied with 75 per cent recommended dose of nitrogen, phosphorus +100 per cent potassium+ vermicompost + *Azospirillum brasilense* + *Bacillus megaterium* + *Glomus fasciculatum* (VAM fungi) + panchagavya + jeevamrutha + *Trichoderma harzianum* (158.40cm^2) (T_7) at 270 DAP, followed by treatment T_5 (75 % RD N, P and 100 % K + *Azospirillum brasilense* + *Bacillus megaterium* + *Glomus fasciculatum* (VAM fungi) + vermicompost + jeevamrutha) (155.1cm^2) and treatment T_6 (75 % RD N, P and 100 % K + *Azospirillum brasilense* + *Bacillus megaterium* + *Glomus fasciculatum* (VAM fungi) + vermicompost + panchagavya) (154.26 cm^2). While significantly lowest leaf area (144.13 cm^2) was recorded in the treatment T_1 (100% recommended dose of fertilizer).

Increased leaf area observed in these treatments could be attributed to positive response of gerbera to the integrated nutrient management practices. *Azospirillum* and biostimulants like panchagavya and jeevamrutha increased the availability and uptake of the element nitrogen by the plant. Nitrogen being a constituent of chlorophyll might have increased the leaf area (Mengel and Kirkby, 1969) and (Sindhu and Gupta, 1993) thereby more synthesis of carbohydrates, which are utilized in building up of new cells.

Apart from the reasons mentioned earlier, enhanced growth parameters like plant height, number of leaves, leaf area, plant spread due to *Azospirillum* might also be attributed to the influence of nitrogen, the chief constituent of protein which is essential for formation of protoplasm and ultimately enhances cell division and cell enlargement. Moreover, nitrogen is an important component of amino acids and co-enzymes, which are of considerable biological importance. The mechanisms by which PSB augment plant growth is through phosphate dissolution and in the biosynthesis of auxin (Sattar and Gaur, 1987) and IAA (Barea *et al*., 1976), besides providing protection against the non-parasitic root pathogens and transforming unavailable mineral and organic compounds into available forms in plants. Any of these effects would have lead to increase in plant growth.

5.1.5 Number of suckers per plant

The number of suckers produced per plant at the end of two years was maximum when treated with 75 per cent recommended dose of nitrogen, phosphorus +100 per cent potassium+ vermicompost + *Azospirillum brasilense* + *Bacillus megaterium* + *Glomus fasciculatum* (VAM fungi) + panchagavya + jeevamrutha+ *Trichoderma harzianum* (T_7) (6.06) followed by 75 per cent recommended dose of nitrogen, phosphorus +100 per cent potassium+ vermicompost + *Azospirillum brasilense* + *Bacillus megaterium* + *Glomus fasciculatum* (VAM fungi) + jeevamrutha (T_5) (5.60), which was on par with 75 per cent recommended dose of nitrogen, phosphorus +100 per cent potassium+ vermicompost + *Azospirillum brasilense* + *Bacillus megaterium* + *Glomus fasciculatum* (VAM fungi) + panchagavya (T_6) (5.40) whereas T_1(100% recommended dose of NPK) (4.26) and T_2 (100% recommended dose of NPK + vermicompost) (4.33) produced minimum number of suckers per plant per year. This is attributed to the positive effect of application of biofertilisers and biostimulants in combination with fertilisers. The presence of phytohormones in the biostimulants and biofertilisers results in production of large sized and increased number of leaves and after the diversion of the photosynthates to the sink, the rest would have been used in the production of suckers. Cytokinins are known for their potential to arrest apical dominance and thereby induce more suckers or lateral branches. Similar observations were made by Puttaswamy (2004) in gerbera.

5.2 Effect of Integrated nutrient management on the flower characters of gerbera cutflower

Ultimate aim of any grower is to get higher yield, coupled with better quality to generate more revenue. Among the several parameters which either directly or indirectly influence the yield and quality of gerbera, the important ones are number of flowers per plant per year, number of flowers per meter square per year, earliness in flowering, flower stalk length, flower stalk diameter, length of ray florets and diameter of flower which ultimately decide the market value of harvested produce.

5.2.1 Number of days taken for first flower bud initiation

Number of days taken for first flower bud initiation was significantly influenced by biofertilisers and biostimulants application at different levels of nitrogen and phosphorus. Early flowering was noticed in the plants supplied with 75 per cent recommended dose of nitrogen, phosphorus +100 per cent potassium+ vermicompost + *Azospirillum brasilense* + *Bacillus megaterium* + *Glomus fasciculatum* (VAM fungi) + panchagavya + jeevamrutha+ *Trichoderma harzianum* (T_7) (24.27 days) which was followed by 75 per cent recommended dose of nitrogen, phosphorus +100 per cent potassium+ vermicompost + *Azospirillum brasilense* + *Bacillus megaterium* + *Glomus fasciculatum* (VAM fungi) + jeevamrutha (T_5) (25.47 days). This could be attributed to vigourous growth of the plants due to balanced nutrient levels in combination with biofertilisers and biostimulants. Ultimately, they resulted in better sink for faster mobilization of photosynthates and early transformation of plant parts from vegetative to reproductive phase. The results of the current findings were in accordance with earlier reports of Singh Bharti *et al.* (2007) in rose, Renukaradhya (2005) and Gangadhar Swamy (2010) in carnation. Since phosphorus is an important element and essential for initiation of flowering PSB along with biostimulants and NPK is known to increase the availability of phosphorus which resulted in early flowering. This finding is in line with Mantur (1988) in China aster. Presence of growth promoting substances such as GA_3 and cytokinin and biofertilizers such as *Acetobacter, Azospirillum* and phosphobacteria in jeevamrutha and panchagavya which makes ready availablility of nutrients along with presence of plant growth promoting substances might have lead to early flowering (Somasundaram *et al.,* 2004).

The delayed flowering in treatments T_1 and T_2 could be related to low phosphorus availability and comparatively the presence of higher amount of nitrogen might have helped in prolonging the vegetative phase and shortening the reproductive cum maturation phase. Similar reports were made by Prasanna (2007) in gerbera.

5.2.2 Number of days taken for complete flower opening

The number of days taken for complete flower opening was significantly better in plants supplied with 75 per cent recommended dose of nitrogen, phosphorus +100 per cent potassium+ vermicompost + *Azospirillum brasilense* + *Bacillus megaterium* + *Glomus fasciculatum* (VAM fungi) + panchagavya + jeevamrutha+ *Trichoderma harzianum* (T_7) (12.13). This may be due to the presence of cytokinin in jeevamrutha and panchagavya resulting in early bud break. The earliness of flowering may also be attributed to the presence of biofertilizers especially inoculation with *Azospirillum* and PSB which resulted in easy uptake of nutrients and simultaneous transport of growth promoting substances like cytokinins to the axillary buds resulting in faster flower opening (Somasundaram *et al.,* 2004). These results are in the line with the findings in marigold (Chandrikapure *et al.,* 1999), crossandra (Narasimha Raju and Haripriya, 2001) and limonium (Gayathri *et al.,* 2004).

5.2.3 Number of days taken for 50 per cent flowering

The number of days taken for 50 per cent flowering was found to be significantly higher in plants treated with 75 per cent recommended dose of Nitrogen, Phosphorus +100 per cent potassium+ vermicompost + *Azospirillum brasilense* + *Bacillus megaterium* +*Glomus fasciculatum* (VAM fungi) + panchagavya + jeevamrutha+ *Trichoderma harzianum* (T_7) (83.67). Phosphorus is an important element required at the time of flowering, since PSB and VAM are known to enhance P uptake, it may have resulted in early flower bud initiation and 50 per cent flowering in T_7. The results are in conformation with reports of Puttaswamy (2004) and Prasanna (2007) in gerbera.

5.2.4 Flower diameter

Gerbera cut flower quality depends largely on the flower diameter. Cut flowers with higher diameter was obtained in plants supplied with 75 per cent recommended dose of nitrogen, phosphorus +100 per cent potassium+ vermicompost + *Azospirillum brasilense* + *Bacillus megaterium* + *Glomus fasciculatum* (VAM fungi) + panchagavya + jeevamrutha+ *Trichoderma harzianum* (T_7) (9.66cm) followed by T_5 (75 % RD N, P and 100 % K + *Azospirillum brasilense* **+** *Bacillus megaterium* + *Glomus fasciculatum* (VAM fungi) + vermicompost + jeevamrutha) (9.51cm) and treatment T_6 (75 % RD N, P and 100 % K + *Azospirillum brasilense* + *Bacillus megaterium* + *Glomus fasciculatum* (VAM fungi) + vermicompost + panchagavya) (9.46cm) compared to T_1 (100% RDF) (9.18cm). The increased uptake of phosphorus by PSB and the phytohormonal effects produced by jeevamrutha and panchagavya might have resulted in higher diameter of gerbera flowers. Results are in accordance with the findings of Renukaradya (2005) in carnation, Puttaswamy (2004) and Prasanna (2007) in gerbera.

5.2.5 Length of ray florets

Length of the ray floret is one of the parts of the flowers of the Asteracea family that contributes for increasing the flower diameter. Longer length of the ray florets was found in the flowers of the treatment involving 75 per cent recommended dose of nitrogen, phosphorus +100 per cent potassium+ vermicompost + *Azospirillum brasilense* + *Bacillus megaterium* + *Glomus fasciculatum* (VAM fungi) + panchagavya + jeevamrutha + *Trichoderma harzianum* (T_7) (3.93cm) followed by T_5 (3.86cm) (75 % RD N, P and 100 % K + *Azospirillum brasilense* + *Bacillus megaterium* + *Glomus fasciculatum* (VAM fungi) + vermicompost + jeevamrutha) which was on par with T_6 (3.80cm) (75 % RD N, P and 100 % K + *Azospirillum brasilense* + *Bacillus megaterium* + *Glomus fasciculatum* (VAM fungi) + vermicompost + panchagavya) while minimum length (3.43cm) was noticed in T_1 (100 % RDF). Improvement in quality parameters of flower may be due to balanced uptake of NPK and micronutrients as influenced by panchagavya, jeevamrutha and biofertilisers. Similar reports were obtained in gerbera (Seetha, 1999 and Prasanna, 2007).

5.2.6 Flower stalk length

Gerbera cut flowers are graded in the international market based on the flower stalk length. Stalk length was significantly higher in plants treated with 75 per cent recommended dose of nitrogen, phosphorus +100 per cent potassium+ vermicompost + *Azospirillum brasilense* + *Bacillus megaterium* + *Glomus fasciculatum* (VAM fungi) + panchagavya + jeevamrutha+ *Trichoderma harzianum* (T_7) (59.53cm) and was minimum in plants supplied with recommended dose of nutrients alone (T_1) (54.73cm). This could be due to better nutrient uptake, higher photosynthetic efficiency, source-sink relationship besides excellent physiological and biochemical activities due to the presence of *Azospirillum*, VAM and PSB. Similar effects of *Azospirillum* and PSB on tuberose spike length was reported by Swaminathan *et al.* (1999) and Wang *et al.* (1995). The positive effect of vermicompost in increasing stalk length has been reported in golden rod (Kusuma, 2001) and gladiolus (Gangadharan and Gopinath, 2000). Similar results were obtained in carnation (Rajesh Bhalla *et al.*, 2007; Suman Bhatia *et al.*, 2004), Padmadevi *et al*. (2001) in anthurium, Bonita *et al*. (1994) in gerbera and Singh Bharti *et al*. (2007) in rose. Growth promoting substances, particularly GA like substances in the biostimulants might have also contributed to flower stalk elongation.

5.2.7 Flower stalk diameter (cm)

Diameter of flower stalk plays an important role in the vase life of cut flowers. It has been found that the diameter of the stalk also increases the carbohydrate content of the stalk and thereby due to the increase in stability; vase life of cut flowers is prolonged. Diameter of the flower stalk was significantly higher in plants treated with 75 per cent recommended dose of nitrogen, phosphorus +100 per cent potassium+ vermicompost + *Azospirillum brasilense* + *Bacillus megaterium* + *Glomus fasciculatum* (VAM fungi) + panchagavya + jeevamrutha+ *Trichoderma harzianum* (T_7) (0.568cm) and was minimum in plants supplied with recommended dose of nutrients alone(T_1) (0.541cm). Application of vermicompost along with panchagavya as foliar spray and as soil application contributed to an increase in stem girth. Similar observations were made in China aster by Kale *et al.* (1987) when worm cast was used as substrate. The stem girth was increased due to the mychorhizal root colonization, which enhanced availability of phosphorus. Similar results were observed by Nethra (1996) and Verma *et al*. (2011).

5.3 Effect of Integrated nutrient management on yield of gerbera cut flower

5.3.1 Number of flowers per plant and per square meter

Number of flowers produced per plant, per square meter and per hectare per year was significantly affected by the INM treatments. The plants supplied with T_7 (75 % recommended dose of N, P and 100 % K + *Azospirillum brasilense* + *Bacillus* *megaterium* + *Glomus fasciculatum* (VAM fungi) + vermicompost + panchagavya + jeevamrutha + *Trichoderma harzianum*) recorded significantly maximum number of flowers per plant, per square meter and per hectare per year followed by the treatment T_5 (75 % recommended dose of N, P and 100 % K + *Azospirillum brasilense* + *Bacillus megaterium* + *Glomus fasciculatum* (VAM fungi) + vermicompost + jeevamrutha) and treatment T_6 (75 % recommended dose of N, P and 100 % K + *Azospirillum brasilense* + *Bacillus megaterium* + *Glomus fasciculatum* (VAM fungi) + vermicompost + panchagavya) as compared to T_1 (100 % RDF). The increase in number of flowers may be due to possible role of bioinoculants such as *Azospirillum,* VAM fungi and phosphobacteria through better nitrogen fixation from atmosphere, better root proliferation, uptake of nutrients and water, higher leaf number and area in carnation plants. More photosynthesis enhanced food accumulation which might have resulted in better plant growth and subsequently higher number of flowers per plant and, hence, more number of flower yield per m^2. Besides this, increase in flower yield may be attributed to increased availability of phosphorous and its greater uptake due to application PSB (Kundu and Gaur, 1980). Vermicompost, being the source of macro and micro nutrients like Fe and Zn, enzymes, growth hormones and beneficial effects of microflora might have played a secondary role in increasing the flower yield. The higher flower yield due to application of vermicompost has been reported in China aster (Nethra, 1996, Srinivas *et al*., 1994), marigold (Mashaldi, 2000) and golden rod (Kusuma, 2001) combination of biofertilizers and vermicompost along with recommended NPK produced higher flower yield in limonium (Gayathri *et al.,* 2004). Similarly, Chandrikapure *et al.* (1999) reported higher flower yield in marigold due to combined applications of *Azotobacter* and PSB with 75 per cent recommended dose of nitrogen.

Presence of growth promoting substances such as GA and cytokinins, which are present in panchagavya, might have been responsible in increasing the number of flowers. Apart from this effective microorganisms predominately lactic acid bacteria, yeast, actionomycetes has been proven to help in increasing the yield.

The beneficial effects of jeevamrut reported by Palekar (2006) and Vasanthkumar (2006) was attributed to huge quantity of microbial load and growth hormones which might have enhanced the soil biomass thereby sustaining the availability and uptake of applied as well as native soil nutrients which ultimately resulted in growth and yield of crops.

5.3.2 Percentage of marketable flowers

Irrespective of yield, it is the percentage of marketable and unmarketable flowers which decide the economy of production. The ratio of marketable and unmarketable flowers should be high for the cultivation to be profitable. In the present investigation, significantly higher percentage of marketable flowers and lowest unmarketable flowers were recorded in T_7 (75 % RD N, P and 100 % K + *Azospirillum brasilense* + *Bacillus megaterium* + *Glomus fasciculatum* (VAM fungi) + vermicompost + panchagavya + jeevamrutha + *Trichoderma harzianum*) (92.33%) followed by the treatment T_5 (75 % RD N, P and 100 % K + *Azospirillum brasilense* + *Bacillus megaterium* + *Glomus fasciculatum* (VAM fungi) + vermicompost + jeevamrutha) (90.67%) which was on par with treatment T_6 (75 % RD N, P and 100 % K + *Azospirillum brasilense* + *Bacillus megaterium* + *Glomus fasciculatum* (VAM fungi)+ vermicompost + panchagavya) (90.33%) as compared to T_1 (100 % RDF) (86.66%). This may be due to possible role of biofertilizers and biostimulants in secreting growth regulators, which helped in better photosynthetic activity with enhanced CHO accumulation in leaves, which might have resulted in quality flower production. Similar observations were made by Prasanna (2007) in gerbera. Panchagavya and jeevamrutha application helped in better uptake of nutrients leading to better quality flowers. Jeevamrutha and panchagavya are also known to contain naturally occurring beneficial effective microorganisms predominantly lactic acid bacteria, yeast actinomycetes, and plant protection substrates (*Pseudomonas* and saprophytic yeasts) which are responsible for controlling the pests and diseases (Somasundaram *et al*., 2004).

5.4 Shelf life studies

Pre harvest factors will have their influence on the post harvest aspects of a cut flower. Significantly maximum shelf life was observed in the flowers of T_7 (75 per cent recommended dose of nitrogen, phosphorus +100 per cent potassium+ Vermicompost +

Azospirillum brasilense + *Bacillus megaterium* + *Glomus fasciculatum* (VAM fungi) + panchagavya + jeevamrutha+ *Trichoderma harzianum*) (15.33 days) followed by the treatment T_5 (75 % RD N, P and 100 % K + *Azospirillum brasilense* + *Bacillus megaterium* + *Glomus fasciculatum* (VAM fungi) + vermicompost + jeevamrutha) (15.00 days) and treatment T_6 (75 % RD N,P and 100 % K + *Azospirillum brasilense* + *Bacillus megaterium* + *Glomus fasciculatum* (VAM fungi) + vermicompost + panchagavya) (14.67 days) as compared to T_1 (100 % RDF) (12.67 days). This could be due to longer stalk length and excessive accumulation of sugars in the stem, which might have translocated to corolla, thus increasing the water uptake and maintaining turgidity in the stem, resulting in prolonged shelf life of the flower. This can be attributed to the development of water conducting tissues facilitated by biofertilizers. Similar beneficial effects of biofertilizers and vermicompost on vase life have been also reported in China aster (Nethra, 1996), chrysanthemum (Hemavathi, 1997) and gerbera (Thane *et al*., 2007). Increased vase life of gerbera was reported with the use of *Azospirillum* + VAM fungi by Narayana Gowda (2003). Growth promoting substances like cytokinins present in jeevamrutha and panchagavya might be responsible for longer shelf life.

Significantly higher cumulative uptake of water by cut flowers was obtained by the application of 75 per cent recommended dose of nitrogen, phosphorus +100 per cent potassium+ vermicompost + *Azospirillum brasilense* + *Bacillus megaterium* + *Glomus fasciculatum* (VAM fungi)+ panchagavya + jeevamrutha+ *Trichoderma harzianum* (T_7) (93.66g). Better quality cut flowers produced as a result of the treatment could be the probable cause for recording maximum cumulative uptake and transpirational loss of water. This may be due to better development of water conducting tissue and longer vase life of the flower due to better absorption of water. There will be better nutrient supplement to crop. Such improved vase life of flowers obtained from microbial inoculated plants were reported in several flower crops like gerbera (Prasanna (2007), Seetha (1999)), Anthurium (Padmadevi *et al*., 2001), gladiolus (Kathiresan, 1999).

Number of bacteria associated with cut surface and xylem interior of gerbera stems were reduced by antimicrobial treatments and as a result stem blockage was reduced enhancing the water uptake. A positive influence on vase life of gerbera was recorded by treating flowers with sucrose and silver nitrate in combination with germicide. Similar results were obtained earlier by Yumnam (2008) in gerbera.

5.5 Influence of integrated nutrient management on the available NPK status of soil

Estimation of nutrient contents and their forms in materials which are involved in nutrient supply and dynamics is a crucial step towards planning scientific nutrient management. Both total and available forms of nutrients are important. Information on available soil nutrients is used for advising individual farmers on the fertiliser needs and in the preparation of area wise soil fertility over a period of time (Tandon, 1993). The application of nitrogen fixers with different levels of N and P resulted in increased availability of Nitrogen content in soil. The available nitrogen, phosphorous and potassium were highest in T_7 (75 % RD N,P and 100 % K + *Azospirillum brasilense* + *Bacillus megaterium* + *Glomus fasciculatum* (VAM fungi) + vermicompost + panchagavya + jeevamrutha + *Trichoderma harzianum*) followed by the treatment T_5 (75 % RD N,P and 100 % K + *Azospirillum brasilense* + *Bacillus megaterium* + *Glomus fasciculatum* (VAM fungi) + vermicompost + jeevamrutha) and treatment T_6 (75 % RD N,P and 100 % K + *Azospirillum brasilense* + *Bacillus megaterium* + *Glomus fasciculatum* (VAM fungi) + vermicompost + panchagavya). The least availability of NPK was recorded in treatment T_1 (100 % RDF). Reports are also available on the role of biofertilizers in improving the availability of nutrients (Mishra *et al.*, 1999 and Sukhada Mohandas, 1999).

Similar results of better availability of Nitrogen and Phosphorus due to biofertilizers and vermicompost were reported in crossandra Cv. Dindigul local (Narasimaha Raju and Haripriya, 2001), in marigold (Mashaldi, 2000) and in carnation (Gangadhar Swamy,2010). The increase in available nitrogen due to application of FYM, vermicompost, biostimulants and biofertilizers might be attributed to the greater multiplication of soil microbes by application of nitrogen through nitrogenous fertilizers along with organics. These organics during mineralization convert organically bound N to inorganic form resulting in higher available nitrogen of soil. It is also found that by the application of phosphate solubilising bacteria and VAM fungi, addition of inorganic phosphates can be reduced by about 25-50 per cent as reported by Prasanna (2007) in gerbera.

However, available potassium in soil was least in T_7 (75 % RD N,P and 100 % K + *Azospirillum brasilense* + *Bacillus megaterium* + *Glomus fasciculatum* (VAM fungi) + vermicompost + panchagavya + jeevamrutha + *Trichoderma harzianum*) followed by the treatment T_5 (75 % RD N,P and 100 % K + *Azospirillum brasilense* + *Bacillus megaterium* + VAM + vermicompost + jeevamrutha) and treatment T_6 (75 % RD N,P and 100 % K + *Azospirillum brasilense* + *Bacillus megaterium* + *Glomus fasciculatum* (VAM fungi) +vermicompost + panchagavya) whereas it was highest in treatment receiving 100 per cent RDF. High yielding treatment like T_7, T_5 and T_6 might have exhausted the available potassium in soil as there was no extra application of potassium containing organic sources to compensate the loss of potassium in the soil. Although vermicompost, panchagavya and jeevamrutha contain potassium in traces, significant increase in available potassium was not observed.

5.6 Influence of integrated nutrient management on general and beneficial microbial population in the soil

The microbial analysis of soil at six and twelve months interval has showed improvement in general microflora, compared to the initial microbial population of the soil due to application of microbial inoculants. Maximum bacteria, actinomycetes and fungi population was found in the soils inoculated with *Azospirillum brasilense* + *Bacillus megaterium* + *Glomus fasciculatum* (VAM fungi) + panchagavya + jeevamrutha + *Trichoderma harzianum* with 75 per cent recommended dose of nitrogen, phosphorus +100 per cent potassium and vermicompost. Minimum bacteria, actinomycetes and fungi population was found in the treatment T_1 which was provided only with recommended dose of NPK. The increased number of colonies may be due to more availability of organic manures for the multiplication of microbes. These results are in accordance with the observations made earlier by Prasanna (2007) who recorded higher microbial population in gerbera when inoculated with *Azospirillum brasilense, Bacillus subtilis,* *Pseudomonas fluorescens* and *Trichoderma harzianum* as compared to uninoculated plants.

In general the population of beneficial microorganisms in the soil differed significantly and the population of individual microorganisms were highest in the treatments whereever they were applied. The maximum population of *Azospirillum,* VAM fungi and *Bacillus* were recorded in the treatment of 75 per cent recommended dose of nitrogen, phosphorus +100 per cent potassium+ vermicompost + *Azospirillum brasilense* + *Bacillus megaterium* + *Glomus fasciculatum* (VAM fungi) + panchagavya + jeevamrutha+ *Trichoderma harzianum* (T_7). The maximum *Trichoderma* population was recorded in T_7 and T_{12} (50 per cent recommended dose of nitrogen, phosphorus +100 per cent potassium + vermicompost + *Azospirillum brasilense* + *Bacillus megaterium* + *Glomus fasciculatum* (VAM fungi) + panchagavya + jeevamrutha+ *Trichoderma harzianum*.) The lowest population of *Azospirillum, Bacillus,* VAM and *Trichoderma* were found in uninoculated treatments which had only the recommended dose of NPK (T_1). This shows that a synergistic relationship exists between the N-fixers, P-solubilisers and biostimulants which resulted in increased population of these organisms in the treatments wherever they were applied. Similar reports of presence of increased population of introduced microorganisms were reported by Prasanna (2007) in gerbera.

5.7 Leaf analysis

The analysis of plant materials provides an idea of nutritional status which is used as diagonistic tool to arrive at need based manuring schedule for various crops. It also helps in estimating the rate of nutrient uptake, computation of nutrient absorbed, removed and finally the nutrient balance sheets. When compared with pre established standard norms, it indicates whether the nutrient status is in deficiency, optimum or excessive range. They can also be used to follow up the effectiveness of fertiliser application in terms of changes in tissue concentration (Tandon, 1993). In the present investigation leaf nutrient content was significantly influenced by different levels of fertilisation. The results indicated that panchagavya and vermicompost application enhanced the uptake of nutrients. Similar observations were recorded by Mantur (1988) in China aster and

Renukaradhya (2005) in carnation. The influence of various treatments on leaf N, P and K status is presented here. Among all the treatments, significantly higher N, P and K concentration and their uptake by gerbera were found to be maximum in treatment T_7 (75 % RD N,P and 100 % K + *Azospirillum brasilense* **+** *Bacillus megaterium* + *Glomus fasciculatum* (VAM fungi) + vermicompost + panchagavya + jeevamrutha + *Trichoderma harzianum*) followed by the treatment T_5 (75 % RD N,P and 100 % K + *Azospirillum brasilense* **+** *Bacillus megaterium* + *Glomus fasciculatum* (VAM fungi) + vermicompost + jeevamrutha) and treatment T_6 (75 % RD N,P and 100 % K + *Azospirillum brasilense* **+** *Bacillus megaterium* + *Glomus fasciculatum* (VAM fungi) + vermicompost + panchagavya).

This is attributed to the better availability and uptake of nutrients facilitated by biostimulants, biofertilizers and organic manures. *Azospirillum* inoculation might have resulted in better fixation of nitrogen in soil, thus resulting in increased uptake of nitrogen in plants. The beneficial effect of PSB on nutrient uptake was reported in tuberose by Swaminathan *et al*. (1999). The results also indicate that vermicompost application enhanced the uptake of nutrients in all the treatments which is similar to the observation made by Mantur (1988) in China aster. The acquisition of P may also be attributed due to activity of VAM fungi. The hyphae of VAM act as an extension of the root system and help the plant acquire water and nutrients. This is confirmed by the earlier findings of Dufault *et al*. (1990) that mycorrhizal inoculation in gerbera improves the phosphorus and potassium uptake which results in improved flower quality.

Increase in uptake of nutrients in plants applied with jeevamrutha might be due to increased availability of nutrients due to build up of soil microflora resulting in increased enzymatic activity. However, the increase in uptake of nutrients with foliar spray of panchagavya was ascribed to increased biological efficiency of crop plants and creating greater source and sink in the plant system (Vivekanandan, 1999) that might have helped in absorption of the nutrients. It may also be due to increased leaf area index in panchagavya treatments indicating increased photosynthetic efficiency of plants leading to increased uptake of nutrients.

5.8 Benefit: Cost ratio as influenced by INM

Profit depends not only on the productivity of the crop but also the quality of the produce in association with the competitive price in the market. This can be achieved by lowering the cost of production, which is possible with the optimisation of nutrients, efficient mode and form of application. The maximum benefit cost ratio (1:1.49) was obtained in 75 per cent recommended dose of nitrogen, phosphorus +100 per cent potassium + vermicompost + *Azospirillum brasilense* + *Bacillus megaterium* + *Glomus fasciculatum* (VAM fungi) + panchagavya + jeevamrutha+ *Trichoderma harzianum* (T_7). Since the total crop duration is three to four years, the incurred expenditure during second year may reflect for 3rd year.

Practical utility of the study

The present investigation reveals that there was an improvement in the nutrient uptake, growth, yield and quality parameters of gerbera cv. Galileo Red with application of biofertilisers and biostimulants in combination with different levels of recommended dose of fertilizers. Based on the results of the study, it is concluded that, 75 per cent recommended dose of nitrogen, phosphorus + 100 per cent potassium+ vermicompost + *Azospirillum brasilense* + *Bacillus megaterium* + *Glomus fasciculatum* (VAM fungi) + panchagavya + jeevamrutha + *Trichoderma harzianum* proved to be the best considering the growth, yield, quality and vase life parameters. Application of 75 per cent recommended dose of nitrogen, phosphorus +100 per cent potassium+ vermicompost + *Azospirillum brasilense* + *Bacillus megaterium* + *Glomus fasciculatum* (VAM fungi) + jeevamrutha proved to be the second best treatment. Hence these treatments can be applied for commercial cultivation of gerbera. Application of 50 per cent recommended dose of fertilisers along with biofertilisers, organic manures and biostimulants also proved better than application of inorganic sources of nutrients alone.

5.9 Future line of work

1. The application of organic manure, biofertilisers and biostimulants along with graded inorganic fertilisers may be tried for different cultivars to assess differential response of cultivars.
2. In the present study, the growth, flower yield and quality were studied for first two years only. INM studies should be continued for entire crop period to assess performance during later stages.
3. Role of micronutrients and growth regulator treatments may be studied.
4. Need to standardise the levels, method of application and intervals of application of biofertilisers, biostimulants, micronutrients and growth regulators to achieve quality production.
5. Timely availability, certification, quality of biofertilisers, biostimulants and other organic sources need to be addressed to get better results.

Summary

VI. SUMMARY

Studies were conducted to know the Effect of integrated nutrient management on growth, flower yield and postharvest quality of gerbera (*Gerbera jamesonii* Bolus.) cv. Galileo Red under poly house condition during the year 2010-2012 at the Floriculture unit, Department of Horticulture, University of Agricultural Sciences, GKVK, Bangalore. The salient findings of this investigation are summarized in this chapter.

The results of the research study has clearly showed that application of biofertilisers and biostimulants in conjunction with reduced levels of chemical fertilisers has beneficial effects in improving the plant growth parameters, quality, yield and vase life of gerbera. Significant differences were observed among the treatments with respect to growth, yield, quality and vase life parameters.

Among the growth parameters, significantly highest plant height and plant spread was recorded in plants receiving 75 per cent recommended dose of nitrogen, phosphorus +100 per cent potassium+ vermicompost + *Azospirillum brasilense* + *Bacillus megaterium* + *Glomus fasciculatum* (VAM fungi) + panchagavya + jeevamrutha+ *Trichoderma harzianum* (47.53cm and 49.66cm^2) at 270 DAP and lowest plant height (40.13cm) and plant spread (42.30cm^2) was recorded in plants receiving the recommended dose of fertilisers alone.

Significantly maximum number of leaves (28.80) and maximum leaf area (158.40 cm^2) were recorded in plants receiving 75 per cent recommended dose of nitrogen, phosphorus +100 per cent potassium+ vermicompost + *Azospirillum brasilense* + *Bacillus megaterium* + *Glomus fasciculatum* (VAM fungi)+ panchagavya + jeevamrutha+ *Trichoderma harzianum* at 270 DAP.

Significantly maximum number of suckers (6.06) were recorded in plants receiving 75 per cent recommended dose of nitrogen, phosphorus +100 per cent potassium+ vermicompost + *Azospirillum brasilense* + *Bacillus megaterium* + *Glomus fasciculatum* (VAM fungi)+ panchagavya + jeevamrutha+ *Trichoderma harzianum.*

Treatment receiving 75 per cent recommended dose of nitrogen, phosphorus +100 per cent potassium+ vermicompost + *Azospirillum brasilense* + *Bacillus megaterium* + *Glomus fasciculatum* (VAM fungi) + panchagavya + jeevamrutha+ *Trichoderma harzianum* showed early flower bud initiation (24.27 days after planting) took significantly least number of days for complete flower opening (12.13days) and 50 per cent flowering (83.66days).

Maximum diameter of flower (9.66cm) and length of ray florets (3.93 cm) was recorded in plants receiving 75 per cent recommended dose of nitrogen, phosphorus +100 per cent potassium+ vermicompost + *Azospirillum brasilense* + *Bacillus megaterium* + *Glomus fasciculatum* (VAM fungi)+ Panchagavya + Jeevamrutha+ *Trichoderma harzianum* which was significant over control.

Significantly longest flower stalk length (59.53cm) and maximum stalk diameter (0.568cm) was recorded in the treatment receiving 75 per cent recommended dose of nitrogen, phosphorus +100 per cent potassium + vermicompost + *Azospirillum brasilense* + *Bacillus megaterium* + *Glomus fasciculatum* (VAM fungi)+ panchagavya + jeevamrutha+ *Trichoderma harzianum.*

Number of flowers per plant per year (31.47 and 38.80 flowers in first and second year respectively), number of flowers per meter square per year (220.26 and 271.66 flowers for the first and second year) and number of flowers per 1000m^2 for two years (491920) was significantly higher in plants receiving 75 per cent recommended dose of nitrogen, phosphorus +100 per cent potassium + vermicompost + *Azospirillum brasilense* + *Bacillus megaterium* + *Glomus fasciculatum* (VAM fungi) + panchagavya + jeevamrutha+ *Trichoderma harzianum*. Least number of flowers per plant and flowers per square meter was recorded in plants receiving 100% recommended dose of NPK (184.13 and 220.73 flowers for the first and second year respectively).

Significantly longer shelf life (15.33days), higher water uptake (93.66g), was recorded in plants receiving 75 per cent recommended dose of nitrogen, phosphorus +100 per cent potassium+ vermicompost + *Azospirillum brasilense* + *Bacillus* *megaterium* + *Glomus fasciculatum* (VAM fungi)+ panchagavya + jeevamrutha+ *Trichoderma harzianum.*

Results of soil and leaf analysis showed significantly maximum available soil nutrients (258.13, 36.56, kg/ha N, P_2O_5 respectively) and highest NPK content in leaves (2.96% N, 0.45% P, 4.40% K) of plants receiving 75 per cent recommended dose of nitrogen, phosphorus +100 per cent potassium + vermicompost + *Azospirillum brasilense* + *Bacillus megaterium* + *Glomus fasciculatum* (VAM fungi) + panchagavya + jeevamrutha+ *Trichoderma harzianum* at twelve months after planting.

The microbial analysis of soil showed that general microorganisms *viz.*, bacteria, fungi and actinomycetes (94.67 x 10^6cfu g^{-1}soil, 28.33 x 10^3cfu g^{-1}soil and 18.67 x 10^4cfu g^{-1} soil respectively) and beneficial microorganisms like *Azospirillum brasilense, Bacillus megaterium, Trichoderma harzianum* and VAM spores were maximum (19.33 x 10^6cfu g^{-1}soil, 15.33 x 10^6cfu g^{-1} soil, 15.33 x 10^3cfu g^{-1} soil and 85.33 spores/50g soil) at twelve months after planting, in plots treated with 75 per cent recommended dose of nitrogen, phosphorus +100 per cent potassium + vermicompost + *Azospirillum brasilense* + *Bacillus megaterium* + *Glomus fasciculatum* (VAM fungi) + panchagavya + jeevamrutha+ *Trichoderma harzianum.*

The highest net returns (Rs. 884977 per $1000m^2$) and cost benefit ratio (1:1.49)for a period of two years were in the treatment receiving 75 per cent recommended dose of nitrogen, phosphorus +100 per cent potassium+ vermicompost + *Azospirillum brasilense* + *Bacillus megaterium* + *Glomus fasciculatum* (VAM fungi) + panchagavya + jeevamrutha+ *Trichoderma harzianum*.

The results clearly elucidated that gerbera responds very well to bio fertilisers and bio stimulants application. In integrated nutrient management practice the application of 75 per cent recommended dose of nitrogen, phosphorus +100 per cent potassium+ vermicompost + *Azospirillum brasilense* + *Bacillus megaterium* + *Glomus fasciculatum* (VAM fungi) + panchagavya + jeevamrutha+ *Trichoderma harzianum* proved to be the best considering the growth, yield and returns.

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* Originals not seen

Appendices

APPENDIX -I

Mean monthly weather data of G.K.V.K, UAS., Bangalore for the period from June 2010 to June 2012

Months	Temperature (°C)		Relative Humidity (%)		Rainfall (mm)	Sunshine (hrs/day)
	Max	Min	I hr.	II hr.		
June 2010	29.70	19.70	89	46	95.4	5.9
July 2010	27.80	19.20	94	53	142.2	3.3
August 2010	27.10	19.20	94	58	158.2	3.2
September 2010	27.20	19.10	92	59	89.4	3.8
October 2010	28.00	19.00	93	54	119.2	5.0
November 2010	26.30	17.70	95	58	128.6	4.2
December 2010	25.70	15.20	92	53	9.8	5.1
January 2011	27.80	12.70	89.9	41.3	0.0	9.1
February 2011	29.50	13.60	87.0	39.2	16.6	8.9
March 2011	32.90	16.40	85.0	33	0.0	9.0
April 2011	32.60	20.20	89.3	38.9	57.4	7.3
May 2011	32.10	19.90	90	40	126.00	7.8
June 2011	29.10	19.50	94	48	30.00	6.1
July 2011	27.80	19.30	94	53	95.8	4.2
August 2011	27.30	19.30	94	55	253.2	3.3
September 2011	28.00	18.90	94	51	59.7	5.9
October 2011	28.60	19.20	93	51	122.6	5.6
November 2011	26.60	15.90	89	53	38	6.2
December 2011	26.90	14.40	91	52	5.2	7.3
January 2012	28.00	14.30	90	46	0	9.2
February 2012	30.50	15.10	86	36	0	9.3
March 2012	33.70	18.70	82	32	0.4	8.9
April 2012	34.60	21.20	82	32	8.6	8.2
May 2012	33.00	21.10	88	49	84.4	7.5
June 2012	30.9	20.3	87	44	26.6	6.3

APPENDIX -II

Physico chemical and biological properties of Panchagavya

Chemical composition	
pH	5.45
EC dSm2	10.22
Total N(ppm)	229
Total P(ppm)	209
Total K(ppm)	232
Sodium	90
Calcium	25
IAA (ppm)	8.5
GA(ppm)	3.5
Microbial load	
Fungi	38800/ml
Bacteria	1880000/ml
Lactobacillus	2260000/ml
Total anaerobes	10000/ml
Acid formers	360/ml
Methanogen	250/ml

APPENDIX-III

Chemical properties of soil before planting

Available Nitrogen (kg ha^{-1})	247.4
Available Phosphorus (kg ha^{-1})	20.6
Available Potassium (kg ha^{-1})	315.4

APPENDIX-IV

MEDIA COMPOSITION

1. Soil extract agar (g/l)

Sl.No.	Ingredients	Quantity
1	Glucose	10.00g
2	KH_2PO_4	0.50g
3	Yeast extract	10.00g
4	Agar	15.00g
5	pH	6.7-7.2
6	Soil extract	100ml
7	Distilled water	900ml

Soil extract is prepared by autoclaving 1000gms of garden soil with 1000ml of water for 30 minutes at 1.10kg/cm^2 pressure. Pinch of $CaCo_3$ is added and filtered through filter paper till a clear suspension is obtained.

2. Martin's rose Bengal agar medium(g/l)

Sl.No.	Ingredients	Quantity
1	Glucose	10.00g
2	$MgSO_4.7H_2O$	0.50g
3	KH_2PO_4	1.00g
4	Peptone	5.00g
5	Rose Bengal	0.33g
6	Streptomycin sulphate (10% solution)	3ml
7	Agar	15.00g
8	Distilled water	1000ml
9	pH	7.00

3. **Kuster's agar (g/l)**

Sl. No.	Ingredients	Quantity
1	Glycerol	10.00g
2	Casein	0.30g
3	KNO_3	2.00g
4	NaCl	2.00g
5	KH_2PO_4	2.00g
6	$MgSO_4.\ 7H_2O$	0.50g
7	$CaCO_3$	2.00g
8	Agar	15.00g
9	Distilled water	1000ml
10	pH	7.2

4. **Doberiner's medium (g/l)**

Sl. No.	Ingredients	Quantity
1	Malic acid	5.00g
2	KOH	4.00g
3	KH_2PO_4	0.50g
4	$FeSO_4.\ 7H_2O$	0.01g
5	$MnSO_4.7H_2O$	0.01g
6	$MgSO_4.\ 7H_2O$	0.10g
7	NaCl	0.02g
8	$CaCl_2$	0.01g
9	Na_2MoO_4	0.002g
10	Distilled water	1000ml
11	Agar	15.00g
12	pH	6.6-7.0

5. Pikovoskaya's Agar(g/l)

Sl.No.	Ingredients	Quantity
1	Glucose	10.00g
2	$Ca(PO_4)_2$	5.00g
3	$(NH_4)_2SO_4$	0.50g
4	KCl	0.20g
5	$MgSO_4.\ 7H_2O$	0.10g
6	$MnSO_4$	Trace
7	$FeSO_4$	Trace
8	Yeast extract	0.50g
9	Agar	15.0g
10	Distilled water	1000ml
11	pH	7.0

6. Trichoderma specific medium (g/l)

Sl.No.	Ingredients	Quantity
1	$Mg\ SO_4.\ 7H_2O$	0.20g
2	$KH_2\ PO_4$	0.90g
3	KCl	0.15g
4	NH_4Cl	3.00g
5	PCNB	0.30g
6	Rose Bengal	0.15g
7	Agar	20.0
8	Chloromphenicol	0.25g
9	Propanocarb/Metaloxyl	1.60g
10	Distilled water	1000ml
11	pH	6.0

APPENDIX-V

General microbiological population of soil before planting

Bacteria (No. 10^6 X $Cfug^{-1}$ soil)	20.00
Fungi (No. 10^3 X Cfug-^{1} soil)	11.33
Actinomycetes (No. 10^4 X $Cfug^{-1}$ soil)	3.00
***Azospirillum* sp.** (No.10^6 X $Cfug^{-1}$ soil)	4.00
***Bacillus* sp.** (No. 10^6 X $Cfug^{-1}$ soil)	6.00
Trichoderma (No. 10^3 X $Cfug^{-1}$ soil)	2.00
VAM (Spores per 50g soil)	28.00

APPENDIX - VI

Calculation of detailed cost of cultivation of Gerbera (*Gerbera jamesonii* Bolus.) cv. Galileo Red grown under naturally ventilated polyhouse (1000 sq.m) for two years.

I. Fixed cost for construction of 1000 m^2 poly house

Sl. no	Particulars	Total cost (Rs)	Depreciation (Rs)
1	Polyhouse structure (Excluding cladding material) at Rs. 610/m^2 for the life span of 10 years	6,10,000	1,22,000
2	Cladding material at Rs.33/m^2 for the life span of 3 years	33,000	22,000
3	Drip irrigation system at Rs. 40/ m^2 for a life span of 10 years	40,000	8,000
4	Fertigation system (ventury system) at Rs. 1000 for a life span of 3 years	1,000	1,000
5	Planting material at 28 Rs (7plants/m^2) for 3 years	196000	65333
6	Repair and maintenance		5,000
7	Total operational cost		223333

II. Cost of Organic fertilizer

Sl. No.	Organic fertilizer	Cost(Rs.)
1.	Farm Yard manure 5 tones @ Rs.1200 /tone	6000
2.	Vermicompost @ Rs.5/kg	12,500

III. Cost of Biofertilizers

Sl. No.	Biofertilizers	Quantity (kg)	Cost(Rs.)
1.	*Azospirillum brasilense*	40	3,200
2.	*Bacillus megaterium*	40	3,200
3.	*Glomus fasciculatum* (VAM fungi)	40	1,200
4.	*Trichoderma harzianum*	20	1,600

* *Azospirillum brasilense*- Rs. 80/kg

* *Bacillus megaterium*- Rs. 80/kg

* *Glomus fasciculatum* (VAM fungi) - Rs. 30/kg

* *Trichoderma harzianum*- Rs. 80/kg

IV. Cost of Biostimulants

1. Panchagavya- Rs.4560
2. Jeevamrutha- Rs. 2200

V. Cost of Inorganic fertilizers

Treatments	Quantity			Cost			Total cost (Rs)
	19 all (kg)	Urea (kg)	MOP (kg)	19 all (Rs)	Urea (Rs)	MOP (Rs)	
100 % NPK	1515	678	518	121200	4746	3108	129054
75 % NP & 100% K	1136	500	640	90880	3500	3840	98220
50 % NP & 100% K	757	338	732	60560	2366	4392	67318

*Rs.2,000/25 Kg bag of 19:19:19 (water soluble)

*Rs. 6/kg of MOP

*Rs. 7/Kg of Urea

VI. Cost of plant protection measures

Sl. No	Chemicals	Total cost (Rs.)
1.	**Formalin (for fumigation)**	8,760
2.	**Insecticides and Fungicides**	90,000
3.	**Micro nutrients**	10,000
	Total	1,00,000

VII. Cost of Labour

Sl. No.	Particulars	Total cost (Rs.)
1.	**Men:** 500 man days @ Rs.140/man	70,000
2.	**Women:** 540 women days@ Rs.120/woman	64,800
3.	Total cost	1,34,800

Note: Cost for labour includes fumigation, soil preparation, planting, plant protection, irrigation, intercultivation and harvesting.