INTEGRATED NUTRIENT MANAGEMENT AND VASE LIFE OF GLADIOLUS (*Gladiolus grandiflora* L.)

Thesis

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NAGALAND UNIVERSITY

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of

DOCTOR OF PHILOSOPHY

in

HORTICULTURE

by

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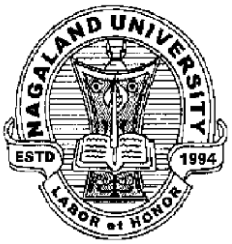

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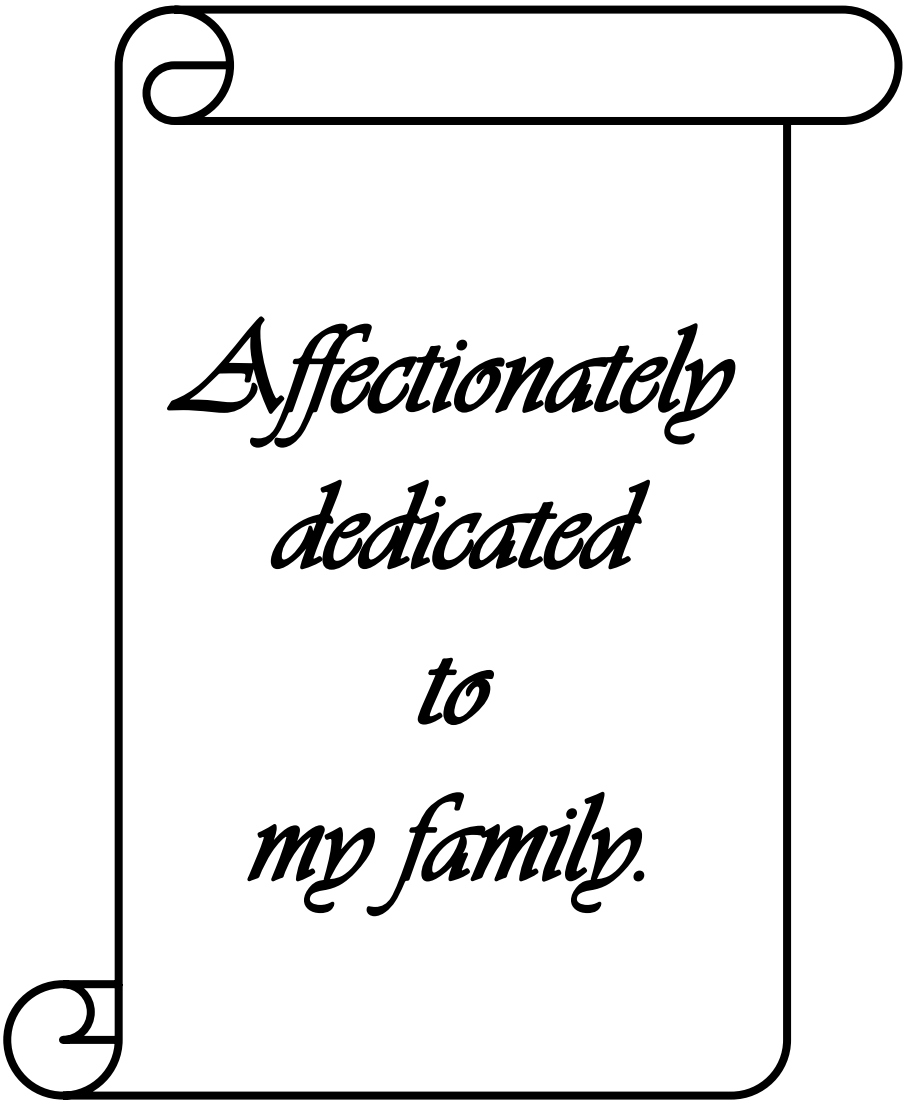
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I, M Jangyukala, hereby declare that the subject matter of this thesis is the record of work done by me, that the contents of this thesis did not form the basis of the award of any previous degree to me or to the best of my knowledge to anybody else, and that the thesis had not been submitted by me for any research degree in any other university/institute.

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CERTIFICATE – I

This is to certify that the thesis entitled **"Integrated nutrient management and vase life of Gladiolus (*Gladiolus grandiflora* L.)"** submitted to Nagaland University in partial fulfillment of the requirements for the award of degree of Doctor of Philosophy in Horticulture is the record of research work carried out by Ms. M Jangyukala Registration No. Ph.D./HOR/00348 under my personal supervision and guidance.

The result of the investigation reported in the thesis have not been submitted for any other degree or diploma. The assistance of all kinds received by the student has been duly acknowledged.

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VIVA VOCE ON THESIS OF DOCTOR OF PHILOSOPHY IN HORTICULTURE

This is to certify that the thesis entitled **"Integrated nutrient management and vase life of Gladiolus (*Gladiolus grandiflora* L.)"** submitted by Ms. M Jangyukala, Admission No. Ph-246/18 Registration No. Ph.D./HOR/00348 to the NAGALAND UNIVERSITY in partial fulfillment of the requirements for the award of degree of Doctor of Philosophy in Horticulture has been examined by the Advisory Board and External examiner on …….....

The performance of the student has been found **Satisfactory/Unsatisfactory.**

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CONTENTS

3.3.2 Flowering attributes
- 3.3.2.1 Days taken for spike initiation
- 3.3.2.2 Days taken for first floret opening
- 3.3.2.3 Spike length (cm)
- 3.3.2.4 Rachis length (cm)
- 3.3.2.5 Number of spikes per plant
- 3.3.2.6 Number of florets per spike
- 3.3.2.7 Floret diameter
- 3.3.2.8 Days to harvesting of spikes

3.3.3 Corm parameters
- 3.3.3.1 Number of corms per plant
- 3.3.3.2 Corm diameter (cm)
- 3.3.3.3 Weight of corms per mother corm
- 3.3.3.4 Number of cormels per plant
- 3.3.3.5 Weight of cormels per mother corm

3.3.4 Quality parameters
- 3.3.4.1 Self life
- 3.3.4.2 Vase life in distilled water

3.3.5 To study the chemical properties and nutrient status of the soil and nutrient content in Bio-inputs
- 3.3.5.1 Available Nitrogen
- 3.3.5.2 Available Phosphorus
- 3.3.5.3 Available Potassium
- 3.3.5.4 Estimation of pH
- 3.3.5.5 Estimation of electrical conductivity
- 3.3.5.6 Organic carbon

3.3.6 To study the effect of integrated nutrient management (INM) on nutrient uptake by the plants
- 3.3.6.1 Leaf sampling and nutrient analysis
  - 3.3.6.1.1 Nitrogen
  - 3.3.6.1.2 Phosphorus & Potassium
- 3.3.6.2 Corm sampling and nutrient analysis

3.3.7 To study the economics for different treatments
- 3.3.7.1 Cost of cultivation
- 3.3.7.2 Gross income
- 3.3.7.3 Net income
- 3.3.7.4 Benefit cost ratio

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

LIST OF APPENDICES

LIST OF ABBREVIATIONS

%	Percent
±	Plus or minus
$^{-1}$	Per
@	At the rate of
^{o}C	Degree Celsius
/	Per
%	Percentage
₹	Rupee(s)
ANOVA	Analysis of variance
CD	Critical Difference
Cm	Centimetre
CRD	Completely Randomized Design
cv.	Cultivar
DAP	Days After Planting
E	East
EM	Effective Microorganism
et al.	And others
etc	etcetera
Fig	Figure
FYM	Farm Yard Manure
g	gram
ha	hectare

i.e.	That is
IEM	Indigenous Effective Microorganism
IMO	Indigenous Microorganism
INM	Integrated Nutrient Management
K	Potassium
Kg	Kilogram
L	Litre
M	Metre
N	Nitrogen
N	North
No.	Number
NS	Non Significant
P	Phosphorus
pH	negative logarithm oh hydrogen ion activity of a soil
RBD	Randomized Block Design
RDF	Recommended Dose of Fertilizer
S	Significant
S	South
SEm±	Standard Error Mean
t	Tonnes
Viz.	Namely
W	West

ABSTRACT

A study entitled "**Integrated nutrient management and vase life of gladiolus (Gladiolus grandiflorus L.)**" was conducted during the year 2021-2022 in the Experimental farm at Department of Horticulture, SASRD, Nagaland University, Medziphema Campus, Nagaland. Two experiments were carried out to study the effect of different sources of nutrients and their combination on growth, flowering, corm characters, nutrient uptake, economics of cultivation and vase life of gladiolus (*Gladiolus grandiflorus* L.) using locally available preservatives. Gladiolus cultivar Candyman procured from Pushpanjali nursery located at Midnapur, West Bengal was used for the experiment.

The First experiment was laid out in Randomized Block Design with 8 treatments and 3 replications. 16 corms were planted at a spacing of 40cm × 30cm in plot size of 1.6 m × 1.5 m with african double marigold as intercrop. The treatments were T_0 (Control *i.e.*Untreated), T_1 (100% Recommended Dose of Fertilizer *i.e.* 40:20:20 gm NPK m^{-2}), T_2 (EM *i.e.* 100 ml activated Effective Microorganism m^{-2}), T_3 (IEM *i.e.* 500 ml activated Indigenous Effective Microorganism m^{-2}), T_4 (Jeevamrutha 50 ml m^{-2})**,** T_5 (50% RDF + 50% EM), T_6(50% RDF + 50% IEM) and T_7 (50% RDF + 50% Jeevamrutha). Pooled results revealed that T_0 (Control *i.e.*Untreated) recorded the maximum rachis length (33.66 cm), T_2 (EM *i.e.* 100 ml activated EM m^{-2}) recorded the minimum days to sprouting (6.83 days),maximum number of leaves (7.73), leaf length (46.16 cm), maximum no. of spikes per plant (1.03), minimum days for spike emergence(68.48 days), first floret opening (74.24 days) and harvesting of spikes (7.91 days), T_3 (IEM *i.e.* 500 ml activated IEM m^{-2}) recorded the maximum spike length (89.62 cm), no. of florets per spike (10.47), floral diameter (9.97 cm) and no. of corms per plant (1.76), T_5 (50% RDF + 50% EM) recorded the maximum girth of plant base (6.23 cm), corm diameter (4.90 cm), weight of corm per mother plant (25.93 gms), no. of cormels per plant (15.73), weight of cormels per mother corm (14.07 gms) and T_6(50% RDF + 50% IEM) recorded the maximum plant height (108.09 cm), leaf area at spike emergence (125.32 cm^2) and vase life in distilled water (11.17 days). Nitrogen, phosphorus and potassium content in soil

was found to be maximum in T_2 (EM *i.e.* 100 ml activated EM m^{-2}) with 961.71 kg/ha N, 61.96 kg/ha P and 516.50 kg/ha K while T_5 (50% RDF + 50% EM) recorded the maximum content of organic carbon (2.81 %). Highest content of N (4.33 %) in gladiolus leaves was recorded in T_2 (EM *i.e.* 100 ml activated EM m^{-2}) while P (0.011 %) was recorded in T_3 (IEM *i.e.* 500 ml activated IEM m^{-2}). T_1 (100% RDF *i.e.* 40:20:20 gm NPK m^{-2}) recorded the highest content of N (3.08 %) in gladiolus corms and T_3 in P (0.016 %). T_3 (IEM *i.e.* 500 ml activated IEM m^{-2} exhibited the highest net income (Rs 676,653) and benefit cost ratio (2.46). It was concluded that the application of Effective microorganism (EM) as in T_2 (100 ml activated EM m^{-2}) and T_5 (50% RDF + 50% EM) recorded the best results in growth, flowering and corm characters of gladiolus.

The second experiment had 10 treatments, replicated 5 times with one spike in each replication in Completely Randomized Design. The treatments were T_1 (Control *i.e.* distilled water), T_2 (Lime Juice 1%), T_3 (Citric acid 0.05%**),** T_4(Cane Sugar 10%), T_5 (Commercial bleaching powder 0.005%), T_6 (Lime Juice 1%+ Cane Sugar 10%**)**, T_7 (Citric acid 0.05%+ Cane Sugar 10%), T_8 (Cane Sugar 2%**+** Commercial bleaching powder 0.005%), T_9 (Lime Juice 1%+ Cane Sugar 2% **+** Commercial bleaching powder 0.005%) and T_{10} (Citric acid 0.05%+ Cane Sugar 2% **+** Commercial bleaching powder 0.005%). Cut gladiolus flowers were placed in 500 ml bottles containing 300 ml aqueous solution of various preservatives and distilled water as control was prepared. T_{10} (Citric acid 0.05%+ Cane Sugar 2% **+** Commercial bleaching powder 0.005%) recorded the minimum number of days to basal floret opening (2.10 days), maximum basal floret size (9.99 cm) and also the longest total blooming period and vase life of 9.60 and 7.60 days, respectively. On the other hand, use of commercial bleaching powder 0.005% as a locally available vase life preservative was economically more capable to extend the vase life of gladiolus as the benefit cost returns were recorded to be the highest (3.60) in this treatment.

CHAPTER I

INTRODUCTION

INTRODUCTION

Flowers are associated with mankind in every aspect of life. They are an essential component of human life that symbolize love, happiness, and emotions. They are the perfect gift of nature, bringing beauty, scent and cheerfulness to our lives. They play a vital role in rituals, celebrations, and provide many environmental benefits. They have been used for centuries for various purposes, including religious ceremonies, decoration, medicine, and as a source of perfume.

Floriculture is the aesthetic part of horticulture. All over the world, the floricultural sector is experiencing rapid changes and has become an important commercial activity in agriculture. The Government of India has identified floriculture as “sunrise industry”. It is also one of the fastest growing sectors in the Horticulture sector of the state. The floriculture industry comprises of both commercial and traditional flower production, mainly for export purposes. This development has led to the emergence of this sector as an important segment of trade. Among the popular commercial cut flowers is the queen of ornamental bulbous crop, Gladiolus (*Gladiolus grandiflora* L.) which is a tender herbaceous perennial plant, commonly called Sword lily and belongs to the family *Iridaceae*. It is a tall and beautiful flower with sword-like leaves and comes in a wide range of colors. The inflorescence is a spike that can take on multiple blooms. Gladiolus is a symbol of strength, integrity, and honor. It has a wide range of applications in Indian culture, as well as a promising market in the North East. Gladiolus, especially in India and the northeastern states, is a popular flower and are commonly used in art and for decoration.

The flowers are used in flower arrangement, in bouquets and for indoor decorations. It ranks fourth in the international trade for ornamental cut flowers and ranks first in terms of returns. There is a vast market for gladiolus farming, making it a vital source of income and an integral part of our culture.

However to increase production, excessive use of chemical fertilizers is implemented and it degrades the soil. In order to achieve sustainability of the soil quality, it is highly advisable to reduce or replace with some non-chemical alternatives. Thus, organic inputs are found to successfully meet the requirements in many agricultural and horticultural crops. The key to a fertile soil lies in the organic content present in it. The use of organic manures, effective microorganisms (EM), indigenous effective microorganisms (IEM) and jeevamrutha are crucial for maintaining soil health. They play a pivotal role in enhancing the soil's natural fertility by improving its structure, water holding capacity and nutrient content. Adopting these practices is not only good for the environment but also for our health as they reduce the use of harmful chemicals in agriculture. These organic inputs provide essential nutrients to the soil for better plant growth and yield. These days, many farmers are realizing the importance of organic farming and are shifting towards this eco-friendly method of agriculture.

Organic farming is a recyclable and sustainable strategy for farming. It is an effective and cost-efficient method to attain sustainable advancement in the agriculture sector (IFOAM, 2010). Currently, organic farming has been accepted by the global and local agriculture system and is proven beneficial for both socio-economic and environmental factors. Organic sources have been reported to improve yield as well as soil condition. They also provide all the essential nutrients unlike chemical fertilizers that deprive the soil of its nutrients and cause it to degrade. In floriculture, organic inputs that are commonly utilized as

substrate media are cocopeat, vermicompost, FYM, panchgavya, biofetilizers and livestock waste manures. Very limited work has been done in application of effective micro-organism (EM), indigenous effective micro-organism (IEM) and jeevamrutha in floriculture.

Effective micro-organism (EM) was developed at the University of Ryukyus, Japan in 1989 by Prof. Dr. Terou Higa. EM is a fermented live mixed culture of 83 bacterial and fungal strains of different species naturally isolated from the soil. The use of EM as an addictive to manure or as a spray directly in the field increase the micro-fauna biodiversity of the soil, leading to an improvement in field production. The main species involved in EM include Photosynthetic bacteria (*Rhodopseudomonas palustrus, Rhodobacter spaeroides*), Lactic acid bacteria (*Lactobacillus plantarum*, *L. casei*, *Streptoccus lactis*), Yeast (*Saccharomyces cereviasiae, Candida utilis*), Actinomycete (*Streptomyces albus, S.griseus*) and Fermenting fungi (*Aspergillus oryzae, Mucor hiemalis*). Photosynthetic bacteria are the backbone of the EM, working in synergy with other microorganisms to improve the absorption of nutrients from the soil and reduce the incidence of disease. Lactic acid is a strong sterilizer and these bacteria have the ability to suppress *Fusarium* propagation which is a harmful microorganism that causes disease problem in continuous cropping. The occurrence of nematodes disappears gradually, as lactic acid bacteria suppress the propagation and function of *Fusarium*. Bioactive substances such as hormones and enzymes produced by yeasts promote active cell and root division. Antimicrobial substances suppress harmful fungi and bacteria. Fermenting fungi such as *Aspergillus* and *Penicillium* decompose organic matter rapidly to produce alcohol, esters and antimicrobial substances. These suppress odors and prevent infestation of harmful insects and maggots. Therefore, EM has more advantage over natural organisms in organic amendments because the beneficial micro-organisms are in

much greater numbers, optimally-balanced populations when introduced. They persist in the soil environment for a much longer time enough to bring about the beneficial effects. Studies have shown that EM improves the soil quality and crop health. EM is used as organic pesticide and fungicides. It interact with the soil-plant ecosystem by controlling plant pathogens and disease agents, solubilizing minerals, increasing plant energy availability, stimulating the photosynthetic system and maintaining the microbiological balance of the soil. The products based on Effective Microorganisms, given the microbial multiplicity may contain various organic acids, antioxidants, enzymes and chelates. Research on the application of EM microorganisms on different cultivated plants has shown that these microorganisms at agronomic level can significantly influence seed germination, plant vigour, leaf photosynthesis, early fructification, plant height, number of fruits (Prisa, 2019a). This technology was developed with the intention to use natural organisms to help and nurture nature to make the environment cleaner and sustainable for the future generations.

Indigenous effective micro-organism (IEM) is another technology which is widely applied for the extraction of minerals, enhancement of agriculture and waste management. They are a group of beneficial microorganisms that originally exist in all the living things and have the potential to biodegrade, bioleach, biocompost, nitrificate, improve soil fertility and enhance the synthesis of plant growth hormones. The IEM is considered to be naturally made, while EMs are man-made as it a laboratory-cultured mixture of microorganisms (Kumar and Gopal, 2015).

Jeevamrutha is a cheap, ecofriendly organic fermented liquid product. It is a mixture of cow dung, cow urine, jaggery, gram flour and soil. The mixture is reported to act as a soil tonic because it contains lots of microbial load which

enhances the soil health and ensures availability of important nutrients for the plant.

Apart from application of organic inputs, it's reported that intercropping monocot with a dicot (marigold) plant ensures replenishment of soil fertility and health by trapping beneficial microbes. Marigold is a valuable traditional flower. It belongs to the family *Asteraceae* and it holds high demand in India as a loose flower. Both the crops are promising in generating high revenue and therefore, increase the income per unit area and reduce the production cost.

Also, the economic value of cut flowers is dependent on their shelf life but synthetic preservatives can be costly and hence locally available ones are proven to be handy and affordable by local florist. The basic components for an effective flower food must include sugar to provide energy to the flowers, a biocide to kill the microbes and an acidifier to lower pH of solution.

Considering the importance of sustainable flower production, the present study entitled **"Integrated nutrient management and vase life of Gladiolus (*Gladiolus grandiflora* L.)"** was undertaken with the following objectives.

1. To study the effect of different sources of nutrients and their combination on growth, flowering and corm characters.
2. To study the effect of integrated nutrient management (INM) on nutrient uptake by the plants.
3. The study the vase life using locally available preservatives.
4. To study the economics for different treatments.

CHAPTER II

REVIEW OF LITERATURE

REVIEW OF LITERATURE

An attempt has been made to collect and review the relevant literatures available on various aspects of work done so far on the application of organic inputs such as effective microorganisms, indigenous microorganisms, jeevamrutha and local floral preservatives for the best growth, yield and flower quality. Literatures on above aspects of the present study are reviewed in this chapter under the following heads.

2.1 Organic amendments

2.2 Effective microorganisms

2.3 Indigenous microorganisms

2.4 Jeevamrutha

2.5 Local floral preservatives

2.1. Organic amendments

Rajhansa (2010) investigated on integrated nitrogen management in gladiolus cv. Candyman and observed that 50% urea + 50% N (FYM) + P and K @ 20gm/m^2 performed the best in growth, yield and flower quality. Also, net return and benefit ratio was recorded highest in the same treatment.

Namdeo (2015) carried out an investigation to study about the effect of different levels of organic and inorganic nitrogen on growth and yield of Mogra (*Jasmium sambac* L.) cv. Bela and concluded that application of 50% vermicompost with 50% RDF (100kg N, 50kg P and 50kg K) enhanced the length of shoot, plant spread, number of leaves, yield and quality of flower of cv. Bela.

Pradhan (2016) standardized the organic nutrient in Sarpagandha and observed that maximum diameter of branches, seed yield and reserpine alkaloid content were recorded in the plants supplied with vermicompost @ 10 tonnes/ha. The highest net return and cost-benefit ratio was recorded in application of FYM @ 20 tonnes/ha.

Pattnaik (2016) carried out an investigation to find out the effect of organic manures on growth and flowering (*Polianthes tuberosa*) cv. Phule Rajani and the result of the study revealed that among the organic manures, application of vermicompost @ 1 Kg/m^2 and mustard oil cake @ 250 g/m^2 recorded maximum for vegetative growth and bulb parameters. Floral characters like spike length, rachis length and diameter of spike were maximum in mustard oil cake @ 500g/m^2 compared to other treatments. It was observed that application of vermicompost in combination with karanja oil cake (Pongamia oil cake) significantly influenced flower production in tuberose cv. Phule Rajani.

Priyadarshini (2017) studied on substitution of nutritional source through organics and bio-inputs on growth, flowering and corm production in gladiolus (*Gladiolus grandiflorus* L.) cv. American Beauty and recorded maximum values for vegetative, floral, corm, soil analysis parameters and net returns by the application of 75% RDF (22.5N: 15P: 6.75K g/m^2) + 25% RDN through vermicompost + *Azotobacter* + Potassium solubilizing bacteria (PSB) + Potassium mobilizing biofertiliser (KMB). Application of inorganics alone in the treatment of 100% RDF (30: 20P: 9K g/m^2) was found to record significantly lower performance than the above nutritional treatments.

Deepthi (2018) carried out an experiment to study the effect of controlled release fertilizers and organic amendments on pot mum production. Among the

genotypes, ‘UHFS Chr-56’ had more number of flowers and side shoots, earlier arrival of visible bud formation stage, peak flowering, greater pot presentability score and marketability. However, larger plants with more spread, larger flowers with longer flower duration were found in genotype ‘UHFS Chr-68’. Application of controlled released fertilizers (CRF) B (11.2g/pot) along with jeevamrit @ 5% (250ml/pot at monthly interval) was effective in increasing the plant height, plant spread, number of side shoots per plant, number of flowers per plant and earlier arrival of visible bud formation, peak flowering, stage of marketability and increased the pot presentablity score of potted chrysanthemums. However, CRF B (11.2g/pot) + PGRS (KS_2 + KS_3 as root dip method) were effective in increasing the duration of flowering and flower diameter. The benefit cost ratio was more for the treatment CRF B (11.2g/pot) along with Jeevamrit @ 5% (250ml/pot at monthly interval) as compared with recommended dose of fertilizers.

Singh (2018) studied the effect of jeevamrit and different growing media on growth and flowering of gerbera (*Gerbera jamesonii* Bolus ex. Hook) and the results revealed that the use of cocopeat and vermicompost (1:1) along with application of at 20 days interval was the best combination for better growth, flowering and yield parameters in gerbera.

2.2. Effective microorganisms

Chantal *et al.* (2010) performed a comparative assessment on the responses of cabbage to effective microorganisms and chemical fertilizer (NP). EM, N and P were considered with two levels for each: L_1 (2% of EM, 100 mg N/kg and 75 mg P_2O_5/kg) and L_2 (5% of EM, 200 mg N/kg and 150 mg P_2O_5/kg). 150 mg K_2O/kg were supplied as a basal fertilizer. Results showed that EM effectively increases the leaf area; due to the effect of EM on plant root development, followed by better fostering with nutrients to the plant. Compared to fertilizer applied and

controlled grown vegetable-cabbage, the EM positively impacts by increasing the photosynthesis. The outcomes showed improvement in production due to the effect of EM. Hence, it should be considered as a support fertilizer, to enhance other fertilizer's capacity to supply nutrients to plants and fulfill sustainable development of agriculture.

Górski and Kleiber (2010) conducted studies was to assess the effect of the application of Effective Microorganisms (EM) on changes in contents of available and readily soluble forms of nutrients in the peat substrate as well as growth, development and yielding of rose (*Rosa* x *hybrida*) and gerbera (*Gerbera jamesonii*) grown on the substrate. In the conducted studies the effect of EM, applied both to the roots and as foliar application, was found on changes in contents of available nutrients in the substrate, at the simultaneous substrate acidification, in relation to the control combination. The significantly highest yield of flowers in case of both examined species was recorded at the application of the EM inoculum to the roots. This had a positive effect on the number or formed shoots and the diameter of flowers (in case of roses) and the number of formed inflorescences (in case of gerberas). Foliar application of Effective Microorganisms had a positive effect on the diameter of flowers in roses and the number of formed inflorescences and the number of leaves in case of gerberas.

Muthaura *et al.* (2010) designed a study to evaluate the effect of inoculation of effective microorganism on growth and yield of pigweed. The experiment was performed in five liter pots representing various conditions in the field. One set of the treatments consisted of soil collected from the field, while the other treatments consisted of soil and organic manure prepared using effective microorganisms, sterilized soil treated with effective microorganisms, and sterilized soil plus organic manure without application of effective microorganisms respectively.

Shoot height, stem diameter, leaf number per plant, leaf area, leaf fresh weight, leaf dry weight, root fresh weight, root dry weight and chlorophyll a and b contents were determined. Inoculated pigweeds with effective microorganisms recorded highest values in all the parameters measured except the root dry matter accumulation. The results from this study demonstrated that growth and yield of pigweeds may be improved by inoculating the plants with effective microorganisms, and as a result reduce the use of fertilizers in production of this vegetable promoting sustainable agriculture.

Shaheen *et al.* (2017) conducted an experiment to study the changes in soil fertility and spinach growth after the application of EM with organic wastes and chemical fertilizers. The six treatments were; control (T_0), 10 tons (t) ha^{-1} farm yard manure (FYM) (T_1), 20 t ha^{-1} pressmud (T_2), 0.7 t ha^{-1} compost (T_3), 5 t ha^{-1} poultry manure (T_4) and mixed chemical fertilizer in the ratio of 100 : 40 : 56 kg ha^{-1} as N, P and K (T_5). Each treatment was applied alone and with EM. It was concluded that EM-inoculated pressmud has higher potential to increases soil fertility as well as stimulate spinach growth and quality.

Sharma *et al.* (2017) conducted a study on the benefit of Efficient Microorganism (EM) compost on plant grown and soil health improvement in calendula and marigold. The study dealt with the effect of organic compost prepared using Efficient Microorganism (EM) consortium and applied along with full or half of the recommended dose of chemical fertilizers, on the growth of Calendula and Marigold plants, soil physico-chemical parameters and soil enzyme activities. Soil enzyme activities were improved with the increase in the rate of EM compost application in both Calendula and Marigold. Carotenoid pigment increased by 46.11% and 12.19% with application of EM compost over the control in Calendula and Marigold flowers respectively. Soil humus, available nitrogen

and organic carbon content also increased due to the supplementation of EM compost resulting in better soil fertility. For Calendula, treatment T_5 (Half dose NPK + EM compost 20 000 kg·hm^{-2}) was found to be the most promising in terms of acid phosphatase (82.63 g p-Nitrophenyl Phosphate·g^{-1}·h^{-1}), dehydrogenase (10.46 g Triphenyl Formazan·g^{-1}·d^{-1}) and β-glucosidase (0.30 IU·g^{-1}) activities. In Marigold, treatment C (Half dose NPK + EM compost 5 000 kg·hm^{-2}) was the most promising in terms of amendment in soil enzyme activities.

Al-Naqeeb *et al.* (2018) conducted a field experiment to investigate the response of three bread wheat (*Triticum aestivum* L.) cultivars (Ibaa99, Abu-Ghraib3 and Buhooth22) to the frequency of spraying with biofertilizer (EM-1) (one time at tillering stage, twice at tillering and stem elongation stages and three times at tillering, stem elongation and booting stages) in addition to the control (without spraying), to the increase of grain yield. The results showed that Ibaa99 cultivar, three times of EM-1 spraying and their interaction gave the highest averages of grain yield (3.89 and 4.31), (3.85 and 4.36) and (4.11 and 4.58 ton*ha^{-1}), respectively, for both seasons. It was concluded that yield responded significantly to the frequency of EM-1 spraying during vegetative stages.

Singh *et al.* (2018) designed a study to explore the possibilities of spray of effective microorganism on growth and yield of sponge gourd. The treatments involving different concentrations of effective microorganism were imposed by two foliar sprays at two and four true leaf stages of the crop. The results demonstrated that the spray of plants with effective microorganisms was found to be effective for the improvement of growth, physiology and yield and yield attributing characters of sponge gourd.

Prisa (2019a) performed a test for quality improvement of *Echinopsis* hybrids using effective microorganisms and chabazitic-zeolites and the results

showed that it increase the quality characteristics of the plant, in terms of vegetative and radical growth, better use of fertilizers and water, increase in seed germination and flowering duration. The test also showed that EM can attract pollinating insects to flowers, in particular bees.

Prisa (2019b) conducted a trial to evaluate the influence of EM microoganisms on growth and nitrate content on pepper and chilli plants. The results showed significantly higher and larger stem growth in plants treated with EM microorganisms and can therefore lead to an increase in production quality and a reduction in nitrate content on pepper and chilli plants.

Prisa (2019c) studied the possibility of using effective micro-organisms for germination and root growth in *Kalanchoe daigremontiana* and the results showed a significant increase in the agronomic and physiological parameters. The experiment also showed an increase in the percentage of seed germination and a significant reduction in the average germination time. Effective micro-organisms can be a valuable tool for grafting before planting new plants, for spraying and irrigation of crops, for reducing or eliminating completely the use of plant protection products against pathogens and diseases, during the storage of plant raw materials and to increase the biological activity of the soil.

Prisa (2019d) has tested the possible use of EM in the cultivation and qualitative improvement of onion (*Allium cepa L.*) cvs. “Dorata di Bologna”, “Lunga di Firenze”, “Bianca Musona” and “Rossa di Tropea”. The test showed a significant increase in the agronomic parameters analysed in the plants treated with EM. All the onions of the different varieties, treated with EM, showed a significant increase in bulbs weight, bulbs diameter, bulbs length and root weight. Increased root growth results in improved resistance to water and transplant stress and a higher supply of nutrients to the plant, which consequently grows better. It is

therefore clear from the evidence that the use of this selection of microorganisms, inoculated into the soil, can significantly improve the quality of onions bulbs.

Prisa (2019e) investigated how effective microorganisms (EM) affect the quality and growth of aubergine plants. The experiment was carried out with 2 treatments *viz*. soil inoculated with EM microorganisms and soil without EM microorganisms (control). Plants treated with the micro-organisms EM were significantly higher and showed a larger stem diameter. The number of leaves was significantly higher in plants treated with EM, as was the number of flowers. The use of EM microorganisms has also led to a significant increase in the number of aubergines produced per plant. It was therefore clear from the evidence that the use of this selection of microorganisms, inoculated into the soil, can significantly improve the quality of aubergine plants.

Ngilangil and Vilar (2020) studied on the use of EM as remediation for marginal soil. Formulated EM from fish amino acid, lactic acid bacterial serum, and commercial EM were applied to marginal soil weekly for 10 weeks. The physical and chemical properties were analyzed before and after treatment application. With the objectives of determining the change, results revealed that there was a change on the selected physical and chemical properties of the soil. Soil texture has changed from light to medium in all treatments. The highest increase in pH (5.4 %), organic matter content (200 %) and phosphorous content (115.7 %) was noted in fish amino acid; while the highest increase in electrical conductivity (514.3 %) and potassium content (89.1 %) was noted in the commercial EM. They concluded that EM can be utilized to remediate soil problems in relation to improvements on soil texture, electrical conductivity, organic matter, and phosphorous content.

Prisa (2020) evaluated the effect of introducing different amounts of EM-Bokashi into the growing medium of *Kalanchoe Blossfeldiana* to determine whether this organic soil was able to improve the growth and flowering of these succulents. The five experimental groups in cultivation were: i) group without beneficial EM-Bokashi; ii) group with 5% EM-Bokashi; iii) group with 10% EM-Bokashi; iv) group with 15% EM-Bokashi; v) group with 20% EM-Bokashi. All plants treated with EM-Bokashi showed a significant increase in the agronomic parameters analysed compared to the untreated control. The results show that the addition of Bokashi to the growing medium of Kalanchoe Blossfeldiana can improve plant quality, in particular agronomic and physiological characteristics and increased nutrient and water uptake.

Prisa (2021) aimed to develop an innovative technology for the cultivation of *Myrtillocactus geometrizans,* using Effective microorganisms and at the same time, limiting the use of mineral fertilizers, plant protection products and improving the physico-chemical and organoleptic characteristics of garambullos for consumption and processing. The trial showed a significant improvement in the agronomic parameters analysed on *Myrtillocactus geometrizans* plants treated with Effective microorganisms. In particular, there was an increase in plant height and circumference, vegetative and root weight, number of flowers and fruits, number and length of thornes in plants treated with microorganisms. In addition, the use of EM microorganisms showed a significant increase in total betalains, ascorbic acid, phenols and total flavonoids in garambullos. There was reduction of irrigation and fertilisation by 50% in the growing medium, as compared to control under optimal conditions. Therefore, application of EM guarantees higher production standards, with a possible reduction in costs fertilizer and water. Particularly for those farms that want to focus on the production of ornamental and fruit cacti. Fruits obtained from growing plants treated with Effective

microorganisms have a high antioxidant and nutraceutical potential, which is very important especially in this age where food is also a medicine.

Belova and Protasova (2021) carried out an experiment to study the effect of technology of effective microorganisms on the growth and development of *Pisum sativum* L. plants in a moderate climate on gray forest soils of the Kursk region. In the experimental work, the seeds of sugar peas "Ambrosia" were used, provided by the group of companies "Gavrish" and agents of cultures of effective microorganisms, created on the basis of EM - technologies – "Baikal EM – 1" and "Vostok EM – 1". The most significant activity of the preparations was observed from the flowering phase, which leads to an increase in plant growth rates, the formation of generative buds, and an increase in the number of beans. Microbiological preparations showed reliably significant results indicating the effectiveness of legume-rhizobial symbiosis: treatment of *Pisum sativum* L. plants with EM preparations provided a pronounced positive dynamics in the development of symbiotic relations between nitrogen-fixing bacteria and pea plants, while control plants acquired many inactive and even partially parasitic nodules.

Keruba *et al.* (2021) tested two varieties (MSL-17 and MSL-F3) of *Cleome gynandra* under different concentrations of Effective Microorganisms (EM) (0, 50, 100, 150 and 200 g/L) on ferralsol soil in Kibabii. Increased EM concentration at 200g/L significantly increased ($P \leq 0.05$) plant height, number of leaves per plant, single leaf area, chlorophyll content, leaf relative water content, and leaf yield. There exist significant genotypic differences in adaptation to EM concentration levels among the evaluated genotypes. Spider plant varieties varied significantly ($P \leq 0.05$) in agronomic traits, with variety MSL-17 at EM 200g/L, recording superior agronomic traits for growth, hence may be used for production and in the

development of improved spider plants. In conclusion, MSL-F17 was recommended for adoption by small scale farmers for direct production.

Zhang *et al.* (2021) studied the Compound Effective Microorganisms (CEM) in vegetable production, where three fertilizer treatments were used to study their effects on the growth characteristics and quality of lettuce, spinach and pakchoi. There were five treatments in the experiment including Control Treatment (CK), 0. 3 % (Mass volume ratio:w/v) of urea: Water (T_1), 0. 3 % (w/v) of compound fertilizer: Water (T_2), CEM fertilizer was diluted to 1:1,000 (CEM fertilizer: Water, Volume ratio: v/v) before application (T_3), 1: 500 (CEM fertilizer: Water, v/v) (T_4), 1: 100 (CEM fertilizer: Water, v/v) (T_5). It was observed that CEM could maintain the productivity of green vegetable and contained a variety of beneficial bacteria. The cultivation of EM increased the yield of plants and increased the growth of vegetables. The results concluded that vegetables could produce high yield and high quality through CEM management.

2.3. Indigenous microorganisms

Mbouobda *et al.* (2013) studied the impact of EM and IMO manures on *Colocassia esculenta* in Bambili-Cameroon and observed that the plants treated with EM manure gave the heaviest corms and cormels (15.549 ± 2.17 tons/ha) followed by plants treated with IMO manure (12.335 ± 1.69 tons/ha) and then the control plants (10.539 ± 2.24 tons/ha).

Kumar and Gopal (2015) defined indigenous microorganisms are a group of innate microbial consortium that inhabits the soil and the surfaces of all living things inside and outside which have the potentiality in biodegradation, bioleaching, biocomposting, nitrogen fixation, improving soil fertility and as well

in the production of plant growth hormones. Without these microbes, the life will be wretched and melancholic on this lively planet for the survival of human race.

Sakimin *et al.* (2017) carried out a study on the application of indigenous microorganism (IMO) and system of rice intensification (SRI) Anak formulation on growth and nutrient uptake of rice variety MR219 at nursery level. Results showed the highest plant height, leaf area, fresh and dry weight of rice variety MR219 when treated with IMO and SRI Anak formulation. Accumulation of N, P and K content in leaf and root tissue is much affected by spraying with SRI formulation. IMO had less influence in increasing the nutrient content in leaf and root tissue at nursery level. IMO and SRI formulation is potentially to be used as bio-fertilizer and bio-regulator to reduce environmental problems.

Desiré *et al.* (2018) conducted an experiment to study the effect of indigenous and effective microorganism fertilizers on soil microorganisms and yield of Irish potato in Bambili, Cameroon. Fertilizers were applied one week before planting and repeated four and eight weeks after planting. The study concluded that both IMO and EM fertilizers had a better effect on the yield of Irish potato with IMO producing the best yields in terms of number and weight of tubers.

Sanchez *et al.* (2018) preformed an experiment and the findings showed that application of 1L of Indigenous Microorganism Extended Solution (IMO-ES) every four weeks in Basmati rice has significantly improved the plant height, productive tiller that results to higher panicle and also improved the yield components such as number of filled grains per panicle and harvest yield per hectare. Application of IMO-ES once a month in rice plant to supply nutrients for growth and yield showed significant interaction indicating appropriate frequency application of IMO-ES is needed. The presence of *Bacillus pumilus*, *Bacillus*

cereus and *Bacillus thuringiensis* bacteria in the solution enhance pest and disease resistance for better growth and development of Basmati rice.

Enebe and Babalola (2019) reported that certain microbes known as plant growth-promoting microbes (PGPM) aid in the sensitization and priming of the plant immune defense arsenal for it to conquer invading pathogens. PGPM perform this function by the production of elicitors such as volatile organic compounds, antimicrobials, and/or through competition. These elicitors are capable of inducing the expression of pathogenesis-related genes in plants through induced systemic resistance or acquired systemic resistance channels.

Jan *et al.* (2020) conducted a study to understand the dynamics of microbial communities of soil microorganisms, and their distribution and abundance in the indigenous microorganisms (IMOs) manipulated from humus collected from the forest near the crop field. The soil microorganisms originated from humus and artificially cultured microbial-based soil amendments were characterized by molecular and biochemical analyses. The 16S rDNA and ITS sequence analyses showed that the bacterial and fungal communities in humus and IMOs were mainly composed of *Bacillus* and *Pseudomonas*, and *Trichoderma* and *Aspergillus* species, respectively. Some of the bacterial isolates from the humus and IMOs showed strong inhibitory activity against soil-borne pathogenic fungi *Fusarium oxysporum* and *Sclerotinia sclerotiorum*. These bacteria also showed the siderophore production activity as well as phosphate solubilizing activity, which are requisite traits for biological control of plant pathogenic fungi. These results suggest that humus and IMOs could be a useful resource for sustainable agriculture.

Araújo *et al.* (2020) studied the application of growth-promoting bacteria to select efficient bacteria for production and evaluate their influence on the

phytotechnical characteristics and composition of the essential oils of roses. Seven species of bacteria were evaluated for the potential to promote growth in vitro, being tested for nitrogen fixation, phosphate solubilization, protease production and auxin production. From bacteria tested, four were selected and inoculated on rose plants of cultivar Black Prince to evaluate the influence on phytotechnical variables of flower and stem and the oil production. The application of *B. acidiceler*, *B. subtilis* and *B. pumilus* resulted in flowers with a diameter up to 29% larger. The floral stem was increased by up to 24.5% when *B. acidiceler* and *B. pumilus* were used. Meanwhile, the stem diameter was around 41% greater in the presence of *B. acidiceler*, *B. subtilis* and in the control. *Bacillus pumilus* also increased the weight of fresh petals (104%) and essential oil yield (26%), changing the chemical composition of the extracted essential oil. Thus, it is concluded that *B. acidiceler*, *B. pumilus*, and *B. subtilis* improved the phytotechnical characteristics of roses. Among bacteria, *B. pumilus* increased the essential oil content as well as positively changed the chemical composition of the extracted essential oil.

Al-Amri (2021) planned a study to enhance the growth and productivity of common bean plants (*Phaseolus vulgaris* L.) grown under different water stress level by using different microorganisms as bio-fertilizer agents. The interaction effect between water stress (WW as recommended irrigation after 6 days, WS1 after 12 days and WS2 after 18 days) and inoculation with different microorganisms [AMF (*Glomus mosseae*) and endophytic bacteria, (*Bacillus amyloliquefaciens*)] used alone or in mixed was examined on the development and productivity of common bean plants. Mutual application of AMF and endophytic bacteria significantly increased the average values of most of growth, water relations (photosynthetic rate, transpiration rate and stomatal conductance) and yield parameters of common bean plants grown at WS1 and WS2 comparing with

non-colonized plants. In this connection, colonization with AMF and endophytic bacteria with WS1 are the greater pods number, pod length, pods weight, 100 seeds weight, Yield by ton/Fed and water-use efficiency (WUE) by ton/m^3 than other treatments. Common bean yielded seeds had significantly increased nutrients content (nitrogen, potassium, phosphorus, magnesium and calcium), vitamin B1, Folic acid, crude protein and crude fibers at AMF + endophytic bacteria under second water stress (WS1) when compared to other treatments.

2.4. Jeevamrutha

Gore and Sreenivasa (2011) studied the influence of liquid organic manures viz., panchagavya, jeevamruth and beejamruth on the growth, nutrient content and yield of tomato in the sterilized soil during kharif 2009. In the present study, significantly highest plant growth and root length was recorded with the application of RDF + Beejamruth + Jeevamruth + Panchagavya and it was found to be significantly superior over other treatments. The application of Beejamruth + Jeevamruth + Panchagavya was next best treatment and resulted in significantly highest yield as compared to RDF alone. The N, P and K concentration of plants was significantly highest in the treatment given RDF + Beejamruth + Jeevamruth +Panchagavya.

Amareswari and Sujathammato (2014) evaluate the impact of Jeevamrutha on yield and returns of two varieties of rice (*Oryza sativa*) Masura and Hamsa. It indicated that application of Jeevamrutham could yield better than chemical farming in Hamsa variety. In both the varieties benefit-cost ratio was better with application of Jeevamrutha method being 3.39 in Masura variety 3.0 in Hamsa as compared to 1.09 and 0.6 in chemical methods of rice production respectively.

Boraiah *et al.* (2017) conducted experiment to study effect of organic liquid formulations on growth and yield of capsicum and application of jeevamrutha recorded significantly higher fruit yield.

2.5. Local floral preservatives

De Silva *et al.* (2013) investigated that highest fresh weight of flower heads (7.4 g) and stems (4.3 g) were observed wit sucrose 2% + vinegar 0.6 + Cacl2 1% with distilled water.

Mehraj *et al.* (2013) studied the effect of vase life analysis of yellow gladiolus using different vase solutions. And revealed that, cut gladioli recorded maximum (18.3) days in flower vase when treated with 100 ppm sucrose + lemon juice solution.

Terannum *et al.* (2014) studied that the effect of different chemical preservatives on vase life of carnation (*Dianthus caryophyllus* L.) cv. Soto. with eight treatment combinations comprising i.e., citric acid at 200 ppm and sucrose at 4 per cent resulted in maximum (12.00 days) vase life of cut carnation flower cv. Soto.

Murthy *et al.* (2015) carried out a laboratory trail to investigate the effectiveness of different locally available floral preservatives on extension of vase life of cut gerbera cv. Savannah under ambient storage condition. All the cut gerberas were precooled at 5°C for 6 hours and followed by pulsing with sucrose at 20%+sodium hypochlorite at 50 ppm for 12 hours and then kept in locally available preservative floral solutions i.e. sugar, commercial vinegar, lime (*Citrus aurantifolia*) juice, commercial bleach (calcium hypochlorite-$CaOCl_2$) and neem (*Azadirachta indica*) extract at different concentrations in combination with 4% sucrose. Using the solution of neem extract at 1% coupled with 4% sucrose

significantly maintained water relations and reduced scape bending curvature as compared to all other treatments.

Mehrdad *et al.* (2016) investigated to vaerify the use of natural ingredients in flower preservative solutions. And reported that highest vase life (15 days) was recorded in 500 ml/L of cola, while in control it (distilled water) was 9 days. The highest flower diameter was recorded in apple extract (45 ml/L) + Rosemary essence (2000 mg/L) and the highest amount of anthocyanin was obtained in cola treatments of 500 ml/L + essence of peppermint in Alstroemeria cut flowers (cv. Balance).

Amin (2017) stated that copper sulfate at 150 mg/l + sucrose at 20g/l + citric acid at 0.2 g/l, was best treatment as it enhanced the longevity of cut chrysanthemum, reduced water loss and induced the highest rate of relative fresh weight.

Khattab *et al.* (2017) investigated the possibility of opening the florets of the cut spikes of *Gladiolus grandiflorus* cv. "White Prosperity" at show color stage, inflorescence keeping quality, leaves chemical analysis and the growth of microorganisms in the vase solution using three concentrations of each of ascorbic acid (150, 200 and 250 ppm), boric acid (30, 60 and 120 ppm), glycine amino - acid (20, 40 and 80 ppm) and 5-salfosalicylic acid (100, 200 and 300 ppm). Results indicated that all the used acids had positive effects on the keeping quality of cut Gladiolus spikes and using boric acid at level ranged between 30 to 120 ppm to the vase solution led to increase the florets diameter, duration period and inhibit the growth of microorganisms in the vase solution. While using 5-salfosalicylic acid at 100-200 ppm gave a fast opening of the florets, increased the number of the opened florets, decreased the number of the non-opened florets per spike and increased the amount of the absorbed vase solution.

Chaudhary and khanal (2018) conducted an experiment to find out the best concentration of sucrose that enhances and prolongs the better flower quality and longevity. Experiment was laid out with 10 treatments viz. tap water, tap water + 2% sucrose, tap water + 4% sucrose , tap water + 6% sucrose, tap water + 8% sucrose, distilled water, distilled water + 2% sucrose, distilled water + 4% sucrose, distilled water + 6% sucrose and distilled water + 8% sucrose under completely randomized design with three replications. Rose sticks were harvested at flower bud stage and two sticks were kept in each vase solution. Effect of different concentrations of sucrose solution on water uptake, weight gain or loss, neck bending, flower diameter, days to full bloom and vase life was affected significantly. The rose flower held in distilled water + 6% Sucrose was recorded to have higher value (7.77cm) for flower diameter at 10 days followed by Tap water + 6% Sucrose with value 7.62cm. Similarly, lower flower diameter (2.29cm) was observed in Tap water at Day16 followed by Distilled water with value 3.21cm. Similar pattern was observed in all other parameters having highest vase life (19.5 days) in Distilled water + 6% Sucrose and lowest (15.17 days) in tap water only. Among different concentrations of sucrose solution, distilled water + 6% sucrose was found highly effective for longevity of cultivar.

Nirmala *et al.* (2019) carried out an investigation to find out the efficacy of different locally available preservatives on physical (fresh weight of flower, diameter of flower, percent neck bending, vase life and over all acceptability of flowers), physiological (water uptake, transpiration loss of water, fresh weight change, relative water content, chlorophyll content in calyx), biochemical parameters (TSS of petals, pH of vase solution, optical density of vase solution, electrolyte leakage) in two days interval during the vase life period of cut chrysanthemums. Among the different locally available preservatives studied, pongamia seed oil 1 percent was very effective in increasing the fresh weight of

flower (6.70 g), flower diameter (6.3 cm), water uptake (19.18 g), fresh weight change (95.68 g), relative water content (83.94%), chlorophyll content of calyx (34.91), Total soluble solids (5.8 degrees), over all acceptability of flowers (9.46), vase life of chrysanthemum cut flowers (15.93 days). It has led to lowest electrolyte leakage (76.21%) and transpiration loss of water (11.36 g/f).

Sravanthi (2019) conducted studies on the effect of locally available floral preservatives on postharvest vase life of cut gerbera (*Gerbera jamesonii* Bolus ex. Hook) cv. 'Stanza' and concluded that the postharvest life of cut gerbera can be successfully enhanced by locally available preservatives. The longest vase life (10.03 days) was registered in combinational treatment of citric acid 500 ppm + sugar 20g/l + commercial bleaching powder 50 ppm.

Arunesh *et al.* (2020) evaluated the vase life of cut gerbera flowers using different chemical floral preservatives. 'Goliath' variety of gerbera is chosen and subjected to eight different treatments of preservative solutions viz. T_1 - 2% sucrose + distilled water, T_2 - 25 ppm $AgNO_3$ + distilled water, T_3 - 200 ppm 8-HQS + distilled water, T_4 - 2% sucrose + 25 ppm $AgNO_3$ + distilled water, T_5 - 2% sucrose + 200 ppm 8-HQS + distilled water, T_6 - 25 ppm $AgNO_3$ + 200 ppm 8-HQS + distilled water, T_7 - 2% sucrose + 25 ppm $AgNO_3$ + 200 ppm 8-HQS + distilled water, T_8 - Distilled water (control). The minimum weight loss, number of days taken for flower head drooping, petal discolouration, petal fall and the solution uptake was observed higher in treatment T_7 (2% sucrose + 25 ppm $AgNO_3$ + 200 ppm 8-HQS + distilled water) followed by treatment T_4 (2% sucrose + 25 ppm $AgNO_3$ + distilled water). The vase life characters were significantly reduced when the cut flower stems are placed in control (T_8).

Parween and Gupta (2022) conducted studies to determine the best combination of different organic and inorganic preservative solutions for cut

gerbera cv. Stanza. The effect of essential oil with different chemical preservative was investigated. Data were recorded for solution uptake, capitulum diameter, petal water content, microbial count, membrane stability index, Vase-life and analysed statistically. Combination of Thymus oil 5 mg/l+ citric acid 300 ppm + sucrose 4% were most effective treatments for enhancement of quality attributes of cut gerbera flowers.

CHAPTER III

MATERIALS AND METHODS

MATERIALS AND METHODS

The present investigation entitled "**Integrated nutrient management and vase life of Gladiolus (*Gladiolus grandiflorus* L.)**" was carried out in the Experimental farm, Department of Horticulture, School of Agricultural Sciences and Rural Development (SASRD), Nagaland University, Medziphema campus, Nagaland during 2021 to 2022. The details of the materials used and methods followed for the experiment is present below.

3.1. General information

3.1.1. Geographical location

The experimental farm of Horticulture, School of Agricultural Sciences and Rural Development, Medziphema, Nagaland is located at 25º45′43″ N latitude and 93º53′04″ E longitude at an elevation of 305 m above mean sea level.

3.1.2. Climatic condition

Medziphema lies in humid sub-tropical zone with moderate temperature and medium to high rainfall ranging from 200 to 250 cm. The mean temperature ranges from 21ºC to 32ºC during summer while in winter it varies between 13ºC to 26ºC which rarely goes below 8ºC. The meteorological data recorded during the entire period of investigation is depicted in Fig 3.1.

3.1.3. Soil

The soil of the experimental field was categorized as sandy loam and acidic in nature. The results for the initial soil fertility status of experiment plot are

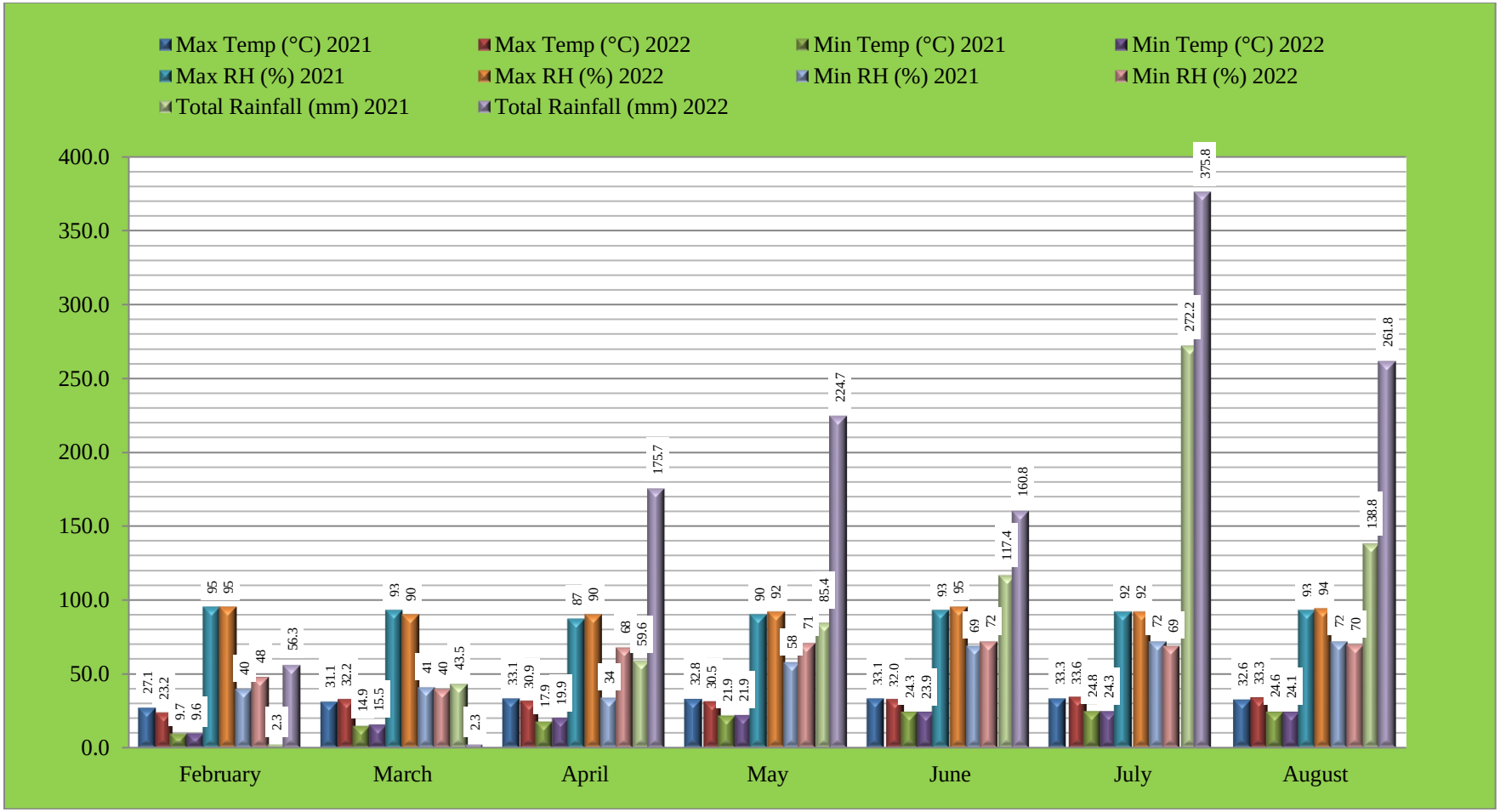

Fig 3.1: Meteorological data during the period of investigation (February-August, 2021 and 2022)

Source: ICAR Research Complex for NEH Region, Jharnapani, Medziphema, Nagaland.

Table 3.1: Initial soil fertility status of experimental plots

Parameter	Value	Interpretation		Status	Method employed
		Availability	Comments		
pH	5.3	< 6.5 6.5 – 7.5 7.5 – 8.5 >8.7	Acidic Normal Saline/calcareous Alkaline	Acidic	Potentiometric method
Organic carbon (%)	2.04	< 0.5 0.5 – 0.75 >0.75	Low Medium High	High	Walkley and Black titration method (1934)
Available N (Kg/ha)	1191.7	202 Kg/ha 202-251 Kg/ha 251-504 Kg/ha 504 Kg/ha	Very low Low Medium High	High	Alkaline potassium permanganate method (Subbiah and Asija, 1956)
Available P (Kg/ha)	67.2	< 22.5 22.5 – 56.0 >56.0	Low Medium High	High	Bray and Kurtz method, 1945
Available K (Kg/ha)	212.8	< 136 136 – 337.5 >337.5	Low Medium High	Medium	Neutral Normal Ammonium Acetate method (Hanway and Heidal, 1952)

Table 3.2: Nutrient profiling of different organic manures

Organic fertilizers	Nutrient concentration %		
	N	P	K
Effective microorganism (EM)	140	22	275
IEM (Indigenous Effective microorganism)	28	20	135
Jeevamrutha	252	19	230

presented in Table 3.1. While the Table 3.2 depicts the nutrient profile of the various source of organic inputs used in the experiment.

3.2 Experimental details

3.2.1 Planting materials

Gladiolus cultivar Candyman was used for the experiment. Healthy disease-free corms having diameter of 4-5 cm were procured from Pushpanjali nursery located at Midnapur, West Bengal.

3.2.2 Field preparation

The land was brought to a fine tilth by ploughing and harrowing. Plots measuring 1.6 m × 1.5 m were prepared. Layout of the plot is shown in Fig. 3.2.

3.2.3 Technical details

Crop	:	Gladiolus
Cultivar	:	Candyman
Spacing	:	40cm × 30cm
Net plot size	:	1.6 m × 1.5 m
Design	:	Randomized block Design (RBD)
Number of replications	:	3
Number of treatments	:	8
Intercrop	:	African double Marigold
First experiment	:	February 2021 – August 2021
Second experiment	:	February 2022 – August 2022

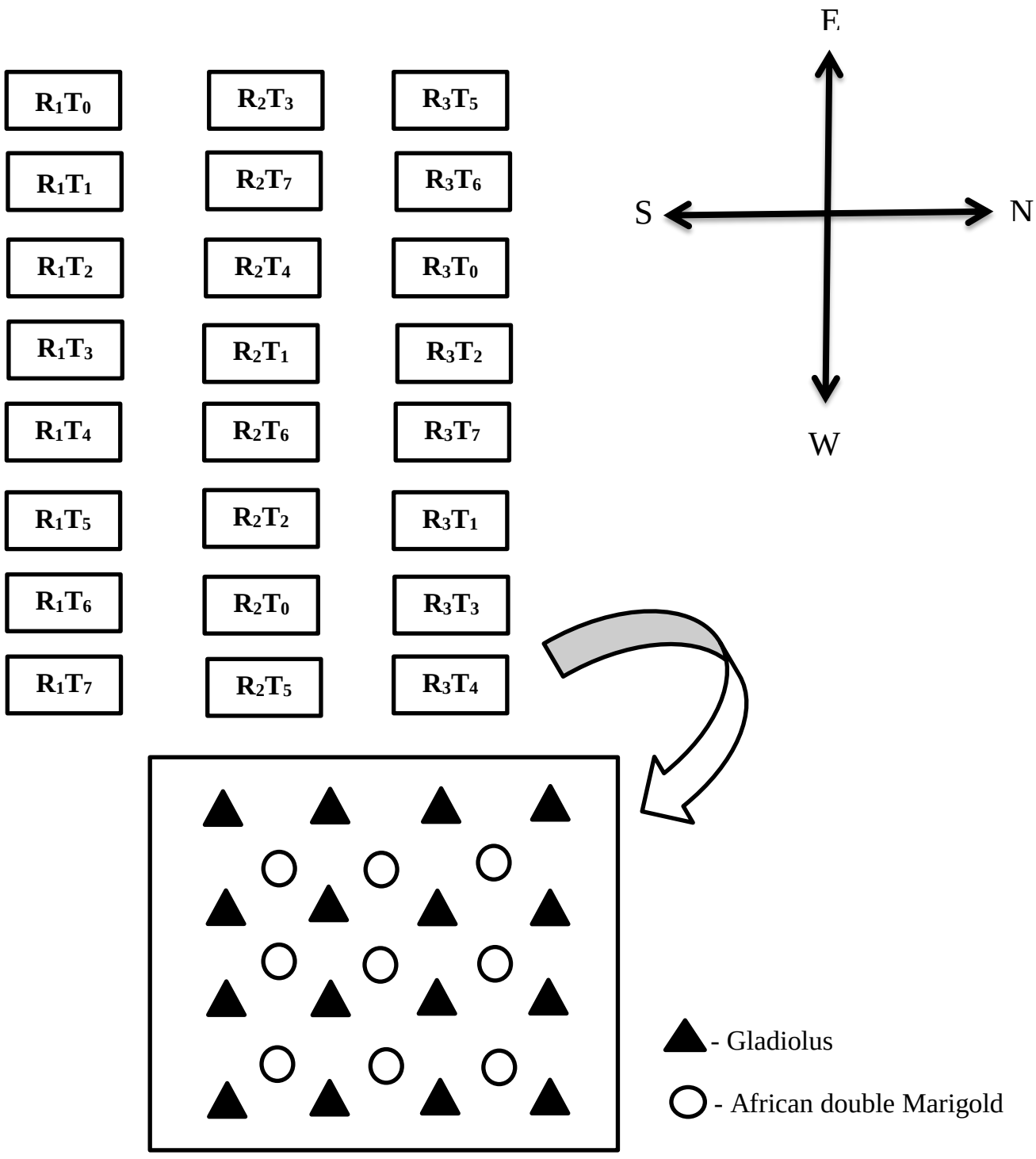

Fig. 3.2: Field layout of experiment

Plate 1. General view of experimental site at 40 Days after planting

Plate 2. General view of experimental site at 60 Days after planting

Treatments:

T_0 : Control (untreated)

T_1 : 100% RDF (40:20:20 gm m^{-2})

T_2 : Effective Microorganisms (100 ml activated EM m^{-2})

T_3 : Indigenous Effective Microorganisms (500 ml activated IEM m^{-2})

T_4 : Jeevamrutha (50 ml m^{-2})

T_5 : 50% RDF + 50% EM

T_6 : 50% RDF + 50% IEM

T_7 : 50% RDF + 50% Jeevamrutha

3.2.4 Planting

The corms were taken and cleaned. 16 corms were planted per plot at a depth of 5-6 cm. Light irrigation was given immediately after planting.

3.2.5 Manures and fertilizers

Uniform application of FYM at 5 kg m^{-2} and fertilizers as per dosage mentioned in the following.

3.2.5.1 Inorganic fertilizer

The recommended dosage of N, P and K 40:20:20 gm/m^2 was supplied through urea, single super phosphate and muriate of potash respectively. Full doses of potassium and phosphorus was given as basal application at the time of planting and nitrogen was given in three split doses i.e. one fourth as basal and remaining three fourth in two equal and split dozes i.e one at 3 and another at 6 leaf stages (Rajhansa, 2010).

3.2.5.2 Organic inputs

Effective Microorganism (EM)

1 Litre of Maple EM1 and 1 kg jaggery were mixed in 20 litres water to activate the EM stock solution. The mixture was left to sit a plastic bucket with an airtight lid and kept for a week for fermentation. The gas pressure which was developed during the fermentation was released for a second every day to prevent pressure build up and bursting of the container. After 7 days the EM was activated. It turned sour with a pH below 4, giving out a mild sweet sour smell and was ready for use. It had to be used within one month after activation. It was applied twice a month at 15 days interval from day of planting of the corms till spike initiation.

Preparation of IEM (Indigenous Effective Microorganisms)

It was produced through four stages. The first stage involved use of cooked rice which was stuffed into a bamboo/wooden container and left buried under the leaf litter. Microorganisms started growing over the surface of the rice in 3-5 days. The collected microorganisms were called IMO-1. The second stage involved the preparation of IMO-2 which was done by mixing IMO-1 with jaggery at the ratio of 1:1. After this, IMO-3 was prepared by mixing 1 kg of soil, 2 kg of rice bran, 0.5 kg of jaggery and 0.5 kg of beans oil cake with 1-2 tablespoon of IMO-2 and then diluted in water. The mixture was poured into a polyethylene or vinyl bag and was sealed airtight to maintain anaerobic condition and kept under the shade for 3-4 days. The sweet smell due to the fermentation was an indication that it was ready to use. The last stage, IMO-4 was prepared by mixing 15 g jaggery diluted in 100 ml of hot water and then putting 50 g IMO-3 to the solution and bringing up the volume to 1 L by water. It was applied twice a month at 15 days interval from day of planting of the corms till spike initiation.

	Item	Quantity used	Duration
IMO-1	Cooked rice	500 gm	3-5 days
IMO-2	IMO-1 + Jaggery	1:1 ratio	7 days
IMO-3	IMO-2 + Soil + Rice bran + Jaggery + Beans oil cake	1-2 Tsp 1 kg 2kg 0.5 kg 0.5 kg	3-4 days
IMO-4	IMO-3 + Jaggery + Hot water + Normal water	50 g 10-15 g 100 ml 900 ml	3-5 days

Preparation of Jeevamrutha

Jeevamrutha is an organic liquid manure which was prepared by using the following ingredients: 10 kg cow dung and 10 litres of cows urine was mixed properly with the help of wooden stick in a plastic drum. To the well mixed cow dung and cow urine 2kg jaggery, 2 kg gram flour and 1 kg live soil were added in and kept for 7 days for fermentation. The solution was shaken regularly three times a day. It could be used up to 15 days. It was applied twice in the field at one month interval after the sprouting of corms..

Sl.no	Item	Quantity used
1.	Cow dung	10 kg
2.	Cow urine	10 litres
3.	Jaggery	2 kg
4.	Besan	2 kg
5.	Live soil	1 kg
6.	Water	200 litres

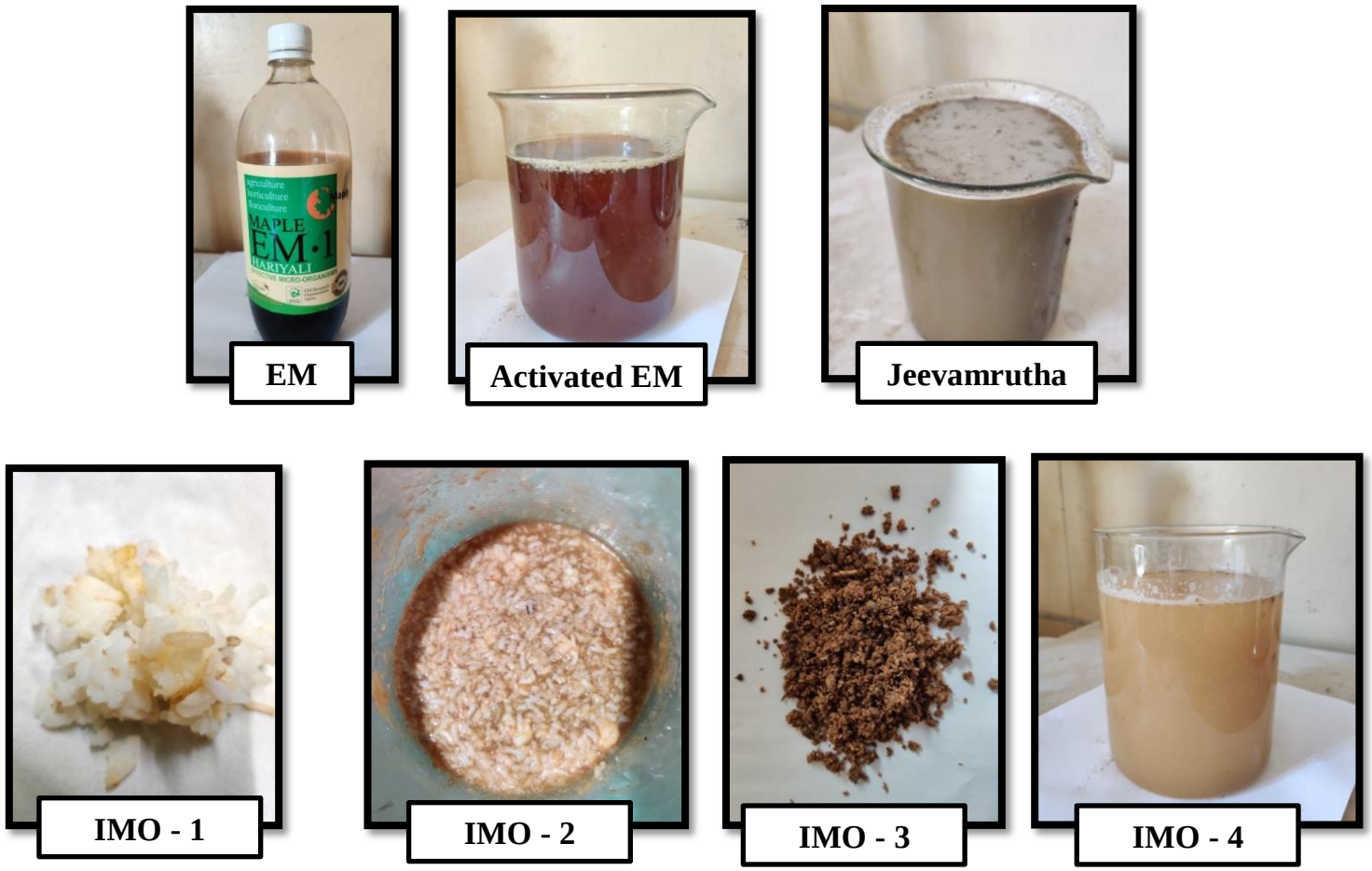

Plate 3. Organic fertilizers *viz.* Effective microorganisms (EM), Jeevamrutha and Indigenous microorganisms (IMO) used for the experiment.

3.2.6 Cultural operations

The plots were kept free of weeds by periodic hand weeding. The field was irrigated depending on the seasonal conditions, as and when required. Irrigation was withheld twenty days prior to lifting of corms.

3.2.7 Intercropping

Gladiolus which is a monocot plant when intercropped with a dicot plant like marigold helps in increasing biodiversity of the soil microflora, which in turn increases availability of nutrients to the plants. Apart from this, marigold was also utilized as a trap crop for pests like nematodes and as repellant for termites.

3.2.8 Plant protection

Leaf caterpillar was the most common pest and was managed by handpicking while no remarkable incidence of disease was observed. Staking of the plants was done at the time of spike emergence to provide mechanical support.

3.2.9 Harvesting

For gladiolus, the spikes were harvested at the stage when their first floret showed colour and was used for recording different parameters. The maturity of corms was identified by browning of leaves and wilting of plants. The corms and cormels were lifted from the ground 60 days after flowering. The corms were dried in shade for one week. The harvested corms and cormels were then used for recording different parameters.

3.3 Sampling and observations recorded

3.3.1 Vegetative parameters

The observations on vegetative parameters *viz.,* days to sprouting, leaf area at spike emergence and longest leaf length, including plant height, number of leaves per plant and girth of plant base at 20, 40, 60 and 80 days after planting (DAP) was recorded as described below. Five plants per replication were selected and average was worked out.

3.3.1.1 Days to sprouting

Number of days taken for 50 percentage sprouting was recorded by counting days from the day of planting corms till the corms sprouted in each treatment recorded and then average days was worked out.

3.3.1.2 Plant height (cm)

Height of plant was recorded from the ground to the tip of the longest leaf with the help of scale meter and the mean height was expressed in centimeters at each stage.

3.3.1.3 Number of leaves per plant

The number of leaves per plant was counted at each stage and the mean was worked out.

3.3.1.4 Girth of plant base (cm)

The girth of the plant base was measured by running the thread along the periphery of the plant base and then measuring the length of the thread with the help of centimeter scale.

3.3.1.5 Leaf area at spike emergence (cm^2)

The leaf area was measured in square centimeter by placing the leaf horizontally on the graph paper and the surrounding area of the leaf will be drawn with the help of a pencil. Two numbers of leaves was taken from the bottom and top portion of the plant and average was worked out.

3.3.1.6 Longest leaf length (cm)

The length of the longest leaf at the time of spike emergence was measured with the help of measuring tape and average was worked out.

3.3.2 Flowering attributes

3.3.2.1 Days taken for spike initiation

The number of days taken from planting of corms to spike initiation in the tagged plants was counted and the average days required for spike initiation was worked out.

3.3.2.2 Days taken for first floret opening

The number of days taken from planting of corms to the opening of basal floret in each spike was recorded and average days required for first floret opening was worked out.

3.3.2.3 Spike length (cm)

Length of spike was measured from the inter node, next to the top most leaf up to the tip of the spike at fifth opened stage and expressed in centimeters.

3.3.2.4 Rachis length (cm)

It is the length of the spike where florets are borne. Length of the rachis was measured from the point of emergence of first floret to that of last floret. It was measured when the 5^{th} floret fully opened and was measured with the help of centimeter scale and average was worked out.

3.3.2.5 Number of spikes per plant

The spike intact with four leaves was served from the plant other than the net plot after just opening of first floret. The number of spikes was counted and the mean number was recorded.

3.3.2.6 Number of florets per spike

The total number of florets per spike was counted and the mean number of florets was recorded.

3.3.2.7 Floret diameter

Diameter of floret from observational five plants was measured by separating three florets from basal, middle and upper portion of the spike with the help of standard scale and average was calculated.

3.3.2.8 Days to harvesting of spikes

Days to harvesting of spikes were counted from days from spike emergence till harvest stage for five plants and then average was taken. The spike was harvested at tight bud stage, with basal florets showing colour and at least four leaves on the plant for development of corms and cormels.

3.3.3 Corm parameters

3.3.3.1 Number of corms per plant

From the observational five plants, the total number of corms produced from all the sprouts arising from a mother corm was counted and the average number of corms was worked out.

3.3.3.2 Corm diameter (cm)

The diameter of corms was measured from each treatment and average diameter of corms was worked out and expressed in centimeters.

3.3.3.3 Weight of corms per mother corm

The weight of all corms produced per mother corm was measured by weighing all the corms from the uprooted tagged plants at harvest on electronic balance and the average value was calculated.

3.3.3.4 Number of cormels per plant

The cormels produced from all the sprouts arising from a mother corm of observational five plants were counted and the average was recorded.

3.3.3.5 Weight of cormels per mother corm

The weight of all cormels produced per mother corm from individual observational plants was measured by weighting on electronic balance and the average value was calculated.

3.3.4 Quality parameters

3.3.4.1 Self life

The selected five plants per replication in field were tagged and the time till 70 % of the florets starts to wilt was counted and average was worked out.

3.3.4.2 Vase life in distilled water

Vase life of cut marketable gladiolus spikes was observed in distilled water and expressed in days. The spikes were harvested with the help of secateur retaining four leaves on cut stem when first floret starts to open and shows colour and the cut ends will be immediately kept in distilled water at room temperature. In the laboratory, the flower spikes were kept in vases having distilled water to study the life of spike in distilled water without any chemicals. The vase life in days were calculated from the date of harvesting of spike to senescence of the last floret.

3.3.5 To study the chemical properties and nutrient status of the soil and nutrient content in Bio-inputs

The soil samples were collected from the experimental site at 0-15 cm depth and air dried in shade, ground with pestle and mortar, passed through 2mm sieve and stored in polythene lined bags. The study was done before planting and after harvest of the crop. The chemical properties of soil were analyzed as per the recommended methods. Also the nutrient content in bio-inputs was analyzed.

3.3.5.1 Available Nitrogen (Subbiah and Asija, 1956)

Five gram of the ground sample was moistened with 20ml of distilled water and was added to Kjeldahl distillation flask. 50 ml of 0.32% $KMnO_4$ and 50 ml of 2.5% NaOH solution were added to the assembly and the cork was filled immediately. 20 ml of 2% boric acid with 5-6 drops of mixed indicator were taken

in a 250 ml conical flask and the end of receiving tube was dipped into it to collect the released ammonia. Start the automatic distillation set and the content was distilled for 9-12 minutes. The distillate in the conical flask was titrated against 0.1 N HCl and the change in colour (pinkest yellow) was noted.

Where,

$$\text{Available Nitrogen percentage} = \frac{(10\text{-}A) \times 0.00028}{\text{Weight of soil}} \times 100$$

A = Volume of 0.1 N HCl used

ppm of available Nitrogen in sample = Available Nitrogen percentage × 10000

Available Nitrogen kg/ha = ppm × 2.24

3.3.5.2 Available Phosphorus (Bray and Kurtz method, 1945)

5 gram of the ground sample was taken in a 150ml conical flask. 3-4 scoops of activated charcoal was added to the sample. Then 50ml P-extractant solution was added to it. The contents was shaken for 5 minutes and thereafter filtered to obtain clear filtrate. Pipette out 5 ml aliquot into a 25 ml volumetric flask, to which 5 ml of Dickman and Bray's reagent was added. Mix thoroughly, the contents of the flask with little amount of distilled water, washing the neck down, to let ammonium molybdate wash down. One ml of working solution of $SnCl_2$ was added and its volume was made to 25 ml in the volumetric flask. The contents were mixed thoroughly and the blue colour intensity was measured after 20 minutes at 660 nm and appropriate blank was also run simultaneously.

Available P_2O_5 (kg/ha) = A × V × 2.24 × 2.29

Where, A = Concentration of P read from the standard curve

V = Volume of extractant used (ml)

3.3.5.3 Available Potassium (Hanway and Heidal, 1952)

Available K_2O was extracted with neutral normal ammonium acetate, after shaking 5 gm of the ground sample in 25 ml of extraction on an electric shaker for 5 minutes and then filtered. The filtrate was fed into the atomizer of the flame photometers, 100 of which has been set with 40 ppm K solution and the reading was noted. The reading was located on the standard curve, which gave the K-concentration in the extract. From this concentration measurement, the amount of K in the sample was calculated.

Available K_2O (kg/ha) = C × Volume extractant used (ml) × 2.24/ weight of soil sample

Where,

C = Concentration of K as read from the curve against R.

3.3.5.4 Estimation of pH

For estimation of pH in soil-water suspension (1:2.5 ratio), 20 g of the sample was taken in a 50 ml beaker and 40 ml of the distilled water was added to it. The beaker was stirred at least four times with in a period of half an hour.

This time was required for the soil and water to attain equilibrium. After half an hour again the soil suspension was stirred and pH was measured on a digital pH-meter **(**Jackson, 1973**).**

3.3.5.5 Estimation of electrical conductivity (EC)

20 g of the sample was taken in a 50 ml beaker and 40 ml of the distilled water was added to it. The beaker was stirred intermittently 4-5 times and left overnight for getting a clear supernatant solution. The Electrical conductivity (EC)

of the supernatant solution was measured by systronic conductivity meter and was expressed in dSm^{-1} **(**Jackson, 1973**).**

3.3.5.6 Organic carbon

Organic carbon content of the sample was determined by Chromic acid titration method suggested by Walkley and Black method **(**1934**).** 1 g of soil sample was taken in a 500 ml conical flask. Add 10 ml $K_2Cr_2O_7$ to the soil and gently rotate the flask to mix. To the mixture 20 ml concentrate H_2SO_4 was added and the flask was rotated for a minute to mix. The flask was allowed to stand for about 30 minutes in dark place and then add 200 ml distilled water and the flask was rotated to mix the content. 10 ml phosphoric acid and 1 ml of diphenylamine indicator was added. Then the content was titrated with 0.5 N ferrous ammonium sulphate solution till the colour changes from blue-violet to green.

$$\text{Organic carbon (\%) in soil} = \frac{(B-C) \times 0.003 \times 100}{2 \times \text{Weight of soil sample}}$$

3.3.6 To study the effect of integrated nutrient management (INM) on nutrient uptake by the plants

3.3.6.1 Leaf sampling and nutrient analysis

Fully expanded index leaves were collected from the sample plants at the time of spike emergence for leaf nutrient analysis. The leaf sample were thoroughly washed, cut and dried in hot air oven. Dried leaf samples were then ground using grinder machine. The samples were then analyzed for determination of NPK contents. The result, thus, obtained was represented in terms of percentage on dry weight basis.

3.3.6.1.1 Nitrogen

Nitrogen in plant sample was determined by KEL PLUS nitrogen estimation system (PELICAN Equipments). Pelicans KEL PLUS System are developed and designed to perform the Micro-Kjeldahl method (Jackson, 1973) for estimation of nitrogen which consists of the following three processes *viz*. digestion, distillation and titration.

Digestion Process:

In this process, 0.5 g of plant sample was transferred to the digestion tube. 10 ml of concentrated sulphuric acid and 2 g of digestion activator (salt mixture) to the sample were added. Digestion tubes were loaded in to the digester and the digestion block was heated. At the end of digestion process, the sample turned colour less or light green colour.

Distillation Process:

During distillation, the ammonium radicals are converted to ammonia under excess alkali condition after neutralizing the acid in the digested sample with 40% alkali (NaOH) on heating. In KELPUS CLASSIC-DX VATS (B), the digested samples were heated by passing steam and the ammonia liberated due to the addition of 40% NaOH was dissolved in 4% boric acid. The boric acid consisting of ammonia was taken for titration.

Titration Process:

The solution of boric acid and mixed indicator containing the “distilled off” ammonia was titrated with the standardized H_2SO_4. The titration value of a blank solution of boric acid and mixed indicator was determined.

$$\text{Nitrogen (\%)} = \frac{(\text{Sample titer} - \text{Blank titer}) \times \text{Normality of } H_2SO_4 \times 14 \times 100}{\text{Sample weight (g)} \times 1000}$$

3.3.6.1.2 Phosphorus and Potassium

One gram oven dried plant sample was taken and digested in 100 ml conical flask with 10 ml of di-acid mixture (2:5) consisting of chemically pure concentrated perchloric acid and nitric acid respectively and digested material was filtered through whatman no. 40 filter paper in 100 ml volumetric flask and filtrate was diluted to mark as outlined by Johnson and Ulrich (1959). This was used for estimation of P and K.

Phosphorus

The phosphorus content in the digested leaves sample was determined by vanado molybdophosphoric acid yellow colour method using spectrophotometer at 660 nm (Jackson, 1973). 5 ml of aliquot from the colourless filtrate was taken in 25 ml volumetric flask for determination and then 5 ml of ammonium molybdate vanadate mixture was added to it and volume was made up to 25 ml after shaking well. It was kept for 30 minutes and colour intensity was measured in Spectronic-20 at 430 nm wave length, after setting the instrument to zero with blank.

Potassium

10 ml aliquot of the filtrate was taken in 100 ml volumetric flask and it was diluted to mark with distilled water. The potassium content in extract was estimated by flame photometer (Jackson, 1973).

3.3.6.2 Corm sampling and nutrient analysis

The corms were lifted from the ground 60 days after flowering. The maturity of corms was identified by browning of leaves and wilting of plants. The corms were thoroughly washed, cut and dried in hot air oven. Dried corm samples

were then ground using grinder machine. The samples were then analyzed for determination of NPK contents. Same method as mentioned earlier was followed for the nutrient analysis of the corms. The result, thus, obtained was represented in terms of percentage on dry weight basis.

3.3.7 To study the economics for different treatments

3.3.7.1 Cost of cultivation

The cost of cultivation (fixed cost + treatment cost) in each treatment combination was worked out based on the actual expenditure incurred on each item (Appendix - B). The cost of corms, manures, fertilizers, labour charges and the cultural practices including harvesting was worked out based on the prevailing prices and wages during the cropping season and expressed as cost of cultivation per hectare.

3.3.7.2 Gross income

The gross income was calculated on the basis of sale price of gladiolus spikes and corms prevailing during the study period. The total yield of gladiolus cut flowers and corms was multiplied with the average price prevailed in the market for each grade and the sum revenue was expressed as total income per hectare.

3.3.7.3 Net income

Gross income minus cost of cultivation in each treatment was recorded as corresponding net income.

3.3.7.4 Benefit cost ratio

The ratio of net income to the total cost of cultivation was calculated and recorded as benefit-cost ratio for a particular treatment combination. It was computed by dividing the net income by corresponding cost of cultivation.

$$\text{Benefit cost ratio} = \frac{\text{Net return}}{\text{Total cost of cultivation}}$$

3.3.8 To study the vase life using locally available preservatives

Technical details:

Crop : Gladiolus

Cultivar : Candyman

Design : Completely Randomized Design Replication : 5

No. of treatment : 10

Treatment:

T_1 : Control (distilled water)

T_2 : Lime Juice 1%

T_3 : Citric acid 0.05%

T_4 : Cane Sugar 10%

T_5 : Commercial bleaching powder 0.005%

T_6 : Lime Juice 1%+ Cane Sugar 10%

T_7 : Citric acid 0.05%+ Cane Sugar 10%

T_8 : Cane Sugar 2%+ Commercial bleaching powder 0.005%

T_9 : Lime Juice 1%+ Cane Sugar 2% + Commercial bleaching powder 0.005%

T_{10} : Citric acid 0.05%+ Cane Sugar 2% + Commercial bleaching powder 0.005%

Preparation of floral preservatives solution

Formula:

Based on the above per cent formulae, citric acid 0.05% solutions was prepared by dissolving 500 mg in one litre of distilled water. Similarly, Calcium hypochlorite (Commercial bleaching powder) 0.005% was prepared by dissolving 50 mg in one litre of distilled water. To prepare 1% lime juice, 10 ml lime juice was extracted and dissolved each in 990 ml of distilled water. 10% and 2% cane sugar solution was prepared by dissolving 100g and 20g, respectively in one litre of distilled water.

Harvesting stage of the spike

Spikes were harvested when 2 basal florets showed colour. The cut was made at the base of the stem at the point just above the forth leaf from the base.

Preparation of spikes for vase-life studies

The cut spikes were immediately placed into a bucket containing clean water. All the leaves were removed and 30 cm stem length was maintained from the cut end of the base to the lower most flower bud. The base of each spike was submerged under water and slantingly cut with a sharp sterile blade, as a preventive measure to avoid entry of air bubbles. Then, 500 ml bottles containing 300 ml aqueous solution of various preservatives and distilled water as control was prepared and one cut spike was placed into each. The neck of the bottle was covered with the help of cotton plugs to check evaporation of the solution or distilled water. The following observations were recorded

3.3.8.1 Days to basal floret open

Days to basal floret open was recorded from the date of placing the spike in vase solution to complete opening of the basal floret.

3.3.8.2 Floret size of basal floret (cm)

The diameter of fully opened basal floret was measured as length and width and the average was calculated.

3.3.8.3 Shelf life of first floret (days)

Time taken from opening to fading of the lowermost floret was recorded.

3.3.8.4 Total blooming period (days)

Duration in days, between opening of the first floret and wilting of last floret was considered as total blooming period.

3.3.8.5 Increase in spike length (cm)

The difference between the length of the spike at the start of experiment and fading was recorded. The length of spike was measured from the basal floret bud to the tip of spike in cm.

3.3.8.6 Vase life (days)

The duration between the opening of the first basal floret and wilting of the 6^{th} floret from the base of spike was taken.

3.3.8.7 Vase solution uptake (ml)

Total quantity of water or aqueous solution used by the spike upto wilting of last opened floret was measured in ml at the termination of the experiment.

3.3.8.8 Benefit cost ratio

The ratio of incremental benefit of shelf life over control to the cost of treatment per scape was calculated and recorded as benefit-cost ratio for a

particular treatment combination. It was computed by dividing the incremental benefit of shelf life over control by corresponding cost of treatment per scape.

$$\text{Benefit cost ratio} = \frac{\text{Incremental benefit of shelf life over control}}{\text{Cost of treatment per scape}}$$

3.4 STASTISTICAL ANALYSIS

The data on various observations recorded during the course of investigation was statistically analyzed. Analysis of variance technique (ANOVA) for different characters was worked out. The appropriate standard error of mean (SEm ±) and the critical difference (CD) was calculated at 5 percent level of probability. Data was depicted by suitable graphs at the appropriate tables.

Standard Error of Mean was computed as-

$$SEm (\pm) = \frac{\sqrt{EMS}}{r}$$

Then, critical difference (CD) at 5% level of significance was computed as-

$$CD \text{ at } 5\% = SEd \times t_{value} \text{ where, } SEd = SEm \times \sqrt{2}$$

$$= SEm \times \sqrt{2} \times t_{(0.025,\ error\ df)}$$

CHAPTER IV

RESULTS AND DISCUSSION

RESULTS AND DISCUSSIONS

The results from the present investigation entitled “Integrated nutrient management and vase life of Gladiolus (*Gladiolus grandiflorus* L.)” are presented in this chapter. The results obtained have been duly supported by tables and figures and presented under the following heads.

1. Growth characters
2. Flowering parameters
3. Corm and cormel characters
4. Quality parameters
5. Plant nutrient uptake and soil fertility
6. Benefit cost ratio of cultivation
7. Vase life parameters
8. Benefit cost ratio of vase life solutions

4.1. Response of different sources of nutrient on growth characters.

Data recorded on growth studies *viz*. days to sprouting, leaf area at spike emergence and longest leaf length, including plant height, number of leaves per plant, girth of plant base at 20, 40, 60 and 80 days after planting (DAP) as affected by different sources of nutrient have been observed during the period of plant growth and discussed below.

4.1.1 Days to sprouting

It was observed from Table 4.1 that the days to sprouting of the gladiolus corms were significantly influenced by the different sources of nutrient during both the season of 2021 and 2022 including pooled data analysis.

The results revealed that the application of T_2 (100 ml activated EM m^{-2}) recorded the earliest sprouting of the corms (7.00 days) in the first season of the experiment. It was at par with T_4 (jeevamrutha 50 ml m^{-2}) (7.33 days), T_6 (50% RDF + 50% IEM) (7.67 days), T_5 (50% RDF + 50% EM) (8.00 days) and T_3 (500 ml activated IEM m^{-2}) (8.33 days). The last to sprout among all the treatments was reported in control (10 days).

In the second seasonal year as well, the treatment T_2 (100 ml activated EM m^{-2}) recorded the earliest sprouting of the corms (6.67 days), which was reportedly found to be at par with T_4 (jeevamrutha 50 ml m^{-2}) (7.67 days), T_5 (50% RDF + 50% EM) (7.67 days) and T_6 (50% RDF + 50% IEM) (8.00 days). Similarly with the previous season, the last to sprout among all the treatments was again reported in control (10.67days).

The pooled data analysis revealed that the treatment T_2 (100 ml activated EM m^{-2}) recorded the earliest sprouting of the corms (6.83 days) among all the other treatments. It was found at par with T_4 (jeevamrutha 50 ml m^{-2}) (7.50 days), T_5 (50% RDF + 50% EM) (7.83 days) and T_6 (50% RDF + 50% IEM) (7.83 days) while control (10.33 days) recorded to be the last to sprout among all the treatments.

The effect of effective microorganisms (EM) on the plant root formation that enhances water and nutrient absorption reflects on the early sprouting of the gladiolus corms. Similar observations have been found to be reported in the application of EM in reducing the average germination time of *Echinopsis* hybrids (Prisa, 2019a) and *Kalanchoe daigremontiana* (Prisa, 2019c) plants.

Table 4.1 Effect of different nutrient sources on days to sprouting of corms

Treatments	Days to sprouting		
	2021	**2022**	**Pooled**
T_0	10.00	10.67	10.33
T_1	9.33	9.00	9.17
T_2	**7.00**	**6.67**	**6.83**
T_3	8.33	8.67	8.50
T_4	7.33	7.67	7.50
T_5	8.00	7.67	7.83
T_6	7.67	8.00	7.83
T_7	9.00	9.33	9.17
SEm±	0.54	0.53	0.49
CD at 5%	1.64	1.60	1.49

4.1.2 Plant height

The significant response of plant height to the different sources of nutrient during both the season of 2021 and 2022 including pooled data analysis have been presented in Table 4.2. The data for plant height were recorded at 20, 40, 60 and 80 days after planting (DAP) for a more detailed observation on the plant growth. During the first field trail in 2021, treatment T_6 (50% RDF + 50% IEM) recorded the tallest plant height (108.57 cm) on the 80th day with 28.09% magnitude of increase over T_1 (100% RDF). It was found to be at par with T_3 (500 ml activated IEM m^{-2}) (102.35 cm), T_5 (50% RDF + 50% EM) (98.83 cm), T_0 (control) (98.46 cm) and T_4 (jeevamrutha 50 ml m^{-2}) (96.79 cm). The shortest plant height (84.76 cm) was recorded in T_1 (100% RDF).

Similarly in the following year of 2022, the tallest plant height (107.61 cm) was recorded in the plants treated with T_6 (50% RDF + 50% IEM) on the 80th day after planting. It was at par with treatment T_3 (500 ml activated IEM m^{-2}) (100.24 cm), T_4 (jeevamrutha 50 ml m^{-2}) (99.07 cm) and T_5 (50% RDF + 50% EM) (95.64 cm) while the shortest plant height (82.13 cm) was recorded in T_1 (100% RDF).

Data from the pooled analysis also revealed significant increase of the plant height with the tallest (108.09 cm) recorded in T_6 (50% RDF + 50% IEM) on the 80th day which was found to be at par with T_3 (500 ml activated IEM m^{-2}) (101.30 cm), T_4 (jeevamrutha 50 ml m^{-2}) (97.93 cm), T_5 (50% RDF + 50% EM) (97.24 cm) and T_0 (control) (94.11 cm). The shortest plant height among all the other treatments was recorded in T_1 (100% RDF) (83.44 cm). The use of organic amendments was found to be significantly superior than the inorganic sources for taller plant growth during both the seasons. The organic sources were able to fulfil the high nutrient requirement demand by the gladiolus crop in comparison to the

Table 4.2 Effect of different nutrient sources on plant height (cm) of gladiolus cv. Candyman.

Treatments	20th Day			40th day			60th Day			80th Day		
	2021	**2022**	**Pooled**	**2021**	**2022**	**Pooled**	**2021**	**2022**	**Pooled**	**2021**	**2022**	**Pooled**
T_0	22.03	21.03	21.53	48.45	47.08	47.76	61.94	60.81	61.37	98.46	89.75	94.11
T_1	21.75	19.41	20.58	47.30	45.93	46.62	61.24	60.54	60.89	84.76	82.13	83.44
T_2	**24.17**	22.84	23.51	51.32	49.98	50.65	66.23	64.57	65.40	90.17	91.31	90.74
T_3	23.58	22.58	23.08	51.03	49.67	50.35	65.87	64.23	65.05	102.35	100.24	101.30
T_4	23.85	22.85	23.35	50.82	49.49	50.15	65.92	64.92	65.42	96.79	99.07	97.93
T_5	23.30	23.63	23.47	49.09	48.42	48.76	67.75	**69.75**	**68.75**	98.83	95.64	97.24
T_6	23.97	**23.63**	**23.80**	**52.51**	**51.17**	**51.84**	**67.83**	67.16	67.49	**108.57**	**107.61**	**108.09**
T_7	22.25	21.91	22.08	48.26	46.89	47.58	62.61	64.61	63.61	87.49	88.36	87.92
SEm±	1.93	1.85	1.87	2.02	1.86	1.93	2.36	2.10	2.15	5.83	4.42	4.65
CD at 5%	NS	NS	NS	NS	NS	NS	7.15	NS	NS	17.69	13.41	14.09

inorganic source. It might be due to the fact that there is increase in the availability of nutrients for the plants in the presence of indigenous microorganisms, including production of phytohormones (Kumar and Gopal, 2015).

These results were also similar with the findings of Shaheen *et al*. (2017) on spinach in which it was reported that co-application of effective microorganisms with fertilizers recorded significant increase in plant height because EM acts as a bio-stimulator for producing and inducing the plant growth hormones that enhances the growth rate of the plant.

4.1.3 Number of leaves per plant

As per the data presented in Table 4.3, the number of leaves per plant was significantly influenced by the different source of nutrient. The results showed that in the first year of the experiment on the 80th day, the highest Number of leaves per plant (8.00) was observed in T_2 (100 ml activated EM m^{-2}) which was at par with T_4 (jeevamrutha 50 ml m^{-2}) (7.40). The lowest count of leaves per plant was reported in T_1 (100% RDF) (6.73).

In the following year of experiment, two treatments recorded the highest nof leaves per plant (7.47) *viz*. T_2 (100 ml activated EM m^{-2}) and T_7 (50% RDF + 50% jeevamrutha) on the 80th day. They were found to be at par with T_5 (50% RDF + 50% EM) (7.27), T_4 (jeevamrutha 50 ml m^{-2}) (7.20) and T_6 (50% RDF + 50% IEM) (7.00). Control recorded the lowest count of leaves per plant (5.47) followed by T_1 (100% RDF) (6.87).

The pooled data analysis revealed that on the 80th day, the highest number of leaves per plant (7.73) was observed in T_2 (100 ml activated EM m^{-2}) which was found to be at par with T_4 (jeevamrutha 50 ml m^{-2}) (7.30), T_7 (50% RDF + 50%

Table 4.3 Number of leaves per plant as influenced by different nutrient sources

Treatments	20th Day			40th day			60th Day			80th Day		
	2021	**2022**	**Pooled**	**2021**	**2022**	**Pooled**	**2021**	**2022**	**Pooled**	**2021**	**2022**	**Pooled**
T_0	1.53	1.00	1.27	4.07	1.07	2.57	5.93	3.20	4.57	6.87	5.47	6.17
T_1	1.40	1.20	1.30	4.00	1.87	2.93	5.80	3.67	4.73	6.73	6.87	6.80
T_2	1.47	1.40	1.43	**4.40**	**2.93**	**3.67**	**6.47**	**5.73**	**6.10**	**8.00**	**7.47**	**7.73**
T_3	**1.80**	**1.53**	**1.67**	4.33	2.00	3.17	6.20	4.20	5.20	7.20	6.93	7.07
T_4	1.60	1.40	1.50	4.33	1.87	3.10	6.27	3.80	5.03	7.40	7.20	7.30
T_5	1.47	1.27	1.37	4.27	1.93	3.10	6.00	4.00	5.00	7.20	7.27	7.23
T_6	1.67	1.40	1.53	4.47	2.27	3.37	6.27	3.87	5.07	7.27	7.00	7.13
T_7	1.47	1.27	1.37	3.87	1.93	2.90	6.07	4.53	5.30	7.13	7.47	7.30
SEm±	0.12	0.11	0.11	0.18	0.31	0.15	0.22	0.39	0.22	0.20	0.22	0.18
CD at 5%	NS	NS	NS	NS	0.93	0.46	NS	1.19	0.66	0.60	0.66	0.55

jeevamrutha) (7.30) and T_5 (50% RDF + 50% EM) (7.23). The lowest count of leaves per plant (6.17) was recorded in control. As observed in both the seasonal year, the plots receiving no organic inputs had the least number of leaves and those plots with organic sources showed higher values. With regard to the number of leaves, the magnitude of increase in T_2 over T_0 is 25.28% and that with T_1 over T_0 is 10.21% depicting that application of EM preformed more effectively than the RDF.

The result supports the role of effective microorganisms in promoting plant growth and supplying nutrient which are readily benefitted by the plants. EM contains living beneficial microorganisms that increases the amount of nutrients and enables in biological nitrogen fixation which directly acts as a catalyst to boost the photosynthetic process thereby increasing the chlorophyll content and hence, resulting in more number of leaves. Similar reports of progressive increase in number of leaves in sponge gourd plants treated with EM have been reported by Singh *et al.* (2018).

4.1.4 Girth of plant base

The data recorded showed significant effect of the different nutrient sources on girth of plant base (Table 4.4). The largest girth of plant base (6.23 cm) on the 80^{th} day in first year was reported in T_6 (50% RDF + 50% IEM) which was found to be at par with T_0 (control) (5.90 cm). The smallest girth of plant base was measured in T_4 (jeevamrutha 50 ml m^{-2}) (5.02 cm).

In the following year on the 80^{th} day, T_5 (50% RDF + 50% EM) (6.90 cm) obtained the largest girth of plant base and T_0 (control) (4.53 cm) recorded the smallest.

Table 4.4 Girth of plant base (cm) as influenced by different nutrient sources

Treatments	20th Day			40th day			60th Day			80th Day		
	2021	**2022**	**Pooled**	**2021**	**2022**	**Pooled**	**2021**	**2022**	**Pooled**	**2021**	**2022**	**Pooled**
T_0	3.44	2.63	3.04	4.78	3.07	3.92	5.63	4.27	4.95	5.90	4.53	5.22
T_1	3.12	2.80	2.96	4.79	3.23	4.01	5.59	4.27	4.93	5.25	4.77	5.01
T_2	3.41	3.36	3.39	5.04	**3.93**	**4.49**	5.72	4.77	5.24	5.41	5.52	5.47
T_3	3.34	**3.47**	**3.40**	4.64	3.83	4.24	5.37	3.97	4.67	5.61	4.67	5.14
T_4	3.29	2.92	3.11	4.80	3.13	3.97	5.57	3.87	4.72	5.02	5.73	5.38
T_5	3.30	3.37	3.33	4.73	3.90	4.31	5.67	**4.87**	**5.27**	5.56	**6.90**	**6.23**
T_6	**3.51**	2.97	3.24	**5.20**	3.47	4.33	**6.14**	4.13	5.14	**6.23**	4.85	5.54
T_7	3.25	2.89	3.07	4.70	3.57	4.13	5.57	4.27	4.92	5.42	5.23	5.33
SEm±	0.09	0.31	0.26	0.19	0.35	0.21	0.23	0.44	0.26	0.19	0.32	0.19
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	0.57	0.98	0.57

The pooled data analysis of both the year reveals that on the 80th day, the largest girth of plant base was obtained by T_5 (50% RDF + 50% EM) (6.23 cm) and the smallest was by T_1 (100% RDF) (5.01).

From the results, it is known that the plants treated with EM were preforming significantly superior than the untreated ones. It may be due to the presence of beneficial bacteria in EM that helps ease the absorption of nutrients by solubilizing the minerals particularly, phosphorus (P), calcium (Ca) and Magnesium (Mg). Plants require Ca for their stem development while, Mg is essential for the synthesis of chlorophyll which helps the plants to utilize the phosphorus to increase plant growth around the lateral meristem stimulating the increase in size of the girth due to the addition of secondary vascular tissue. Increase in the girth of plant base on crops treated with EM was also reported in the findings of Prisa (2019e) in augergine plants and Prisa (2021) in *Myrtillocactus geometrizans*.

4.1.5 Leaf area at spike emergence

The leaf area was reportedly found to be significantly influenced by the different sources of nutrient as per the data represented in Table 4.5. During the year 2021, the maximum value for leaf area at spike emergence (125.51 cm^2) was found in T_6 (50% RDF + 50% IEM) while the minimum leaf area at spike emergence (92.74 cm^2) was observed in control.

In the following year 2022, T_6 (50% RDF + 50% IEM) recorded the maximum value for leaf area at spike emergence measuring 125.13 cm^2. On the contrary, control reported the minimum leaf area at spike emergence with 91.56 cm^2.

The pooled data analysis from both the years shows that the maximum leaf area at spike emergence (125.32 cm^2) was found in T_6 (50% RDF + 50% IEM) while the minimum leaf area at spike emergence (92.15 cm^2) was observed in control.

It is known from the results that the application of indigenous microorganisms (IMO) in combination with the inorganic fertilizers gave better growth of leaf area in comparison to the control. The plants supplemented with IMO shows superior growth because the microorganisms present in them are indigenous to the area and thus, creates that suitable environment for all the beneficial microbes to thrive naturally (Kumar and Gopal, 2015). This causes availability of essential macro and micro nutrients for the plant growth in small quantities for the plants to absorb it gradually and promote a steady supply unlike those inorganic sources that burns out the plant system from the initial phase causing decline in plant growth in the later stage (Onuoha *et al.* 2020). Similar findings were reported in rice plants by Onuoha *et al.* (2020) and Sakimin *et al.* (2017).

4.1.6 Longest leaf length

The length of the longest leaf was measured at the time of spike emergence which determines the end of the vegetative phase for the plant. Different sources of nutrient influenced the leaf length as the data presented in Table 4.5 showed significant differences between the treatments. During the first season in 2021, the longest leaf length (47.35 cm) was measured in T_2 (100 ml activated EM m^{-2}) which was found to be at par with T_5 (50% RDF + 50% EM) (46.51 cm), T_6 (50% RDF + 50% IEM) (45.85 cm), T_4 (jeevamrutha 50 ml m^{-2}) (45.71 cm), T_7 (50% RDF + 50% jeevamrutha) (45.55 cm) and T_3 (500 ml activated IEM m^{-2}) (45.33

cm) while the shortest leaf length was measured in T_1 (100% RDF) (42.63 cm) followed by T_0 (control) (42.73 cm).

During the year 2022, T_6 (50% RDF + 50% IEM) (46.22 cm) recorded the longest leaf length which was found to be at par with T_5 (50% RDF + 50% EM) (45.25 cm), T_7 (50% RDF + 50% jeevamrutha) (45.22 cm), T_2 (100 ml activated EM m^{-2}) (44.98 cm), T_4 (jeevamrutha 50 ml m^{-2}) (44.69 cm) and T_3 (500 ml activated IEM m^{-2}) (44.00 cm). Meanwhile, the shortest leaf length was recorded in T_0 (control) (41.03 cm).

On the basis of both the year data on leaf length, the longest (46.16 cm) was recorded in T_2 (100 ml activated EM m^{-2}). The other treatments found to be at par were T_6 (50% RDF + 50% IEM) (46.04 cm), T_5 (50% RDF + 50% EM) (45.88 cm), T_7 (50% RDF + 50% jeevamrutha) (45.39 cm), T_4 (jeevamrutha 50 ml m^{-2}) (45.20 cm) and T_3 (500 ml activated IEM m^{-2}) (44.67 cm). Significantly shortest leaf length was recorded in T_0 (control) (41.88 cm).

The result provides evidences that the application of effective microorganisms (EM) had a positive impact on the vegetative growth of the plant. The surface of leaf plays an important role in the photosynthetic activity and with proper nutrient enrichment due to EM; there have been reports of increase in synthesis of chlorophyll content because it prevents oxidative damage of chloroplast, lipids and protein by improving the pigment protein complexes thereby, promoting the leaf growth and development (Kerubo *et al.*, 2021). Beneficial effect of EM on the photosynthesis and leaf growth was also reported by Zhang *et al*. (2021) on some green leafy vegetables such as leetuce (*Lactuca sativa* L. var. ramose Hort.), spinach (*Spinacia oleracea* L.) and pakchoi (*Brassica chinensis* L.).

Table 4.5 Leaf area at spike emergence (cm^2) and longest leaf length (cm) as influenced by different nutrient sources

Treatments	Leaf area at spike emergence (cm^2)			Longest leaf length (cm)		
	2021	**2022**	**Pooled**	**2021**	**2022**	**Pooled**
T_0	92.74	91.56	92.15	42.73	41.03	41.88
T_1	104.96	102.45	103.70	42.63	41.63	42.13
T_2	109.80	109.92	109.86	**47.35**	44.98	**46.16**
T_3	105.59	110.74	108.17	45.33	44.00	44.67
T_4	110.21	110.72	110.47	45.71	44.69	45.20
T_5	111.68	112.02	111.85	46.51	45.25	45.88
T_6	**125.51**	**125.13**	**125.32**	45.85	**46.22**	46.04
T_7	107.42	107.84	107.63	45.55	45.22	45.39
SEm±	3.37	3.05	3.08	0.85	0.84	0.83
CD at 5%	10.22	9.24	9.34	2.59	2.55	2.50

4.2 Flowering parameters

Flowering parameters are one of the most important factors in determining the quality of a plant. They can be used to determine how well a plant is growing, and they are often used to help growers determine when to harvest their crops. They are also an important factor in determining market demand. The flower characters were influenced by the different nutrient sources and the reasons are presented in the following discussions.

4.2.1 Days taken for spike initiation

The data presented in Table 4.6 shows that there is a significant difference in the days taken for spike initiation. In the first season, T_2 (100 ml activated EM m^{-2}) recorded the minimum days taken for spike initiation (67.81 days). T_1 (100% RDF) with 72.80 days took the maximum days for spike initiation.

In the following season, T_2 (100 ml activated EM m^{-2}) again recorded the minimum days taken for spike initiation (69.14 days) which was found to be at par with T_0 (control) (70.23 days), T_5 (50% RDF + 50% EM) (70.83 days) and T_7 (50% RDF + 50% jeevamrutha) (72.05 days). Maximum days for spike initiation were recorded in T_4 (jeevamrutha 50 ml m^{-2}) (74.00 days).

The pooled data analysis revealed that T_2 (100 ml activated EM m^{-2}) recorded the minimum days taken for spike initiation (68.48 days) and was found to be at par with T_5 (50% RDF + 50% EM) (70.65 days) and T_0 (control) (70.75 days). Maximum days for spike initiation were recorded in T_1 (100% RDF) with 72.68 days. The results showed that the days taken for spike initiation were reduced when effective microorganisms were added to the soil. This is because they promote root growth, which increases the nutrient uptake by plants.

Plate 4. Spike initiation stage and full opening of Gladiolus cv. Candyman and intercrop marigold.

Plate 5. General view of experimental site at flowering stage of Gladiolus cv. Candyman.

The early initiation of spike must be due to the ability of effective microorganisms (EM) to increase the length and number of internodes, as well as increase the size of leaves and roots. Another reason for this effect could be that EM helps in the initiation of flower spikes by providing nitrogen to the plant cells, which is needed for protein synthesis and an increase in photosynthesis and growth hormone production such as auxin and gibberellins by the plant (Kerubo *et al.,* 2021). These hormones travel through its vascular system until they reach their destination; the apical meristem (the tip) of each branch or stem. There, they induce cell division and elongation as well as differentiation into meristematic tissue, which is where new growth occurs in plants. The results were in close conformity with the findings of Singh *et al.* (2018) in sponge gourd (*Luffa cylindrical* Roem.) where it was stated that plants treated with EM experience early completion of the vegetative phase resulting in early flowering.

4.2.2 Days taken for first floret opening

The days taken for first floret opening were significantly influenced by the different sources of nutrient as presented in Table 4.6. In the first season, the minimum days taken for first floret opening (74.48 days) was observed in T_2 (100 ml activated EM m^{-2}) while T_1 (100% RDF) recorded the maximum with 80.83 days.

Similar results were obtained in the following season where the minimum days taken for first floret opening (74.01 days) was observed in T_2 (100 ml activated EM m^{-2}) and the maximum days for first floret opening was recorded in T_1 (100% RDF) (83.50 days).

The pooled data analysis of both the years also revealed a similar trend. T_2 (100 ml activated EM m^{-2}) recorded the minimum days taken for first floret

Table 4.6 Days taken for spike initiation and first floret opening as influenced by different nutrient sources

Treatments	Days taken for spike initiation			Days taken for first floret opening		
	2021	**2022**	**Pooled**	**2021**	**2022**	**Pooled**
T_0	71.27	70.23	70.75	78.08	79.38	78.73
T_1	72.80	72.57	72.68	80.83	83.50	82.17
T_2	**67.81**	**69.14**	**68.48**	**74.48**	**74.01**	**74.24**
T_3	71.00	72.33	71.67	79.00	80.33	79.67
T_4	72.67	74.00	73.33	80.67	80.67	80.67
T_5	70.47	70.83	70.65	80.00	79.67	79.83
T_6	71.60	73.09	72.35	79.60	78.20	78.90
T_7	70.72	72.05	71.38	79.25	81.97	80.61
SEm±	0.87	0.96	0.88	1.11	1.18	1.03
CD at 5%	2.64	2.91	2.68	3.38	3.58	3.14

opening (74.24 days) and the maximum days for first floret opening was recorded in T_1 (100% RDF) (82.17 days).

The results showed that the first floret opening in flowers was early when the effective microorganisms were added to the medium. Not so long ago, scientists discovered the amazing effect of effective microorganisms (EM) on the opening of the first floret of crop plants. Studies have shown the application of EM to the soil greatly enhances its fertility and triggers the first floret opening faster than would otherwise occur naturally. The science behind this phenomenon has to do with the production of hormones in the plant, which can be influenced by the presence of EM. As the effective microorganisms promote the production of these hormones, the plant is induced to open its first floret sooner. Similar results were reported in the findings of Singh *et al.* (2018) in sponge gourd (*Luffa cylindrical* Roem.) where it was stated that plants treated with EM experience early completion of the vegetative phase resulting in early flowering.

4.2.3 Spike length

It is clear from the data presented in Table 4.7 that the spike length was significantly influenced by the different sources of nutrient during both the seasons and also on the pooled data. In the first year of experiment, the longest spike length (89.92 cm) was recorded in T_3 (500 ml activated IEM m^{-2}) which was found to be at par with T_6 (50% RDF + 50% IEM) (89.65 cm), T_0 (control) (81.44 cm) and T_5 (50% RDF + 50% EM) (81.01 cm). The shortest spike length was observed in T_1 (100% RDF) (74.86 cm).

Similarly in the second year of experiment, the longest spike length (89.32 cm) was recorded in T_3 (500 ml activated IEM m^{-2}) which was found to be at par with T_6 (50% RDF + 50% IEM) (87.50 cm), while T_1 (100% RDF) with 72.85 cm recorded the shortest spike length.

In the pooled data analysis, T_3 (500 ml activated IEM m^{-2}) had the longest spike length (89.62 cm) which was found to be at par with T_6 (50% RDF + 50% IEM) (88.58 cm), T_0 (control) (80.42 cm) and T_5 (50% RDF + 50% EM) (80.27 cm). The least effective treatment was observed in T_1 (100% RDF) (73.85 cm).

Indigenous microorganisms are known to affect plants in various positive ways. As per the results obtained from the data, the effect of indigenous microorganisms on the increase of spike length is also one of them. Indigenous microorganisms in the soil can forward the uptake of nutrients, breakdown organic compounds, and stimulate growth. Hence, the indigenous microorganisms can boost the spike length through increased nutrient availability, the breakdown of organic compounds, and the stimulation of growth. Also, they are known to have a beneficial effect on plant physiology. Studies have found that the use of indigenous microorganisms can lead to increased spike length in wheat. This is because indigenous microorganisms can increase nutrient availability and water absorption, which positively affects the growth of spikes. By providing essential nutrients, indigenous microorganisms can help increase the amount of spike growth in wheat plants (Shah *et al.,* 2022).

4.2.4 Rachis length

Rachis length was reported to be significantly influenced by the different source of nutrients as per the data presented in Table 4.7. In the first season of experiment, the maximum rachis length (34.43 cm) was obtained by T_0 (control) which was at par with T_6 (50% RDF + 50% IEM) (31.13 cm) and T_3 (500 ml activated IEM m^{-2}) (31.02 cm). The minimum rachis length (24.38 cm) was observed by T_7 (50% RDF + 50% jeevamrutha).

In the second year of experiment, the maximum rachis length (34.40 cm) was obtained by T_3 (500 ml activated IEM m^{-2}) which was found to be at par with T_0 (control) (32.90 cm) and T_6 (50% RDF + 50% IEM) (30.75 cm). The least effective treatment was observed in T_1 (100% RDF) (25.57 cm).

The pooled data analysis results revealed that the maximum rachis length (33.66 cm) was obtained by T_0 (control) and it was at par with T_3 (500 ml activated IEM m^{-2}) (32.71 cm) and T_6 (50% RDF + 50% IEM) (30.94 cm). The minimum rachis length (25.57 cm) was recorded by T_1 (100% RDF).

From this research finding, we have come to know that indigenous microorganisms and FYM (Farmed Yard Manure) are natural fertilisers that have been proven to effectively increase rachis length, outperforming inorganic fertilisers. They have an indirect impact on the soil that leads to more nutrient uptake, optimizing soil-air ratio and the overall increase of rachis length. These fertilisers are of particular importance in improving soil fertility and crop yields. They also help improve soil structure and water holding capacity. By understanding the reasons behind their effectiveness, farmers can unlock the potential of their natural resources in a sustainable way. This is mainly due to the positive effect of the indigenous microorganisms and FYM on the rachis length. Thus, indigenous microorganisms and FYM perform better than the inorganic fertilizers due to their influence on the healthy growth of the crop.

It has long been considered as possible solutions to increased rachis length in plants. Research has found that the combination of microbial activity along with the FYM helps to provide better nutrition for plants in comparison to other inorganic fertilizers, which means bigger and longer rachis growth. A deeper understanding of the effect of indigenous microorganisms and FYM is essential to ensure maximum yield and better crop quality. The yields from such crops are able

Table 4.7 Spike length (cm) and rachis length (cm) as influenced by different nutrient sources

Treatments	Spike length (cm)			Rachis length (cm)		
	2021	**2022**	**Pooled**	**2021**	**2022**	**Pooled**
T_0	81.44	79.39	80.42	**34.43**	32.90	**33.66**
T_1	74.86	72.85	73.85	25.57	25.57	25.57
T_2	75.96	75.62	75.79	25.14	26.33	25.73
T_3	**89.92**	**89.32**	**89.62**	31.02	**34.40**	32.71
T_4	78.88	78.52	78.70	26.93	27.38	27.15
T_5	81.01	79.53	80.27	25.81	26.25	26.03
T_6	89.65	87.50	88.58	31.13	30.75	30.94
T_7	78.49	77.70	78.10	24.38	27.56	25.97
SEm±	3.41	2.85	3.11	1.82	1.89	1.95
CD at 5%	10.34	8.64	9.44	5.53	5.73	5.90

to out-perform crops treated with inorganic fertilizers as they can effectively break down complex molecules, including carbon and nitrogen, which help plants grow faster. These microbes could be an important tool in increasing crop yields in the long run. The present result is in close collaboration with the findings of Chamkhi *et al*. (2021).

4.2.5 Number of spikes per plant

From the data presented in Table 4.8 it can be inferred that the number of spikes per plant was significantly influenced by the application of different nutrient sources. Highest number of spikes per plant (1.00) was recorded in T_2 (100 ml activated EM m^{-2}) which was at par with T_3 (500 ml activated IEM m^{-2}) (0.94), T_6 (50% RDF + 50% IEM) (0.94), T_5 (50% RDF + 50% EM) (0.90), T_0 (control) (0.88) and T_4 (jeevamrutha 50 ml m^{-2}) (0.81) in the first year. The lowest number of spikes per plant (0.60) was recorded in both T_1 (100% RDF) and T_7 (50% RDF + 50% jeevamrutha).

Similarly, in the following year, T_2 (100 ml activated EM m^{-2}) obtained the highest number of spikes per plant (1.06) which showed at par values with T_4 (jeevamrutha 50 ml m^{-2}) (0.96), T_5 (50% RDF + 50% EM) (0.94) and T_6 (50% RDF + 50% IEM) (0.90). The lowest number of spikes per plant (0.69) was recorded in T_7 (50% RDF + 50% jeevamrutha).

Pooled data of both the years depicted a similar trend, T_2 (100 ml activated EM m^{-2}) obtained the highest number of spikes per plant (1.03) which was at par with T_5 (50% RDF + 50% EM) (0.92), T_6 (50% RDF + 50% IEM) (0.92), T_3 (500 ml activated IEM m^{-2}) (0.90) and T_4 (jeevamrutha 50 ml m^{-2}) (0.89) while, T_7 (50% RDF + 50% jeevamrutha) recorded the lowest number of spikes per plant (0.65).

In this experiment, the application of effective microorganisms and organic inputs has proved effective in increasing the number of spikes per plant. This is in contrast to jeevamrutha, which did not perform well in this regard. Jeevamrutha is a liquid fertilizer which is made with a combination of jaggery, cow dung, and water, and it was not as effective as EM and organic fertilizers in increasing the number of spikes per plant.

Effective microorganisms (EM) and organic fertilizers are gaining high popularity in today's agricultural landscape as they help farmers to increase their yield. The benefits of EM and organic fertilizers are due to the improved soil composition they bring, which increases plant growth and development. Studies have found that these organic fertilizers have an effect on the number of spikes per plant, as they are rich in nutrients and improve the quality of the soil. Reasons why these EM and fertilizers work are due to their high content of nitrogen and phosphorus, which are essential for aiding plant growth. Similar results were obtained by Al-Naqeeb *et al.* (2018) who reported an increase in the number of spikes per square meter in wheat due to increase in the frequency of EM-1 spraying.

4.2.6 Number of florets per spike

The data presented in Table 4.8 reveals that the application of different nutrient sources significantly affect the number of florets per spike. In the first year of experiment, the highest number florets per spike (10.53) was obtained by T_3 (500 ml activated IEM m^{-2}) which was at par with T_6 (50% RDF + 50% IEM) (9.73), T_0 (control) (9.67) and T_2 (100 ml activated EM m^{-2}) (9.40). The lowest number of florets per spike (8.13) was counted in T_1 (100% RDF).

In the following year of the study, the highest number of florets per spike (10.40) was obtained by T_3 (500 ml activated IEM m^{-2}) which was at par with T_6 (50% RDF + 50% IEM) (9.80) and T_2 (100 ml activated EM m^{-2}) (9.73) while, the lowest number of florets per spike (8.00) were counted in T_1 (100% RDF).

The pooled data analysis data also reveals the similar trend as observed in the seasonal analysis. T_3 (500 ml activated IEM m^{-2}) gave the highest number of florets per spike (10.47) and it was found to be at par with T_6 (50% RDF + 50% IEM) (9.77), T_2 (100 ml activated EM m^{-2}) (9.57) and T_0 (control) (9.47) while, the lowest number florets per spike (8.07) were counted in T_1 (100% RDF).

The application of organic fertilizers, particularly indigenous microorganisms have been proven to increase the number of florets per spike in crops. The natural microorganisms and organic fertilizers are known to be more effective when compared to synthetic or inorganic fertilizers. This is due to the enhanced biological activities of natural substances and the absence of chemicals, resulting in healthier growth and development of the plant. Such conditions favour the photosynthetic process of producing more food materials for the plant and thereby increasing the number of florets per spike. The organic fertilizers provide the necessary elements and trace minerals and also help increase water and nutrient uptake by the plants. The inorganic fertilizers, on the other hand, contain a lot of nutrients and trace minerals but due to their presence, they may lead to a decrease in the florets per spike. These results were also found to be in conformity with the findings of Qasim *et al.* (2014) in *Gladiolus grandiflorus* cv. White Prosperity.

Table 4.8 Number of spikes per plant and Number of florets per spike as influenced by different nutrient sources

Treatments	Number of spikes per plant			Number of florets per spike		
	2021	**2022**	**Pooled**	**2021**	**2022**	**Pooled**
T_0	0.88	0.75	0.81	9.67	9.27	9.47
T_1	0.60	0.79	0.70	8.13	8.00	8.07
T_2	**1.00**	**1.06**	**1.03**	9.40	9.73	9.57
T_3	0.94	0.85	0.90	**10.53**	**10.40**	**10.47**
T_4	0.81	0.96	0.89	8.87	8.80	8.83
T_5	0.90	0.94	0.92	9.07	9.33	9.20
T_6	0.94	0.90	0.92	9.73	9.80	9.77
T_7	0.60	0.69	0.65	9.00	9.00	9.00
SEm±	0.07	0.06	0.06	0.40	0.28	0.33
CD at 5%	0.23	0.18	0.19	1.21	0.84	1.00

4.2.7 Floral diameter

Floral diameter is an important indicator of nutrient uptake in plants, especially gladiolus. With different sources of nutrients varying in availability, it is important to measure the floral diameter of gladiolus to determine the efficacy of the nutrient sources. Results from this experiment give us a better understanding of the effects of different nutrients on overall gladiolus growth and health. By understanding the relationship between nutrient sources and floral diameter, growers can optimize properties of their inputs to produce the best possible gladiolus. Results of the influence of various nutrient sources on floral diameter, thus obtained are depicted in Table 4.9.

In the first year of experiment, the maximum floral diameter (10.04 cm) was measured in T_3 (500 ml activated IEM m^{-2}) which was at par with T_6 (50% RDF + 50% IEM) (9.99 cm) and T_0 (control) (9.79 cm) whereas the minimum floral diameter (7.97 cm) was observed in T_1 (100% RDF).

In the following year of experiment, the maximum floral diameter (9.91 cm) was measured in T_3 (500 ml activated IEM m^{-2}) which was at par with T_6 (50% RDF + 50% IEM) (9.65 cm), T_7 (50% RDF + 50% jeevamrutha) (9.48 cm) and T_0 (control) (9.30 cm). The minimum floral diameter (7.91 cm) was observed in T_1 (100% RDF).

The pooled data analysis of both the years revealed that T_3 (500 ml activated IEM m^{-2}) gave the maximum floral diameter (9.97 cm) and was at par with T_6 (50% RDF + 50% IEM) (9.82 cm) and T_0 (control) (9.54 cm) while the minimum floral diameter (7.94 cm) was observed in T_1 (100% RDF). From the results obtained, it is known that different nutrient sources can have an effect on

the floral diameter of gladiolus. This indicator can provide insight into the surrounding environment and floral health.

Indigenous Effective Microorganisms (IEM) and organic fertilizers have been found to be the most efficient in terms of increasing the diameter of flowers, compared with inorganic fertilizers. This is because IEM and organic fertilizers contain nutrients and beneficial substances that are essential for healthy and fast flowering. Additionally, they promote the growth of the roots and stems, producing healthier and more vibrant flowers. Indigenous effective microorganisms and organic fertilizers have been known to increase floral diameter due to the sulphur, nitrogen, phosphorus and potassium found in them. These microorganisms form a symbiotic relationship with the plant, providing it with essential nutrients thus increasing the floral diameter. Contrastingly, inorganic fertilizers recorded the lowest floral diameter due to their stressful impact on the plant-soil symbiotic relationship. The magnitude of increase with respect to floral diameter of T_3 over T_1 was 25.57% depicting that application of IEM to be more effective in the increase of floral diameter than the inorganic fertilizers. Similar findings were also reported by Araújo *et al.* (2020) in Rose (*Rosa hybrid* L.) cv. Black Prince, where flowers treated with plant growth promoting bacteria resulted in up to 29% larger flower diameter in comparison with the control.

4.2.8 Days to harvesting of spikes

The days to harvesting of spikes was significantly influenced by different sources of nutrients as presented in Table 4.9. In the first year of experiment, the minimum days to harvesting of spikes (7.78 days) was reported in T_2 (100 ml activated EM m^{-2}) whereas T_1 (100% RDF) required the maximum days to harvesting of spikes (10.10 days).

Similar results were obtained in the second year, T_2 (100 ml activated EM m^{-2}) recorded the minimum days to harvesting of spikes (8.04 days) and T_1 (100% RDF) required the maximum days to harvesting of spikes (10.23 days).

Similar trend of result was obtained in the pooled analysis of the two years data, T_2 (100 ml activated EM m^{-2}) recorded the minimum days to harvesting of spikes (7.91 days). On the other hand, the maximum days to harvesting of spikes (10.17 days) was observed in T_1 (100% RDF).

Effective microorganisms (EM) and organic fertilizers are an effective and natural way to encourage early harvesting of spikes in plants. EM products are made up of beneficial bacteria, yeast, and other microorganisms and create an environment that helps plants grow faster and with better quality. Organic fertilizers have substances that act as food for plants, directly providing them with important nutrients. This helps speed up the time for the plant to reach the harvesting stage and get them ready to harvest earlier than usual. On the other hand, inorganic fertilizers are not able to stimulate the spike growth and often lead to a late harvesting stage.

Organic fertilizers made from Effective microorganisms (EM) are beneficial for early harvesting of spikes as it provides the necessary minerals and nutrients for crop growth. EM helps in a better absorption of nutrients present in soil, thereby enhancing the fertility of soil and improving crop quality. The EM helps stimulate the natural microbial activity in soil, which helps in faster absorption of nutrients by the crop leading to early harvesting. The use of inorganic fertilizers often delay the flowering of crops and they are unable to provide the necessary nutrition leading to late harvesting. Similar results were reported in the findings of Singh *et al.* (2018) in sponge gourd (*Luffa cylindrical*

Table 4.9 Floral diameter and Days to harvesting of spikes as influenced by different nutrient sources

Treatments	Floral diameter (cm)			Days to harvesting of spikes		
	2021	**2022**	**Pooled**	**2021**	**2022**	**Pooled**
T_0	9.79	9.30	9.54	8.79	8.84	8.82
T_1	7.97	7.91	7.94	10.10	10.23	10.17
T_2	8.92	9.11	9.02	**7.78**	**8.04**	**7.91**
T_3	**10.04**	**9.91**	**9.97**	8.89	9.00	8.94
T_4	8.71	8.47	8.59	9.07	9.11	9.09
T_5	7.97	8.25	8.11	9.00	8.96	8.98
T_6	9.99	9.65	9.82	9.95	9.99	9.97
T_7	9.29	9.48	9.39	9.91	9.98	9.94
SEm±	0.11	0.23	0.15	0.13	0.09	0.10
CD at 5%	0.34	0.71	0.45	0.40	0.29	0.31

Roem.) where it was stated that plants treated with EM experience early completion of the vegetative phase resulting in early flowering.

4.3 Corm and cormel characters

Corm and cormel production in gladiolus is very important for the local economy and for the sustenance of the people in the area. Study on corm and cormel production in gladiolus is very important in understanding and analysing the significant contributions of different organic and inorganic nutrient sources in their optimum production. Studies have revealed that different organic and inorganic nutrient sources have a significant impact on the growth and development of their corms and cormels. It is for this reason that more research and studies need to be done in order to gain more insight on the influence of diverse nutrient sources on the corm and cormel production in gladiolus. It involves assessing the nutrient requirement and uptake, impact of soils and other environmental factors, and the result of usage of various plant stimulants in corm and cormel production in gladiolus. In this experiment, the corm and cormel characters were influenced by the different nutrient sources and the reasons are presented in the following discussions.

4.3.1 Number of corms per plant

The number of corms per plant was significantly influenced by the application of different nutrient sources as presented in Table 4.10. During the first year of experiment, the highest number of corms per plant (1.70) was given by T_3 (500 ml activated IEM m^{-2}) and found to be at par with T_2 (100 ml activated EM m^{-2}) (1.21) and T_5 (50% RDF + 50% EM) (1.13) while the lowest number of corms per plant was obtained in T_0 (control) (0.70).

Plate 6. Corms at harvest

Plate 7. Cormels at harvest

In the second year, the highest number of corms per plant (1.81) was given by T_3 (500 ml activated IEM m^{-2}) and T_0 (control) recorded the lowest number of corms per plant (0.65).

Similar results were obtained in the pooled data analysis of both the years. The highest number of corms per plant (1.76) was given by T_3 (500 ml activated IEM m^{-2}) which was found to be at par with T_2 (100 ml activated EM m^{-2}) (1.24) while the lowest number of corms per plant was obtained in T_0 (control) (0.67).

The result reveals that indigenous effective microorganisms (IEM) is great for increasing the number of corms per plant. This is because organic and indigenous sources of nutrients provide more efficient nutrients for the plant's growth which results in more corms being produced. In comparison, untreated plants record the least amount of corms on average. These organic nutrients nourish the plant and enrich the soil, leading to improved plant and corm growth, making it a great alternative to untreated plants. Organic fertilizers, like indigenous effective microorganisms and other nutrient sources, have been known to increase the amount of corms per plant in hydroponics and farming alike.

Indigenous effective microorganisms are significantly more effective than other sources of microorganisms in plant growth, sustaining the health and wellbeing of plants, as well as increasing nutrient uptake. The range of effects they have on improving plant health by fostering a natural, balanced environment makes them an ideal choice for any grower. They are vastly more effective in aiding plant growth and nutrient uptake than other microbial products. The microbial properties of indigenous microorganisms help breakdown organic matter and convert it into essential plant nutrients as well as promote healthy root growth. Similar results were reported in the findings of Desiré *et al.* (2018) in Irish potato.

4.3.2 Corm diameter

The corm diameter was found to be significantly influenced by the application of different organic resources as presented in Table 4.10. In the first year of experiment, the highest corm diameter (4.83 cm) was reported in T_5 (50% RDF + 50% EM) while the lowest corm diameter (3.61 cm) was observed in T_1 (100% RDF).

In the following year, T_5 (50% RDF + 50% EM) recorded the highest corm diameter (4.97 cm) which was found to be at par with T_3 (500 ml activated IEM m^{-2}) (4.32 cm). T_1 (100% RDF) gave the lowest corm diameter (3.69 cm).

Results from the pooled data analysis revealed that the highest corm diameter (4.90 cm) from both the year was obtained in T_5 (50% RDF + 50% EM) whereas the lowest corm diameter (3.65 cm) was observed in T_1 (100% RDF).

From the data, we come to know that the organic fertilizers have been proven to be effective in aiding the increase of corm diameter. This is most likely due to their mixture of natural ingredients and organic matter, which are essential in promoting healthy growth. On the other hand, inorganic fertilizers may not perform as well due to their lack of natural elements and potential damaging effects on the environment.

Studies show that the combination of both of them leads to a 38.36% increase of corm diameter over to the sole application of inorganic fertilizers. This is because organic fertilizers may not possess the required essential nutrients in adequate amounts, and the presence of EM helps to improve the condition of soil to enable plant growth.

Table 4.10 Number of corms per plant, corm diameter and weight of corm per mother plant as influenced by different nutrient sources

Treatments	Number of corms per plant			Corm diameter (cm)			Weight of corm per mother corm (gm)		
	2021	**2022**	**Pooled**	**2021**	**2022**	**Pooled**	**2021**	**2022**	**Pooled**
T_0	0.70	0.65	0.67	3.97	3.87	3.92	18.16	17.50	17.83
T_1	0.77	0.72	0.75	3.61	3.69	3.65	19.22	18.22	18.72
T_2	1.21	1.27	1.24	3.63	3.99	3.81	17.17	18.83	18.00
T_3	**1.70**	**1.81**	**1.76**	4.05	4.32	4.19	22.97	22.64	22.80
T_4	0.94	0.89	0.91	3.94	3.89	3.92	19.63	20.63	20.13
T_5	1.13	1.23	1.18	**4.83**	**4.97**	**4.90**	**25.76**	**26.09**	**25.93**
T_6	0.96	0.98	0.97	4.01	4.15	4.08	22.04	21.38	21.71
T_7	0.78	0.73	0.75	3.64	3.81	3.72	21.88	21.21	21.55
SEm±	0.19	0.16	0.17	0.22	0.24	0.21	1.52	1.20	1.29
CD at 5%	0.57	0.50	0.53	0.66	0.74	0.64	4.61	3.64	3.91

4.3.3 Weight of corm per mother plant

The effect of different sources of nutrients on the weight of corm per mother plant was found to be influenced significantly as per the data presented in Table 4.10. The given data reveals that in the first year, the maximum weight of corm per mother plant (25.76 gm) was found in T_5 (50% RDF + 50% EM) which was at par with T_3 (500 ml activated IEM m^{-2}) (22.97 gm), T_6 (50% RDF + 50% IEM) (22.04 gm) and T_7 (50% RDF + 50% jeevamrutha) (21.88 gm). The minimum weight of corm per mother plant (17.17 gm) was recorded by T_2 (100 ml activated EM m^{-2}).

In the following year, the maximum weight of corm per mother plant (26.09 gm) was found in T_5 (50% RDF + 50% EM) which was at par with T_3 (500 ml activated IEM m^{-2}) (22.64 gm) while the minimum weight of corm per mother plant (18.22 gm) was recorded in T_1 (100% RDF).

Pooled data analysis revealed that T_5 (50% RDF + 50% EM) had the maximum weight of corm per mother plant (25.93 gm) and it was at par with T_3 (500 ml activated IEM m^{-2}) (22.80 gm) whereas, the minimum weight of corm per mother plant (18.00 gm) was recorded in T_2 (100 ml activated EM m^{-2}).

The research results are showing that the combined application of effective microorganisms and inorganic fertilizers are a great way to increase the weight of corm per mother plant, whereas sole application of effective microorganisms (EM) recorded the minimum weight of corm per mother plant. The use of effective microorganisms and inorganic fertilizers can dramatically improve the weight of corm per mother plant, making it a highly effective and cost-efficient option for farms. This is also due to the combination of both improving soil fertility by providing essential nutrients and the introduction of beneficial bacteria which

increase soil productivity. Including various factors, such as the use of bacteria, fungi, and protozoa, this contributes to the improvement of corm weight. By using organic fertilizers, plants absorb the necessary nutrient supply to help promote growth. It also enhances root development, which leads to an increase in the corm weight due to the increase in corm size. In addition, effective microorganisms are also known to be effective in promoting natural pest resistance and can stimulate plant growth hormones like gibberellic acid, making it easier for plants to absorb the necessary nutrients in their environment.

4.3.4 Number of cormels per plant

The number of cormels per plant was influenced significantly by the application of various nutrient sources and data for the same is presented in Table 4.11. During the first year of experiment, the maximum number of cormels per plant (15.73) was reported in T_5 (50% RDF + 50% EM) which showed at par values with T_3 (500 ml activated IEM m^{-2}) (11.20). The least number of cormels per plant (6.87) was recorded in T_7 (50% RDF + 50% jeevamrutha).

Similarly in the year 2022, the maximum number of cormels per plant (15.73) was reported in T_5 (50% RDF + 50% EM) which was found to be at par with T_3 (500 ml activated IEM m^{-2}) (11.53) while the least number of cormels per plant (7.07) was obtained by T_7 (50% RDF + 50% jeevamrutha).

In the pooled data analysis from both the years, results followed the similar pattern where T_5 (50% RDF + 50% EM) recorded the maximum number of cormels per plant (15.73) and it was found to be at par with T_3 (500 ml activated IEM m^{-2}) (11.37) whereas the least number of cormels per plant (6.97) was obtained by T_7 (50% RDF + 50% jeevamrutha).

Effective microorganisms (EM) and indigenous effective microorganisms (IEM) are proving to be great allies for increased plant growth and yielding. A study conducted on Cocoyam (*Xanthosoma sagittofolium* L. Schott) by Mbouobda *et al.* (2015) has revealed that the number of cormels per plant increases exponentially on using EM and IMO manures. This is primarily due to the microorganisms quickly break down complex organic matter, thus making it easier for the plants to take in vital nutrients. The improved microbial activity helps to promote higher levels of nutrient absorption capacity by plants, which in turn yields better cormel production.

4.3.5 Weight of cormels per mother corm

Data presented in Table 4.11 revealed that the different sources of nutrients responded significantly on the weight of cormels per mother corm. The maximum weight of cormels per mother corm (16.40 gm) was reported in T_5 (50% RDF + 50% EM) while the minimum weight of cormels per mother corm (1.85 gm) was recorded in T_3 (500 ml activated IEM m^{-2}).

In the following year, similar observations were recorded where the maximum weight of cormels per mother corm (11.74 gm) was reported in T_5 (50% RDF + 50% EM) which showed at par values with T_2 (100 ml activated EM m^{-2}) (8.52 gm) and T_4 (jeevamrutha 50 ml m^{-2}) (8.03 gm). The least weight of cormels per mother corm (2.19 gm) was recorded in T_3 (500 ml activated IEM m^{-2}).

In the pooled data analysis, similar trend was depicted by the results. T_5 (50% RDF + 50% EM) scored the maximum weight of cormels per mother corm (14.07 gm) whereas the minimum weight of cormels per mother corm (2.02 gm) was recorded in T_3 (500 ml activated IEM m^{-2}).

Table 4.11 Number of cormels per plant and weight of cormels per mother corm (gm) as influenced by different nutrient sources

Treatments	Number of cormels per plant			Weight of cormels per mother corm (gm)		
	2021	**2022**	**Pooled**	**2021**	**2022**	**Pooled**
T_0	7.20	7.53	7.37	4.44	4.10	4.27
T_1	7.67	7.33	7.50	6.07	5.73	5.90
T_2	9.67	11.00	10.33	7.85	8.52	8.19
T_3	11.20	11.53	11.37	1.85	2.19	2.02
T_4	7.20	7.77	7.48	6.70	8.03	7.37
T_5	**15.73**	**15.73**	**15.73**	**16.40**	**11.74**	**14.07**
T_6	8.00	9.00	8.50	6.76	6.10	6.43
T_7	6.87	7.07	6.97	7.23	6.89	7.06
SEm±	1.79	1.43	1.55	1.95	1.28	1.56
CD at 5%	5.42	4.33	4.71	5.91	3.89	4.73

The results from studies have shown that effective microorganisms, when used in combination with inorganic fertilizers, can increase the weight of cormels per mother corm. The main reason behind this effect is that the inorganic fertilizers provide the essential nutrients while the effective microorganisms aid in their absorption. In contrast, the use of IMO alone was not as effective in increasing the weight of cormels and this might be attributed to its low nutrient absorption rate. Another reason for this variation could be how different fertilizers interact with the soil, and how long it takes for those fertilizers to be released into the environment. The results were supported by the findings by Elgaml *et al.* (2022) in *Salvia sclarea* plants where it was reported that application of effective microorganisms boost nutrient absorption and has a positive impact on plant growth.

4.4 Quality parameters

Self life and vase life studies, which are essential for monitoring the quality and freshness of gladiolus, are especially important for florists and flower farmers, who need to know how to maintain the flower's freshness for longer periods of time. The effect of different source of nutrient on the gladiolus quality was investigated and has been discussed in this experiment. The study also provides beneficial insights into the health of the gladiolus plants.

4.4.1 Self life

The data presented in Table 4.12 indicated that the application of different sources of nutrient have significantly influenced the self-life of gladiolus. In the first year of experiment, the highest self life (9.43 days) duration was recorded in T_6 (50% RDF + 50% IEM) which was found to be at par with T_2 (100 ml activated EM m^{-2}) (9.22 days). The lowest self life (4.10 days) was obtained in T_0 (control).

In the following year, the highest self life (11.33 days) duration was recorded in T_6 (50% RDF + 50% IEM) and it had par values with T_5 (50% RDF + 50% EM) (11.00 days). T_0 (control) recorded the lowest self life (7.33 days).

Pooled data analysis, also reported that T_6 (50% RDF + 50% IEM) obtained the highest self life (11.00 days) and was found to be at par with T_5 (50% RDF + 50% EM) (10.67 days). The lowest self life (7.00 days) was obtained by T_0 (control).

Indigenous effective microorganisms (IEM) and effective microorganisms (EM) are highly beneficial in extending the self-life of gladiolus. When these microorganisms are applied to the gladiolus, they produce compounds that can improve its overall quality, making it last for a greater amount of time without deteriorating. EM helps to build strong immunity to stress and disease while IEM helps to degrade toxins and promote beneficial microbial activities (Enebe *et al.* 2019). Untreated and inorganic fertilizers, on the other hand, do little to increase shelf-life and are unable to deliver the same results IEM and EM can.

4.4.2 Vase life in distilled water

Regarding vase life in distilled water, it is evident from Table 4.12 that the different sources of nutrients varied significantly and it was found that the plants treated with a combination of organic and inorganic fertilizers resulted in longer vase life. During the first year of experiment, among all the treatments the longest vase life (11.17 days) was observed in T_6 (50% RDF + 50% IEM) and was found to be at par with T_5 (50% RDF + 50% EM) (10.83 days). The minimum vase life (7.17 days) was recorded in T_0 (control).

Table 4.12 Self life (days) and vase life in distilled water (days) as influenced by different nutrient sources

Treatments	Self life (days)			Vase life in distilled water (days)		
	2021	**2021**	**2022**	**Pooled**	**2022**	**Pooled**
T_0	4.10	7.33	7.00	7.17	3.97	4.03
T_1	5.15	8.00	8.33	8.17	5.02	5.08
T_2	9.22	8.67	8.33	8.50	9.05	9.13
T_3	6.97	10.00	9.67	9.83	7.07	7.02
T_4	8.33	8.67	8.33	8.50	8.17	8.25
T_5	7.45	11.00	10.67	10.83	7.38	7.42
T_6	**9.43**	**11.33**	**11.00**	**11.17**	**9.27**	**9.35**
T_7	7.30	9.33	8.67	9.00	7.17	7.23
SEm±	0.15	0.39	0.42	0.37	0.12	0.13
CD at 5%	0.45	1.17	1.26	1.12	0.37	0.38

1st Day

3rd Day

6th Day

9th Day

12th Day

Plate 8. Cut spikes of *Gladiolus* cv. Candyman during vase life studies.

In the second year, the longest vase life (9.27 days) was observed in T_6 (50% RDF + 50% IEM) which had at par values with T_2 (100 ml activated EM m^{-2}) (9.05 days) while T_0 (Control) reported the minimum vase life (3.97 days).

The pooled data analysis also showed similar trend where T_6 (50% RDF + 50% IEM) reported the longest vase life (9.35 days) and was statistically at par with T_2 (100 ml activated EM m^{-2}) (9.13 days). As reported in both the years of experiment, the pooled data also revealed that the minimum vase life (4.03 days) was recorded in T_0 (Control).

The use of indigenous effective microorganisms (IEM) and effective microorganisms (EM) in conjunction with inorganic fertilizers has been found to significantly increase the vase life of gladiolus. The capability of these microorganisms to increase the absorption and utilization rate of nutrients found in inorganic fertilizers is the reason for this improved vase life over plants treated with untreated and inorganic fertilizers alone (Kumar and Gopal, 2015). For optimized growth and vase life of gladiolus, growers can look to utilizing IEM and EM with inorganic fertilizers.

4.5 Plant nutrient uptake and soil fertility

4.5.1 Study of the chemical properties and nutrient status of the soil

The soil chemical properties and nutrient status were studied during both the years of experimentation and the results are presented in Table 4.13.

4.5.1.1 Changes in nutrient status of the soil

In the results obtained during the experiment, it is observed that the application of organic fertilizers can have a big impact on the nutrient status of the soil. Organically-sourced fertilizers can have a huge impact on the nutrient status

of soil, providing more essential elements and more balanced nutrition than untreated soils. Organic fertilizers can also provide benefits to soil structure, aeration, and water-holding capacity while also helping to mitigate soil-borne disease. The study has shown that when compared to untreated soil plots, the nutrient status of the soil had great improvement when treated with organic fertilizers, making them an ideal choice for improving soil health and yield. It proves why plant growth and health can be increased thanks to the extra nutrients given by organic fertilizers. Also, use of organic fertilizers can improve the productivity of crops, leading to better harvests.

4.5.1.1.1 Available nitrogen content

Nitrogen is one of the essential components of the soil composition required for healthy plant growth. It is known to be mobile in nature, which makes it vulnerable to several losses such as leaching, volatilization and denitrification. Because of this, nitrogen in the soil needs to be replenished at regular intervals. Despite the risks of losses, nitrogen is still beneficial for soil fertility, as it provides adequate nutrients to the plants. It helps to promote the growth of beneficial microbes, increases the water holding capacity of the soil, and helps in controlling the pH level of the soil. This ensures that the plant has the right amount of nutrition, and it starts to grow and develop in a healthy way. Nitrogen helps in the faster growth of the plant, as it is a major component in the process of photosynthesis.

During 2021, the maximum available nitrogen content (982.61 kg ha $^{-1}$) was recorded in T_2 (100 ml activated EM m^{-2}) and was at par with T_5 (50% RDF + 50% EM) (961.71 kg ha $^{-1}$), T_6 (50% RDF + 50% IEM) (940.80 kg ha $^{-1}$), T_1 (100% RDF) (898.99 kg ha $^{-1}$), T_7 (50% RDF + 50% jeevamrutha) (878.08 kg ha $^{-1}$), T_4 (jeevamrutha 50 ml m^{-2}) (857.17 kg ha $^{-1}$), T_3 (500 ml activated IEM m^{-2}) (836.27

kg ha $^{-1}$). The lowest available nitrogen content (585.39 kg ha $^{-1}$) was recorded in T_0 (control).

In the following year, the maximum available nitrogen content (940.80 kg ha $^{-1}$) was recorded in T_2 (100 ml activated EM m^{-2}) and was found to be at par with T_5 (50% RDF + 50% EM) (919.89 kg ha $^{-1}$), T_4 (jeevamrutha 50 ml m^{-2}) (898.99 kg ha $^{-1}$), T_6 (50% RDF + 50% IEM) (898.99 kg ha $^{-1}$), T_7 (50% RDF + 50% jeevamrutha) (836.27 kg ha $^{-1}$), T_3 (500 ml activated IEM m^{-2}) (815.36 kg ha $^{-1}$) and T_1 (100% RDF) (815.36 kg ha $^{-1}$). T_0 (control) recorded the lowest available nitrogen content (543.57 kg ha $^{-1}$).

In the pooled data analysis, similar results were reported. The maximum available nitrogen content (961.71 kg ha $^{-1}$) was recorded in T_2 (100 ml activated EM m^{-2}) which had at par values with T_5 (50% RDF + 50% EM) (940.80 kg ha $^{-1}$), T_6 (50% RDF + 50% IEM) (919.89 kg ha $^{-1}$), T_4 (jeevamrutha 50 ml m^{-2}) (878.08 kg ha $^{-1}$), T_7 (50% RDF + 50% jeevamrutha) (857.17 kg ha $^{-1}$), T_1 (100% RDF) (857.17 kg ha $^{-1}$) and T_3 (500 ml activated IEM m^{-2}) (825.81 kg ha $^{-1}$). Also, the lowest available nitrogen content (564.48 kg ha $^{-1}$) was recorded in T_0 (control).

Organic fertilizers, like those containing effective microorganisms, are effective in enhancing nitrogen content in soil. The results from the study have revealed that soil treated with organic fertilizers has significantly higher nitrogen content than untreated plots. This is due to the fact that organic fertilizers contain organic matter which helps in improving soil fertility and releasing nitrogen as organic fertilizers break down in soil. This helps to ensure higher nitrogen content in soil, which is essential for healthy growth of plants. The microorganisms present in the fertilizers help break down organic matter which increases the nitrogen content. Thus, the combination of minerals, organic matter, and microbes present in the fertilizers helps promote nitrogen availability in the soil. Similar

findings of increase in nitrogen content due to the supplementation of EM compost into the soil was also reported by Sharma *et al.* (2017) in calendula and marigold flowers.

4.5.1.1.2 Available phosphorus content

Phosphorus, a commonly found element in the soil plays an important role in the growth and health of plants. It is a part of the energy sources that are used by plants, enabling them to grow and develop. Unfortunately, it is also very immobile, meaning it can't travel easily through the soil and easily gets washed out of the soil or converted to an unavailable form. This leads to a decrease in phosphorus content from the initial value of the soil. Phosphorus is a predominantly immobile element in the soil and is essential for plant development. The initial content of Phosphorus in the soil may decrease over time due to its slow availability, leading to poor crop production. To keep the soil fertile, it's essential to replenish phosphorus regularly. The results obtained from the experiment was able to detect up to what per cent the organic fertilizers helped in retaining this essential nutrient in the soil after crop harvest.

During the first year of experiment, the highest available phosphorus content (62.72 kg ha $^{-1}$) was recorded in T_2 (100 ml activated EM m^{-2}) after crop harvest, while the least available phosphorus content (36.24 kg ha $^{-1}$) was recorded in T_1 (100% RDF).

From the following year data, it was observed that T_2 (100 ml activated EM m^{-2}) gave the highest available phosphorus content (61.19 kg ha $^{-1}$) and the lowest (36.24 kg ha $^{-1}$) was obtained by T_1 (100% RDF).

Pooled data analysis also revealed a similar result which reported that the highest available phosphorus content (61.96 kg ha $^{-1}$) was recorded in T_2 (100 ml

activated EM m^{-2}) after crop harvest, whereas the least available phosphorus content (35.72 kg ha^{-1}) was recorded in T_1 (100% RDF). The magnitude of decrease in soil available phosphorus content after crop harvest was significantly low with T_2 (100 ml activated EM m^{-2}) over T_1 (100% RDF) by 7.80% and 46.85%, respectively from its initial value of 67.2 kg ha^{-1}. Hence, application of organic fertilizers such as effective microorganisms (EM) has improved the soil health by retaining the phosphorus in available form for the plants.

The results obtained from the experiment have proven that EM has significant effect on the retention of available phosphorus content in the soil. Organic fertilizers like effective microorganisms can be used to greatly improve the retention of available phosphorus content in the soil. This is because these organic fertilizers help to recycle phosphorus in an effective way, unlike inorganic fertilizers, leading to an overall increase in the available phosphorus retention in the soil. Also, the microorganisms have the capability to facilitate increase in microbial activities that can boost soil fertility. The increased microbial activities ultimately result in deeper absorption of phosphorus content and thus its availability (Nayak *et al.*, 2020). On the other hand, inorganic fertilizers lack in this property of phosphorus retention. Moreover, organic fertilizers are also considered to be more eco-friendly and sustainable than inorganic fertilizers.

4.5.1.1.3 Available potassium content

Potassium is a mineral essential for the growth of flowering plants. It is naturally found in the soil, and its high retention helps promote strong stems and roots in plants. Excess potassium is retained in the soil due to its hydrophilic nature, meaning it will attract other molecules and form complexes that are resistant to leaching from the soil. It gets retained in the soil by binding to organic matter, clay and other ions, allowing plants to access it and use it as a fertilizer.

This also creates stability in the soil, and helps to maintain the necessary level of potassium for plants' growth and health. It helps plants absorb other nutrients they need to grow, helps build proteins, and is critical for flowering plants. Potassium helps regulate the water balance in plants, which gives them optimal growth, better yields, and strong resistance to disease and pests. The present study reveals that there was a higher content of available potassium in the soil after harvesting of crops during both the years if experiment in comparison to the initial value (212.8 kg ha $^{-1}$). The available potassium content was found to be significantly higher in those plots treated with organic fertilizers than the untreated plots in both the trails. During the first year of experiment, the maximum available potassium content (522.67 kg ha $^{-1}$) was reported in T_2 (100 ml activated EM m^{-2}) after crop harvest, while the minimum (235.20 kg ha $^{-1}$) was obtained by T_0 (control).

Similarly in the second year of experiment, the maximum available potassium content (510.33 kg ha $^{-1}$) was reported in T_2 (100 ml activated EM m^{-2}) and the minimum (231.47 kg ha $^{-1}$) was recorded by T_0 (control).

The pooled data analysis results also revealed no differences in the observations made during the two years of trails. The maximum available potassium content (516.50 kg ha $^{-1}$) was reported in T_2 (100 ml activated EM m^{-2}) and the minimum (233.33 kg ha $^{-1}$) was recorded by T_0 (control).

Effective microorganisms applied as an organic fertilizers have a positive effect on the increase of available potassium content. This is mainly because the beneficial bacterial action of the microorganisms breaks down organic matter and mineralized them, helping the plant absorb more potassium (Joshi *et al*. 2019). At the same time, it can provide an essential source of potassium to the soil. This leads to greater nutrient uptake by crops, allowing for better harvests. As EM fertilizers help break down organic material, more potassium is made available to

Table 4.13 Changes in available nutrient status of the soil in response to various nutrient sources

Treatments	Available nutrients (kg ha $^{-1}$)								
	N			P_2O_5			K_2O		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
T_0	585.39	543.57	564.48	39.13	37.44	38.29	235.20	231.47	233.33
T_1	898.99	815.36	857.17	36.24	35.21	35.72	332.27	329.93	331.10
T_2	**982.61**	**940.80**	**961.71**	**62.72**	**61.19**	**61.96**	**522.67**	**510.33**	**516.50**
T_3	836.27	815.36	825.81	47.04	49.07	48.05	362.13	352.80	357.47
T_4	857.17	898.99	878.08	45.55	44.07	44.81	313.60	309.27	311.43
T_5	961.71	919.89	940.80	39.20	37.73	38.47	332.27	322.37	327.32
T_6	940.80	898.99	919.89	44.05	41.39	42.72	328.53	324.87	326.70
T_7	878.08	836.27	857.17	40.32	38.82	39.57	332.27	335.60	333.93
SEm±	52.71	50.05	48.29	4.61	3.71	4.13	46.37	44.93	45.58
CD at 5%	159.89	151.82	146.47	13.97	11.27	12.52	140.65	136.27	138.27

plants due to increased microbial activity in the soil (Olle and Williams, 2013).

As a result, higher levels of potassium were recorded in the treated soils than the untreated soils. Hence, EM has proven to be beneficial for the porous soil. This can be a cost and labor effective way to improve soil fertility and increase crop yields. Similar results from the findings of Meena *et al.* (2014) reveal that rhizospheric microorganisms solubilizes the fixed form of potassium to soluble form in order to make them available for the plants.

4.5.1.2 Changes in soil pH

Soil pH plays an important role in soil fertility and crop productivity. It is the measure of acidity or alkalinity in the soil and has a great effect on how nutrients are available to the plants. Soil pH is mainly affected by the application of organic fertilizers. The application of organic fertilizers can change the soil pH and make it either acidic or alkaline. Organic fertilizers contain different types of organic matter such as decomposing organic matter, compost, and organic manures. These organic materials contain acids and bases which can influence the pH of the soil. It is important to monitor and maintain an appropriate soil pH. Thus, understanding the importance of soil pH is a key aspect of soil and crop management.

In this experiment, changes in the soil pH was studied and the results are presented in Table 4.14. It was observed that there was no significant change in the soil pH due to the application of different nutrient sources; however it recorded an increase in the pH from its initial value (5.3) in all the treatments. During both years of experiment, the maximum pH value of 6.47 was reported in T_7 (50% RDF + 50% jeevamrutha) and the minimum (5.80) was in T_1 (100% RDF). From the results, it was known that the application of organic fertilizers such as

jeevamrutha, when applied to soil, can help in increasing its pH. This is because organic fertilizers are filled with beneficial nutrients and microorganisms that help balance the soil's acidity. Consequently, this helps to improve the health of the soil, making it ideal for crops to thrive. jeevamrutha is a mixture of plant materials, animal ingredients and soil microbes which help improve the soil structure, increase fertility and enhance the crop yields. It helps balance the pH of the soil and also provides necessary nutrients for healthy crop growth.

Though, the pH did not vary significantly, but results supported the fact that soils supplemented with organic inputs have higher pH. Hence, organic fertilizers can be effective in altering the pH of soil. When these fertilizers are used, they often increase the pH of the soil, making it more alkaline. This can be beneficial for plants, as many require an alkaline soil to absorb nutrients to grow properly. Without an increase in soil pH, plants can suffer from nutrient deficiencies, preventing them from growing to their fullest potential. Organic fertilizers can provide the necessary alkalinity to promote healthy growth in plants. They are a great way to increase and balance the pH of the soil. It is said that the soil microbial biomass is promoted at high pH level (Wu *et al.*, 2020). As organic compounds and nutrients decompose, they break down into minerals which release various alkaline compounds. This helps increase the alkalinity of the soil and raises the pH of the soil. Thus, organic fertilizers are a great way to raise and maintain the pH of soil over time. These results were supported by the findings of Assefa and Tadesse (2019) who stated that application of high organic matter effectively raises the soil pH and acts as a buffer to prevent soil acidification.

4.5.1.3 Changes in soil EC

Electrical conductivity of soil (EC) is an important soil property as it is a measure of how much available plant nutrients are present in the soil in an ionized form. It is an important measuring tool to determine the amount of nutrients, toxins and salts present in the soil. Thus, assessing the EC of soil not only helps to measure the fertility of soil, but also plays an important role in determining the occurrence of nutrient deficiency in crops. With the application of organic fertilizers, the changes in EC can tell us the amount of fertilizer needed. This is because organic fertilizers contain organic matter that provides nutrients, in turn improving soil fertility and soil EC. By measuring the EC of soil, farmers can determine the suitability of the soil for their crops and determine the ideal amount of fertilizer for their crop.

In this experiment, the EC of the soil did not show any significant differences due to the application of different nutrient sources but, it was reported to be higher after the crop harvest in comparison with the initial value. From the data presented on Table 4.14, the maximum EC value (0.66 dSm^{-1}) was obtained in T_2 (100 ml activated EM m^{-2}) and the minimum (0.22 dSm^{-1}) was recorded in T_1 (100% RDF). Therefore, organic fertilizers such as effective microorganisms have been proven to enhance the electrical conductivity of soil. This is because it contain ions, nitrogen, and other substances that are able to interact with the soil's mineral particles and increase the soil's electrical conductivity. Meanwhile, the effective microorganisms can act as catalysts which help to consequently speed up the process of enhancing the electrical conductivity of soil. The plots treated with inorganic fertilizers had the lowest electrical conductivity due to the absence of these catalysts and minerals. It could be also because it lacked the beneficial microorganisms and other nutrients that helped the treated plots to show higher

levels of electrical conductivity. The results were in line with the findings of Ngilangil and Vilar (2020) who observed an increase in electrical conductivity of soil due to the application of EM which causes improvement in the productivity of the soil.

4.5.1.4 Soil organic carbon

Soil organic carbon is the lifeblood of the soil, which can contribute to higher crop yields, better fertility, and better soil structure. Increasing organic matter on soil surfaces can help improve soil water infiltration and improve the soil's ability to hold moisture. The results obtained from this experiment presented in Table 4.14, shows that applying organic fertilizers can help increase the amount of organic carbon in the soil, leading to better soil health and crops yields. This helps create an environment where plants can flourish, leading to better nutrition and healthier foods. During the first year of experiment, the maximum soil organic carbon (2.83%) was reported in T_5 (50% RDF + 50% EM), which was found to be at par with T_2 (100 ml activated EM m^{-2}) (2.75 %). The minimum soil organic carbon (2.16 %) was observed in T_6 (50% RDF + 50% IEM).

Similar observations were made during the following year, where the maximum soil organic carbon (2.78%) was reported in T_5 (50% RDF + 50% EM), which was found to be at par with T_2 (100 ml activated EM m^{-2}) (2.72 %). The minimum soil organic carbon (2.11 %) was observed in T_6 (50% RDF + 50% IEM).

From the pooled data analysis, it was observed that T_5 (50% RDF + 50% EM) had the maximum soil organic carbon (2.81%) and was at par with T_2 (100 ml activated EM m^{-2}) (2.74 %), while the minimum soil organic carbon (2.14 %) was observed in T_6 (50% RDF + 50% IEM).

Table 4.14 Response of various nutrient sources on the soil pH, EC and Organic carbon after harvest

Treatments	pH			EC (dSm^{-1})			Organic carbon (%)		
	2021	**2022**	**Pooled**	**2021**	**2022**	**Pooled**	**2021**	**2022**	**Pooled**
T_0	6.10	6.03	6.07	0.27	0.25	0.26	2.26	2.17	2.22
T_1	5.80	5.47	5.63	0.23	0.21	0.22	2.32	2.30	2.31
T_2	6.17	6.07	6.12	**0.68**	**0.65**	**0.66**	2.75	2.72	2.74
T_3	5.97	5.80	5.88	0.30	0.26	0.28	2.36	2.33	2.34
T_4	6.10	5.77	5.93	0.23	0.24	0.23	2.36	2.30	2.33
T_5	6.10	5.93	6.02	0.36	0.32	0.34	**2.83**	**2.78**	**2.81**
T_6	6.03	5.87	5.95	0.49	0.46	0.48	2.16	2.11	2.14
T_7	**6.47**	**6.23**	**6.35**	0.23	0.21	0.22	2.37	2.25	2.31
SEm±	0.20	0.29	0.20	0.16	0.10	0.12	0.11	0.09	0.09
CD at 5%	NS	NS	NS	NS	NS	NS	0.32	0.28	0.29

Organic fertilizers can be very effective for increasing soil organic carbon. The soil organic carbon after harvesting of crop was reported to be higher than the initial value (2.04%). According to the results obtained, application of effective microorganisms helps in boosting soil organic carbon content. EM is a mixture of naturally occurring beneficial microbes, composed of lactic acid bacteria, photosynthetic bacteria and yeast, that work together to deliver natural fertilizer. They are said to have the ability to increase soil organic carbon while also providing other benefits such as improved soil fertility. They are used to enrich the soil, improve its fertility and help increase soil organic carbon levels. This was in line with the findings of Wu *et al.* (2020) in grape where application of organic fertilizer increases the soil carbon content.

4.5.2 Plant nutrient uptake

4.5.2.1 Nutrient analysis of gladiolus leaves

Nutrient analysis of gladiolus leaves is an important part of ensuring healthy plant growth. It is important in understanding the chemical makeup of fertilizers and the nutrient uptake in gladiolus leaves. The analysis can help to identify nutrient deficiencies and also help to determine the most efficient methods for fertilizing. In this experiment, the nutrient analysis of gladiolus leaves was conducted to determine the effect of the different source of fertilizers on nutrient levels in gladiolus leaves. Organic fertilizers provide a slow release of nutrients which can be beneficial in helping to reduce losses due to leaching or runoff. Application of organic fertilizers contributes to the growth and health of gladiolus plants by providing essential nutrients. These nutrients are absorbed by the plant and are key to the plant's growth and flower development. The data presented in Table 4.15 shows that the application of different fertilizers inputs has significantly influenced the nutrient concentration of gladiolus leaves.

4.5.2.1.1 Leaf nitrogen content

Nutrient analysis is an important tool for understanding the nutritional makeup of gladiolus leaves. Nitrogen is a key element for photosynthesis, protein synthesis and leaf energy storage. A detailed analysis of nitrogen content in gladiolus leaves is essential for understanding the plant's overall health and growth. Knowing the specific nutrients in gladiolus leaves can also help plan fertilizer or soil amendment strategies to meet the needs of the plant. The data concern to the nitrogen content of gladiolus leaves is presented in Table 4.15.

During the first year of experiment, the maximum nitrogen content (4.43%) was reported in T_2 (100 ml activated EM m^{-2}) and was found to be at par with T_1 (100% RDF) (4.34%), T_0 (control) (3.78%) and T_3 (500 ml activated IEM m^{-2}) (3.69%). While the minimum (2.66%) was obtained in T_5 (50% RDF + 50% EM).

Almost similar results were reported during the following year, where the maximum nitrogen content (4.23%) was reported in T_2 (100 ml activated EM m^{-2}) which had at par values with T_1 (100% RDF) (4.11%), T_0 (control) (3.51%) and T_3 (500 ml activated IEM m^{-2}) (3.45%). Also, T_5 (50% RDF + 50% EM) and T_6 (50% RDF + 50% IEM) recorded the minimum nitrogen content (2.59%).

Pooled data analysis also supported the results obtained from data of both the year of experiment. The maximum nitrogen content (4.33%) was reported in T_2 (100 ml activated EM m^{-2}) which was at par with T_1 (100% RDF) (4.22%), T_0 (control) (3.65%) and T_3 (500 ml activated IEM m^{-2}) (3.57%). While the minimum (2.63%) was obtained in T_5 (50% RDF + 50% EM). From the results, it was known that the sole application of fertilizers highly influenced the leaves nitrogen content more than the combined application of both organic and inorganic fertilizers. EM is a mixture of beneficial microorganisms that help in improving

the overall health of plants. EM has a positive effect on the leaf nitrogen content due to its ability to regulate the nitrogen cycle. It helps degrade organic matter in the soil, so that more nitrogen is released for plants. As a result, the leaves contain more nitrogen which helps in proper growth and development of the plant.

4.5.2.1.2 Leaf Phosphorus content

Phosphorus content in the leaves of gladiolus is an important factor contributing to its growth and development. Besides that it helps in flowering, seed and fruit production and increases the health of the plants. It also plays an important role in root growth and helps in the uptake of essential minerals for the plant. But it can be affected by the type of fertilizer used and the amount of phosphorus in the soil. The efficiency of organic fertilizers in increasing the phosphorus content in the leaves of gladiolus has been observed during this experiment and the data for the P_2O_5 content in leaves of gladiolus is presented in Table 4.15. During 2021, the maximum P_2O_5 content (0.011%) was observed in T_3 (500 ml activated IEM m^{-2}), while the minimum (0.005%) was reported by T_6 (50% RDF + 50% IEM).

Similarly, in the following year as well the maximum P_2O_5 content (0.011%) was observed in T_3 (500 ml activated IEM m^{-2}), while T_6 (50% RDF + 50% IEM) and T_7 (50% RDF + 50% jeevamrutha) reported the minimum P_2O_5 content (0.006%).

In pooled data analysis, no difference in the results was reported. The maximum P_2O_5 content (0.011%) was observed in T_3 (500 ml activated IEM m^{-2}), while T_6 (50% RDF + 50% IEM) and T_7 (50% RDF + 50% jeevamrutha) reported the minimum P_2O_5 content (0.006%). From the results obtained, it was observed that the application of indigenous effective microorganisms (IEM) was the best

way to increase the phosphorus content in leaves of gladiolus. The findings from the study have shown that when these beneficial microbes are solely applied, it can lead to a significant increase in the phosphorus content in leaves in comparison to its combined application with chemical fertilizers. This is believed to be caused by their ability to increase the bioavailability of nutrients to plants by breaking down complex organic matter into more easily absorbed simple forms. However, this effect is reduced when IEMs are combined with chemical fertilizers.

4.5.2.1.3 Leaf Potassium content

Potassium is an essential mineral for gladiolus leaves to grow and thrive. Without sufficient levels of potassium, gladiolus leaves may display signs of yellowing and weakened root systems. To prevent this, proper fertilization of potassium content is important. Fertilizers may be used to help replenish the levels of potassium in gladiolus leaves and create a stronger, healthier plant. In this experiment, application of different nutrient sources was studied to find out the effect of the fertilizers on the potassium content of the leaves.

The data presented in Table 4.15 showed that the application of different nutrient sources failed to exert significant effect on the potassium content of the gladiolus leaves. During the first year of experiment, maximum K_2O content (2.21%) was observed in T_1 (100% RDF), while the minimum was reported in T_2 (100 ml activated EM m^{-2}) (1.53%).

In the following year, maximum K_2O content (2.26%) was once again observed in T_1 (100% RDF), while the minimum was reported in T_2 (100 ml activated EM m^{-2}) (1.47%).

The mean data analysis of both the year of experiment also showed similar results, where the maximum K_2O content (2.24%) was once again observed in T_1

Table 4.15 Nutrient analysis of gladiolus leaves in response to various nutrient sources

Treatments	Nutrient content (%)								
	N			P_2O_5			K_2O		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
T_0	3.78	3.51	3.65	0.008	0.007	0.007	2.16	1.97	2.06
T_1	4.34	4.11	4.22	0.007	0.007	0.007	**2.21**	**2.26**	**2.24**
T_2	**4.43**	**4.23**	**4.33**	0.009	0.010	0.010	1.53	1.47	1.50
T_3	3.69	3.45	3.57	**0.011**	**0.011**	**0.011**	1.91	1.96	1.94
T_4	3.13	3.03	3.08	0.009	0.008	0.009	1.71	1.68	1.70
T_5	2.66	2.59	2.63	0.009	0.008	0.008	1.87	1.72	1.80
T_6	2.75	2.59	2.67	0.005	0.006	0.006	1.76	1.69	1.73
T_7	3.36	3.12	3.24	0.006	0.006	0.006	1.87	2.03	1.95
SEm±	0.34	0.32	0.33	0.00	0.00	0.00	0.25	0.22	0.23
CD at 5%	1.02	0.97	0.99	0.00	0.00	0.00	NS	NS	NS

(100% RDF) and the minimum was reported in T_2 (100 ml activated EM m^{-2}) (1.50%).

4.5.2.2 Nutrient analysis of gladiolus corms

It is important to analyse the nutrient content of the gladiolus corms as it affects its growth and survival. It is important to analyse the nutrient content of the gladiolus corms due to the fact that even though the corms are harvested from the same source, the application of different sources of nutrients keeps altering the nutrient content. Different sources of nutrient may result in different levels of nutrient content and the plants adjust the metabolic rate accordingly. Nutrient analysis helps to understand the requirement of the plant and aids to design nutrient management plans for better results. This helps trace the availability or deficiency of certain elements and manage the nutrient requirements for healthy growth. The data presented on Table 4.16 shows that the application of different fertilizers inputs has significantly influenced the nutrient concentration of gladiolus corms.

4.5.2.2.1 Corm Nitrogen content

Nitrogen content in the corms of the gladiolus is important for the growth of this ornamental crop. Research has shown that there is an effect of different nutrient sources on the nitrogen content of the gladiolus corms. Results from these experiments have demonstrated that the nitrogen content can vary significantly depending on the nutrient source as per the data represented in Table 4.16. Different nutrient sources help to improve the nitrogen content in the corms, which in turn increases the corm size. Results of different experiments conducted show that application of organic manures and chemical fertilizers leads to a significant increase in the nitrogen content of the gladiolus corms.

During the first season, the highest nitrogen content in the corms (3.13%) was reported in T_1 (100% RDF), which was found to be at par with T_7 (50% RDF + 50% jeevamrutha) (3.08%), T_6 (50% RDF + 50% IEM) (2.80%), T_3 (500 ml activated IEM m^{-2}) (2.75%) and T_5 (50% RDF + 50% EM) (2.61%), whereas the minimum was reported in T_2 (100 ml activated EM m^{-2}) (2.05%).

In the following season as well, the highest nitrogen content in the corms (3.03%) was reported in T_1 (100% RDF) and it was found to be at par with T_7 (50% RDF + 50% jeevamrutha) (3.03%), T_5 (50% RDF + 50% EM) (2.75%), T_6 (50% RDF + 50% IEM) (2.75%), T_3 (500 ml activated IEM m^{-2}) (2.71%) and T_4 (jeevamrutha 50 ml m^{-2}) (2.52%). The minimum nitrogen content in the corms was reported in T_2 (100 ml activated EM m^{-2}) (2.24%).

During the pooled data analysis, similar trend in the results were observed. The highest nitrogen content in the corms (3.08%) was reported in T_1 (100% RDF) and it had at par values with T_7 (50% RDF + 50% jeevamrutha) (3.06%), T_6 (50% RDF + 50% IEM) (2.78%), T_3 (500 ml activated IEM m^{-2}) (2.73%) and T_5 (50% RDF + 50% EM) (2.68%). The minimum nitrogen content in the corms was reported in T_2 (100 ml activated EM m^{-2}) (2.15%).

The results obtained from this experiment show that application of inorganic and organic fertilizers have a significant effect on the nitrogen content of gladiolus corms. Research results has consistently shown that application of inorganic fertilizers leads to high nitrogen content in the corms, while sole application of organic fertilizers recorded the least amount of nitrogen. This is likely due to the organic fertilizers taking longer to break down and break apart correctly, leading to the corms not being properly nourished. This can be also attributed to the slow release of nutrients and lignin content of organic fertilizers which limits the amount of nitrogen uptake by the plants.

4.5.2.2.2 Corm Phosphorus content

Gladiolus corms are crucial in the production of quality flowers, and the phosphorus (P_2O_5) content of these corms is the most important macronutrient. Different nutrient sources have varying effects on the P_2O_5 content of gladiolus corms, leading to different levels of productivity. Properly balanced nutrients help to keep an optimal P_2O_5 content in gladiolus corms and promote abundant flowering. It is important to understand the impact of different nutrient sources on the P_2O_5 content of gladiolus corms in order to maximize productivity and yields. Different nutrient sources may affect the phosphorus levels differently, so it is important to use the right fertilizer for your gladiolus corms.

As per the data represented in Table 4.16, it is known that the application of different sources of nutrients has a significant effect on the P_2O_5 content of the gladiolus corms. During the first year of experiment, the maximum corm P_2O_5 content (0.015%) was observed in T_3 (500 ml activated IEM m^{-2}) which was found to be at par with the rest of the treatments, while the minimum (0.010%) was obtained in T_5 (50% RDF + 50% EM) and T_6 (50% RDF + 50% IEM).

Similarly, in the following year the results showed that the T_3 (500 ml activated IEM m^{-2}) had the maximum corm P_2O_5 content (0.016%) which was found to be at par with the rest of the treatments, whereas T_4 (jeevamrutha 50 ml m^{-2}), T_6 (50% RDF + 50% IEM) and T_7 (50% RDF + 50% jeevamrutha) recorded the minimum corm P_2O_5 content (0.010%).

During the pooled data analysis no difference in the results were observed, T_3 (500 ml activated IEM m^{-2}) had the maximum corm P_2O_5 content (0.016%) and it is found to be at par with the rest of the treatments, whereas T_6 (50% RDF +

50% IEM) and T_7 (50% RDF + 50% jeevamrutha) recorded the minimum corm P_2O_5 content (0.010%).

The result clearly shows that the sole utilization of indigenous effective microorganisms (IEM) and organic fertilizers in gladiolus corms triggered a significant increase in phosphorus (P_2O_5) content while the combined application of organic fertilizers and chemical fertilizers recorded the minimum P_2O_5 content of the corms. The reason for this phenomenon is that IEM provide an efficient substrate to supply essential macro- and micronutrients such as P_2O_5, essential for optimal growth and optimal corm yields. In addition, IEM also help to increase soil organic matter that is necessary for enhancing the efficiency of chemical fertilizers. This could be also because the microorganisms release phosphorus from organic and soil material, improving its availability for plants. Consequently, this enhances the uptake of soil P_2O_5 and its content in the corms. The results were similar with the findings of Alori *et al.* (2017) where it was reported that microorganisms can solubilise insoluble soil phosphate and makes it readily available to the plants by converting it into soluble forms.

4.5.2.2.3 Corm Potassium content

Potassium (K_2O) is an essential nutrient for the growth and development of gladiolus corms. Gladiolus corms are known to be high in K_2O content and its prevalence can be attributed to the role of K_2O in almost all physiological processes of the plant. Potassium regulates the function of cell organelles and helps in maintaining the turgor pressure in gladiolus plants. It aids in cell wall formation, photosynthesis, protein synthesis, and water and osmotic balance. The level of K_2O in corms can vary depending on the nutrient sources available in the soil. Different sources of potassium, like chemical fertilizers, organic fertilizers,

Table 4.16 Nutrient analysis of gladiolus corms in response to various nutrient sources

Treatments	Nutrient content (%)								
	N			P_2O_5			K_2O		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
T_0	2.43	2.29	2.36	0.012	0.011	0.012	1.63	1.42	1.52
T_1	**3.13**	**3.03**	**3.08**	0.013	0.012	0.013	1.30	1.28	1.29
T_2	2.05	2.24	2.15	0.014	0.015	0.014	1.27	1.29	1.28
T_3	2.75	2.71	2.73	**0.015**	**0.016**	**0.016**	1.51	1.56	1.54
T_4	2.24	2.52	2.38	0.011	0.010	0.011	1.54	1.65	1.59
T_5	2.61	2.75	2.68	0.010	0.011	0.011	1.54	1.51	1.52
T_6	2.80	2.75	2.78	0.010	0.010	0.010	**2.00**	**2.04**	**2.02**
T_7	3.08	3.03	3.06	0.011	0.010	0.010	1.73	1.67	1.70
SEm±	0.21	0.17	0.17	0.00	0.00	0.00	0.19	0.15	0.17
CD at 5%	0.64	0.53	0.53	0.00	0.00	0.00	NS	NS	NS

natural fertilizers, and microbial fertilizers, have been known to have different effects on the K_2O content of gladiolus corms. Therefore, it is essential to understand the source of Potassium in order to ensure its optimum concentration in the corms. During the experiment, the K_2O content of the gladiolus corms was analysed and data represented on Table 4.16 shows that there was no significant difference recorded in the K_2O content with regard to the application of different nutrient sources. Among all the treatments, the maximum K_2O content (2.02%) was observed in T_6 (50% RDF + 50% IEM) whereas, the minimum was in T_2 (100 ml activated EM m^{-2}) (1.28%).

Indigenous effective microorganisms (IEM) as an organic fertilizer is used in many farming and crop production practices. The results from the study have shown that IEM can increase the potassium content in gladiolus corms, which is important for healthy growth. The reason for this is that IEM contains several beneficial microbial species that help to release more potassium from the soil and make it more accessible for plants. The natural microbial community of IEM helps in the release of organic and inorganic minerals, enabling better absorption of nutrients by plants, thus resulting in an increase of potassium content. Organic fertilizers bring about a positive change in the potassium content of gladiolus corms as it increases the soils microbial activity and further mineralises nutrients making it available to the plants (Brempong and Danso, 2022).

4.6 Benefit cost ratio of cultivation

Calculating the benefit cost ratio of cultivation of the gladiolus is essential for proper economics of the treatments. Different sources of nutrients can have a huge effect on the benefit cost ratio. Studies of economics surrounding the cost of

cultivation also help understand how to optimize the benefit cost ratio and maximize profits. Knowing it helps farmer make informed decisions about crop cultivation. Cultivating the gladiolus economically requires a thorough understanding of the benefit cost ratio (BCR). The ratio has taken into account all sources of costs, such as labour, materials, and treatments, to provide a financially viable outcome. From the data presented in Table 4.17, it is known that the different sources of nutrients have influenced the BCR, with various factors such as plant health, yield, and postharvest storage requiring consideration. Calculating the BCR of gladiolus production allows farmers to make informed decisions and add sustainability to their operation. The data on economic efficiency of the various treatments under study are judged for gross return, net return and benefit: cost ratio.

Based on the economics of cost of cultivation (Appendix- A), purchase of the planting material recorded the highest expenses among all the inputs and from the findings of this study, the most profitable treatment for cultivating gladiolus was attained by T_3 (500 ml activated IEM m^{-2}) with net return of ₹ 676,653 and B:C ratio of 2.46, which was followed by T_4 (jeevamrutha 50 ml m^{-2}) at ₹ 530952 net return with B:C ratio of 2.08. The reason for high net return by T_3 (500 ml activated IEM m^{-2}) would be its high yield at very low cost of inputs. The lowest net return (₹ 317,314) and B: C ratio (1.03) was obtained in T_1 (100% RDF) because chemical fertilizers were expensive with low yield.

Indigenous effective microorganisms (IEM) and organic fertilizers are an effective and sustainable method for improving crop production and increasing profits (Jan *et al.*, 2020). When compared to the use of chemical fertilizers, application of organic fertilizers lead to greater soil fertility and higher yields, due

Table 4.17 Influence of different nutrient sources on the economics of cultivation

Treatments	Cost of cultivation			Yield of corms (t/ha)	Value of corms (₹/ha)	Yield of cormels (t/ha)	Value of cormels (t/ha)	Spikes /ha	Value of spikes /ha	Gross income (₹/ha)	Net income (₹/ha)	Benefit cost ratio
	Fixed cost (₹/ha)	Treatment cost (₹/ha)	Total cost (₹/ha)									
T_0	245000	0	245000	44917	134751	0.28	7119	54222	542220	684090	439090	1.79
T_1	245000	62600	307600	49750	149251	0.39	9833	46584	465830	624914	317314	1.03
T_2	245000	89250	334250	82695	248085	0.55	13645	68806	688050	949779	615529	1.84
T_3	245000	30000	275000	117112	351335	0.13	3368	59695	596950	951653	676653	**2.46**
T_4	245000	10000	255000	60945	182834	0.49	12278	59084	590840	785952	530952	2.08
T_5	245000	75925	320925	78500	235501	0.94	23450	61195	611950	870901	549976	1.71
T_6	245000	46300	291300	64778	194334	0.43	10717	61167	611670	816721	525421	1.80
T_7	245000	36300	281300	50111	150334	0.47	11767	43139	431390	593491	312191	1.11

Selling price of corms = ₹3 $corm^{-1}$ Selling price of cormel = ₹25000 t^{-1} Selling price of spike = ₹10 spike

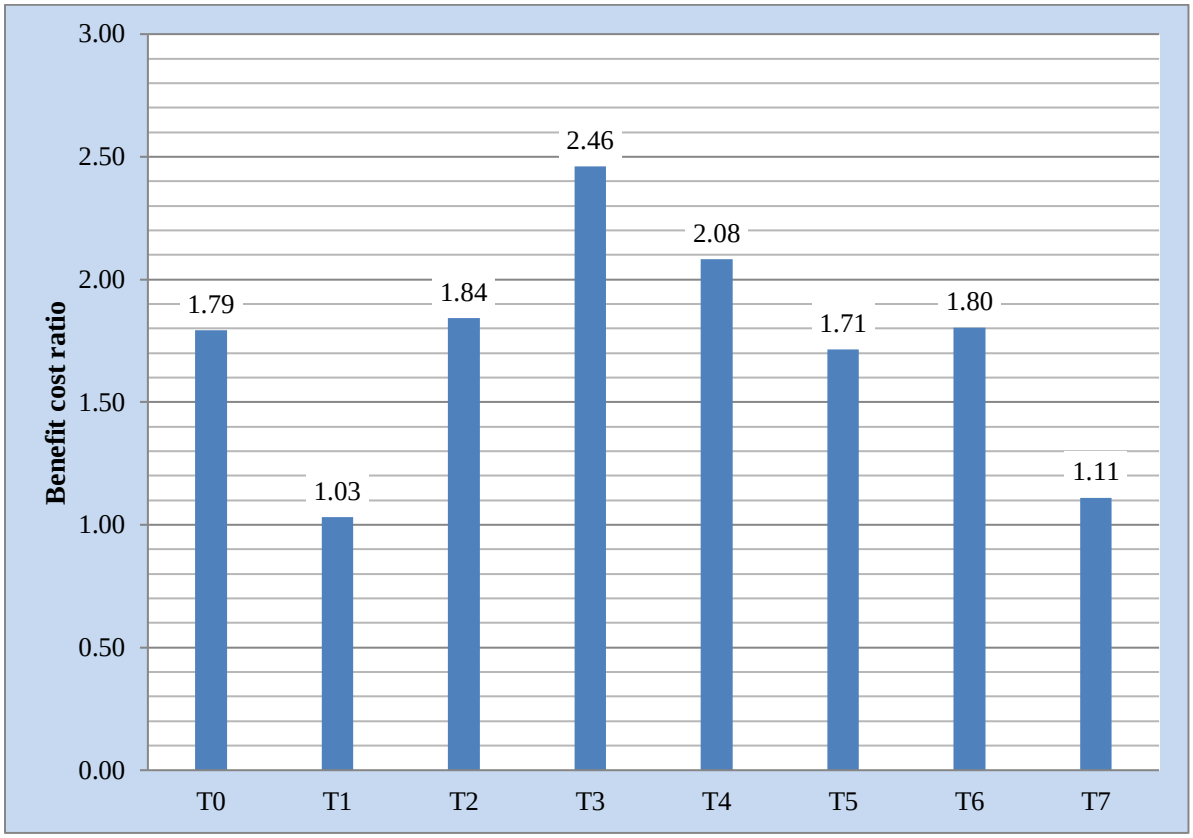

Fig. 4.1: Influence of different treatments on the cost of cultivation.

to their to capacity the bio-diversity of microbial life. This helps to promote the growth of beneficial micro-organisms, while reducing the risk of damaging pests and diseases. Furthermore, such organic fertilizers are much less expensive and remain in the soil for much longer, meaning that the cost benefits are passed on to the farmer. Organic fertilizers have a direct effect on increasing the returns of the land. It is evident from the results that organic fertilizers, when used proactively, could help farmers get more profitable yields, as they are vastly cheaper to buy and use than chemical fertilizers. Organic fertilizers are more beneficial to the soil, enabling better crop yield and thus more returns.

4.7 Vase life parameters

4.7.1 Days to basal floret open

Regarding the days to basal floret opening of cut spikes of gladiolus, it is evident from Table 4.18 that the different treatments was not found to be significant in the first year. Data from the year 2021 indicated that T_5 (commercial bleaching powder 0.005%), T_8 (cane sugar 2% + commercial bleaching powder 0.005%) and T_{10} (citric acid 0.05% + cane sugar 2% + commercial bleaching powder 0.005%) recorded the minimum requirement of time for basal floret opening (2.20 days), while maximum time (2.80 days) were recorded in T_2 (Lime juice 1%), T_4 (cane sugar 10%), T_6 (Lime juice1% + cane sugar 10%) and T_7 (citric acid 0.05% + cane sugar 10%).

However, the following year it was found that the days to basal floret opening were significantly influence by the treatments. Data from the year 2022 indicated that T_5 (commercial bleaching powder 0.005%), T_8 (cane sugar 2% + commercial bleaching powder 0.005%), T_9 (Lime juice 1% + cane sugar 2% + commercial bleaching powder 0.005%) and T_{10} (citric acid 0.05% + cane sugar 2%

Plate 9. General view of experimental site for vase life studies using locally available preservatives

+ commercial bleaching powder 0.005%) recorded the minimum requirement of time for basal floret opening (2.00 days), which also showed at par values with the rest of the remaining treatments. Maximum time (2.60 days) were recorded in T_2 (Lime juice 1%), T_4 (cane sugar 10%), T_6 (Lime juice 1% + cane sugar 10%) and T_7 (citric acid 0.05% + cane sugar 10%).

The pooled analysis of the two years data indictaed that T_5 (commercial bleaching powder 0.005%), T_8 (cane sugar 2% + commercial bleaching powder 0.005%) and T_{10} (citric acid 0.05% + cane sugar 2% + commercial bleaching powder 0.005%) recorded the minimum requirement of time for basal floret opening (2.10) and it also showed at par values with the rest of the treatments. Maximum time (2.70 days) were recorded in T_2 (Lime juice 1%), T_4 (cane sugar 10%), T_6 (Lime juice1% + cane sugar 10%) and T_7 (citric acid 0.05% + cane sugar 10%). The use of bleaching powder i.e. $CaOCl_2$ as a source of chlorine was reported to slightly improve bud opening of commercial rose cultivars (Singh *et al.*, 2004). It was also reported that maximum floret opening occurred when vase solutions were supplemented with 6% sucrose and 6% citric acid for gladiolus cv. Nova Lux (Dwivedi *et al.,* 2018). Sugar also promoted early unfolding of petals in cut rose cv. Top Secret (Das *et al.*, 2020. It is also reported that opening of gladiolus florets was accompanied by carbohydrate concentration.

The obtained results might also be due to a fact that low sugar concentrations promotes bud opening, whereas high sugar concentrations prolongs or delays the same. The pulsed blooms treated with high sugar concentrations last longer and can also withstand transportation to far off destinations (Kumarihami *et al.*, 2017; Lakshman *et al.,* 2014).

4.7.2 Floret size of basal floret

The data recorded for floret size of basal floret is incorporated in Table 4.18. The perusal of the data of 2021 indicated that T_{10} (citric acid 0.05% + cane sugar 2% + commercial bleaching powder 0.005%) recorded the maximum basal floret size (10.09 cm) which was at par with T_9 (Lime juice 1% + cane sugar 2% + commercial bleaching powder 0.005%) (9.66 cm) and T_8 (cane sugar 2% + commercial bleaching powder 0.005%) (9.11 cm), whereas the minimum basal floret size was recorded in T_6 (Lime juice1% + cane sugar 10%) (7.76 cm).

In 2022, T_{10} (citric acid 0.05% + cane sugar 2% + commercial bleaching powder 0.005%) once again recorded the maximum basal floret size (9.88 cm), which was at par with T_9 (Lime juice 1% + cane sugar 2% + commercial bleaching powder 0.005%) (9.54 cm) and T_8 (cane sugar 2% + commercial bleaching powder 0.005%) (9.07 cm), whereas the minimum basal floret size was recorded in T_6 (Lime juice1% + cane sugar 10%) (7.68 cm).

The pooled data analysis of both years revealed that T_{10} (citric acid 0.05% + cane sugar 2% + commercial bleaching powder 0.005%) recorded the maximum basal floret size (9.99 cm) and was at par with T_9 (Lime juice 1% + cane sugar 2% + commercial bleaching powder 0.005%) (9.60 cm). The minimum basal floret size was recorded in T_6 (Lime juice1% + cane sugar 10%) (7.72 cm).

It is now evident from the represented data that the basal floret size was significantly influenced by the different floral preservatives. The increase in size of the basal floret could be due to the fact that sugar supplies the energy required by the flower (Kashyap *et al.*, 2016; Nirmala *et al.*, 2019). Similar results were reported on hybrid tea rose var. Mainu Parle, where maximum flower diameter (7.28 cm) was recorded on treatments which were pulsed with bleaching powder (50 ppm or 0.005% chlorine) (Tripathy *et al.*, 2018).

Table 4.18 Days to basal floret opening and Floret size of basal floret as influenced by different using locally available preservatives

Treatments	Days to basal floret opening			Floret size of basal floret (cm)		
	2021	**2022**	**Pooled**	**2021**	**2022**	**Pooled**
T_1	2.40	2.20	2.30	8.66	8.23	8.45
T_2	2.80	2.60	2.70	7.93	7.88	7.91
T_3	2.60	2.40	2.50	8.77	8.41	8.59
T_4	2.80	2.60	2.70	8.02	7.96	7.99
T_5	**2.20**	**2.00**	**2.10**	9.01	8.95	8.98
T_6	2.80	2.60	2.70	7.76	7.68	7.72
T_7	2.80	2.60	2.70	8.52	8.46	8.49
T_8	**2.20**	**2.00**	**2.10**	9.11	9.07	9.09
T_9	2.40	**2.00**	2.20	9.66	9.54	9.60
T_{10}	**2.20**	**2.00**	**2.10**	**10.09**	**9.88**	**9.99**
SEm±	0.31	0.24	0.24	0.34	0.29	0.29
CD at 5%	NS	0.72	0.73	1.04	0.88	0.89

4.7.3 Shelf life of first floret

The response of different treatments on the shelf life of first floret was studied, the data which are presented in Table 4.19. It was observed that the treatments had no significant effect on the shelf life of the first floret in the first year, the shelf life of first floret was recorded to be maximum (2.40 days) for T_1 (control), T_2 (Lime juice 1%), T_5 (commercial bleaching powder 0.005%) and T_{10} (citric acid 0.05% + cane sugar 2% + Commercial bleaching powder 0.005%). While the least was recorded in T_6 (Lime juice1% + cane sugar 10%) (1.80 days).

During the second year study, shelf life of first floret was recorded to be maximum (2.40 days) for T_1 (control) and T_5 (commercial bleaching powder 0.005%). While the least was recorded in T_6 (Lime juice1% + cane sugar 10%) (1.80 days).

The pool data of the two years study showed that shelf life of first floret was maximum (2.40 days) for T_1 (control) and T_5 (commercial bleaching powder 0.005%) and minimum for T_6 (Lime juice1% + cane sugar 10%) (1.70 days).

The result obtained might be due to the fact that distilled water are free of contaminates such as bacteria and also the addition of commercial bleaching powder which has antimicrobial properties (Singh *et al.*, 2004) that controlled the bacterial growth in the vase life solution, thereby enabling better solution uptake. High water uptake maintained the turgidity and freshness of the spikes and thus increasing the shelf life of the first floret. Similar results were reported by Varun and Barad (2010) in tuberose.

4.7.4 Total blooming period

Regarding total blooming period of cut spikes of gladiolus, it is evident from Table 4.19 that the different treatments varied significantly and it was found that vase life solutions with a combination of citric acid, cane sugar and commercial bleaching powder resulted in longer blooming period. Total blooming period was the duration in days, between opening of the first floret and wilting of last floret. For the year 2021, the longest total blooming period of 9.60 days was observed in T_{10} (citric acid 0.05% + cane sugar 2% + commercial bleaching powder 0.005%) followed by T_5 (commercial bleaching powder 0.005%) (9.20 days), T_7 (citric acid 0.05% + cane sugar 10%) (8.40 days), T_9 (Lime juice 1% + cane sugar 2% + commercial bleaching powder 0.005%) (8.20 days), T_2 (Lime juice 1%) (8.00 days), T_4 (cane sugar 10%) (8.00 days), T_8 (cane sugar 2% + commercial bleaching powder 0.005%) (7.60 days) and T_1 (control) (7.40 days) which has exhibited appreciable duration for the character under observation and were also statistically at bar with T_{10} (citric acid 0.05% + cane sugar 2% + commercial bleaching powder 0.005%). The shortest blooming period was recorded in T_3 (citric acid 0.05%) (6.60 days) and it was also at par with T_6 (Lime juice1% + cane sugar 10%) (7.00 days).

The study in 2022 also showed similar trend where T_{10} (citric acid 0.05% + cane sugar 2% + commercial bleaching powder 0.005%) (9.60 days) registered marked increase in the total blooming period and was statistically at bar with T_5 (commercial bleaching powder 0.005%) (9.20 days), T_7 (citric acid 0.05% + cane sugar 10%) (8.40 days), T_9 (Lime juice 1% + cane sugar 2% + commercial bleaching powder 0.005%) (8.40 days) and T_2 (Lime juice 1%) (8.00 days) while T_3 (citric acid 0.05%) (6.40 days) was noted to give the shortest blooming period which was at par with T_6 (Lime juice1% + cane sugar 10%) (7.00 days).

Mean data of the two years showed that T_{10} (citric acid 0.05% + cane sugar 2% + commercial bleaching powder 0.005%) recorded the longest blooming period (9.60 days) which was at par with T_5 (commercial bleaching powder 0.005%) (9.20 days), T_7 (citric acid 0.05% + cane sugar 10%) (8.40 days), T_9 (Lime juice 1% + cane sugar 2% + commercial bleaching powder 0.005%) (8.30 days) and T_2 (Lime juice 1%) (8.00 days). T_3 (citric acid 0.05%) (6.50 days) noted the shortest blooming period followed by T_6 (Lime juice1% + cane sugar 10%) (7.00 days) and T_1 (control) (7.40 days).

From the results, it was observed that the addition of the commercial bleaching powder as a chlorine source for the vase life solution extended the blooming period in comparison to the treatments where chlorine source was absent. The antimicrobial properties of commercial bleaching powder controlled the bacterial growth in the vase life solution, thereby enabling better solution uptake which leads to higher turgidity and prolong freshness of the spike (Varun and Barad 2010). In addition, it also reported that 50 ppm i.e. 0.005% was the ideal concentration of chlorine, beyond which would result in reduction of vase life and foliar chlorosis. Similar results were also reported in cut stems of hybrid tea rose var. mainu parle by Tripathy *et al.* (2018) where maximum vase life was recorded when the stems were pulsed with bleaching powder (50 ppm chlorine).

However, citric acid when used alone failed to maximize the blooming period and recorded the shortest blooming period among all the treatments. This could have happened due to the high pH of the vase solution caused by leaching out of substrate from the flower stems. Therefore, citric acid must be used in combination with a biocide and a sugar source for more effective results.

Table 4.19 Shelf life of first floret and Total blooming period as influenced by different using locally available preservatives

Treatments	Shelf life of first floret (Days)			Total blooming period (Days)		
	2021	**2022**	**Pooled**	**2021**	**2022**	**Pooled**
T_1	**2.40**	**2.40**	**2.40**	7.40	7.40	7.40
T_2	**2.40**	2.20	2.30	8.00	8.00	8.00
T_3	2.20	2.00	2.10	6.60	6.40	6.50
T_4	2.20	2.00	2.10	8.00	7.80	7.90
T_5	**2.40**	**2.40**	**2.40**	9.20	9.20	9.20
T_6	1.80	1.60	1.70	7.00	7.00	7.00
T_7	2.00	1.80	1.90	8.40	8.40	8.40
T_8	2.00	1.80	1.90	7.60	7.60	7.60
T_9	2.00	1.80	1.90	8.20	8.40	8.30
T_{10}	**2.40**	2.20	2.30	**9.60**	**9.60**	**9.60**
SEm±	0.31	0.36	0.31	0.76	0.60	0.60
CD at 5%	NS	NS	NS	2.31	1.81	2.00

4.7.5 Increase in spike length

The data encamped in Table 4.20 showed that the different vase life solutions failed to exert significant effect on the increase in spike length of gladiolus during the year 2021, 2022 and also in pooled data analysis. The treatments showed non-significant effect on the increase in spike length during 2021 however, T_9 (Lime juice 1% + cane sugar 2% + commercial bleaching powder 0.005%) (7.46 cm) resulted in the maximum increase in spike length and T_6 (Lime juice1% + cane sugar 10%) (2.32 cm) recorded the minimum increase in spike length.

During 2022, T_9 (Lime juice 1% + cane sugar 2% + commercial bleaching powder 0.005%) (7.10 cm) recorded the maximum increase in spike length and T_6 (Lime juice1% + cane sugar 10%) (2.28 cm) recorded the minimum increase in spike length.

Pooled analysis of the two years data showed that T_9 (Lime juice 1% + cane sugar 2% + commercial bleaching powder 0.005%) (7.28 cm) recorded the maximum increase in spike length and the minimum was recorded in T_6 (Lime juice 1% + cane sugar 10%) (2.30 cm). The results obtained were similar to the findings of Gupta *et al.* (2020) on gladiolus cv. Red Beauty. After harvest, the continuation of cell division and elongation was observed in all the treatments.

4.7.6 Vase life

Regarding vase life of cut spikes of gladiolus, it is evident from Table 4.20 that the different treatments varied significantly and it was found that and it was found that vase life solutions with a combination of citric acid, cane sugar and commercial bleaching powder resulted in longer vase life. To record the observations for the vase life characters, the duration between the opening of the

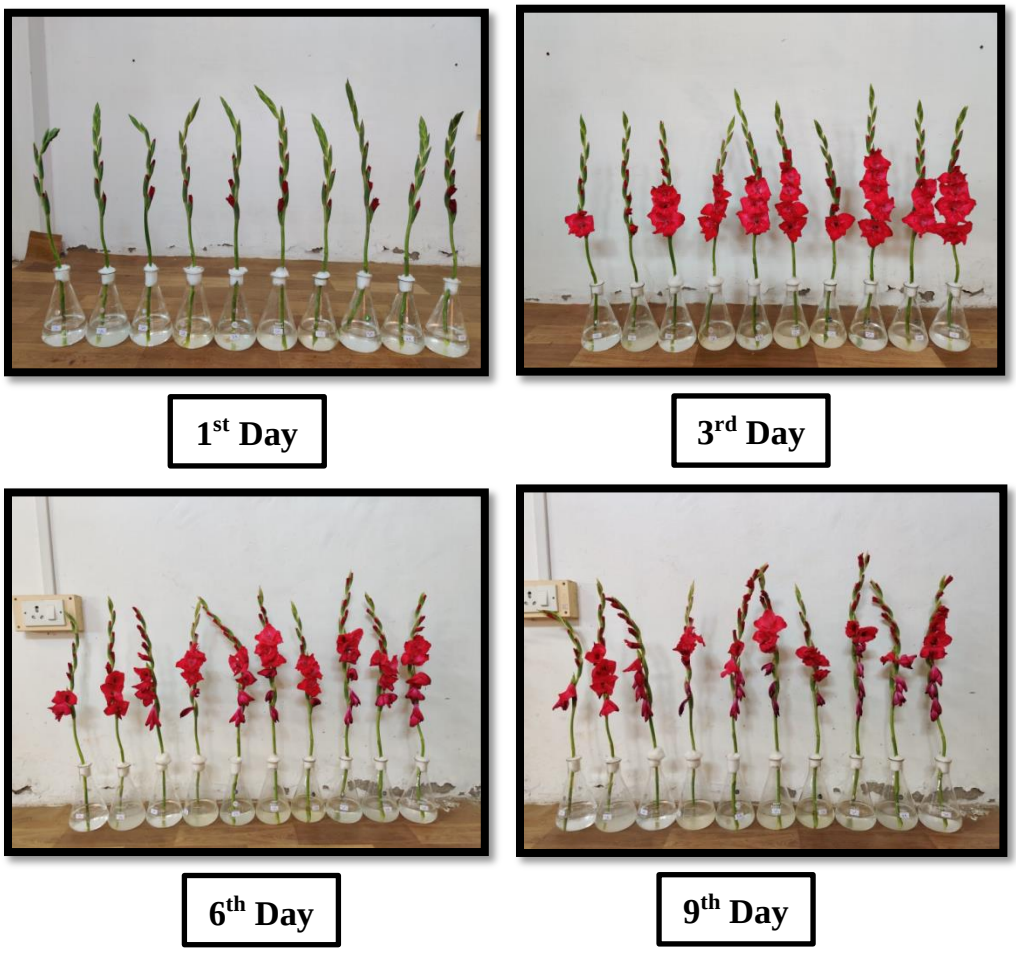

Plate 10. Cut spikes of *Gladiolus* cv. Candyman for vase life studies using locally available preservatives.

first basal floret and wilting of the 6th floret from the base of spike was taken. For the year 2021, the longest vase life of 7.60 days was observed in T_{10} (citric acid 0.05% + cane sugar 2% + commercial bleaching powder 0.005%) followed by T_5 (commercial bleaching powder 0.005%) (7.20 days), T_7 (citric acid 0.05% + cane sugar 10%) (6.40 days), T_9 (Lime juice 1% + cane sugar 2% + commercial bleaching powder 0.005%) (6.20 days), T_2 (Lime juice 1%) (6.00 days), T_4 (Cane sugar 10%) (6.00 days), T_8 (cane sugar 2% + commercial bleaching powder 0.005%) (5.60 days) and T_1 (control) (5.40 days) which has exhibited appreciable duration for the character under observation and were also statistically at bar with T_{10} (citric acid 0.05% + cane sugar 2% + commercial bleaching powder 0.005%). The shortest vase life was recorded in T_3 (citric acid 0.05%) (4.60 days) and it was also at par with T_6 (Lime juice 1% + cane sugar 10%) (5.00 days).

The study in 2022 also showed similar trend where T_{10} (citric acid 0.05% + cane sugar 2% + commercial bleaching powder 0.005%) (7.60 days) registered marked increase in the total vase life and was statistically at bar with T_5 (commercial bleaching powder 0.005%) (7.20 days), T_7 (citric acid 0.05% + cane sugar 10%) (6.40 days) and T_9 (Lime juice 1% + cane sugar 2% + commercial bleaching powder 0.005%) (6.40 days) while T_3 (citric acid 0.05%) (4.40 days) was noted to give the shortest vase life which was at par with T_6 (Lime juice 1% + cane sugar 10%) (5.00 days) and T_1 (control) (5.40 days).

Mean data of the two years showed that T_{10} (citric acid 0.05% + cane sugar 2% + Commercial bleaching powder 0.005%) recorded the longest vase life (7.60 days) which was at par with T_5 (commercial bleaching powder 0.005%) (7.20 days), T_7 (citric acid 0.05% + cane sugar 10%) (6.40 days), T_9 (Lime juice 1% + cane sugar 2% + commercial bleaching powder 0.005%) (6.30 days) and T_2 (Lime juice 1%) (6.00 days). T_3 (citric acid 0.05%) (4.50 days) noted the shortest vase

life followed by T_6 (Lime juice 1% + cane sugar 10%) (5.00 days) and T_1 (control) (5.40 days).

From the results, it was observed that the addition of the commercial bleaching powder as a chlorine source for the vase life solution extended the vase life in comparison to the treatments where chlorine source was absent. Simply placing the cut blooms in vase solution without any biocides reduces the vase life because of the absence of antimicrobials that will suppress the microbial growth which clogs the xylem vessel, hence reducing the water uptake (Vehniwal, 2018). The antimicrobial properties of commercial bleaching powder controlled the bacterial growth in the vase life solution, thereby enabling better solution uptake which leads to higher turgidity and prolong freshness of the spike (Varun and Barad, 2010). In addition, it has been reported that 50 ppm i.e. 0.005% was the ideal concentration of chlorine, beyond which would result in reduction of vase life and foliar chlorosis. Similar results were also reported in cut stems of hybrid tea rose var. mainu parle by Tripathy *et al.* (2018) where maximum vase life was recorded when the stems were pulsed with bleaching powder (50 ppm chlorine). Also, sugar acts a carbon source that helps in sustaining the overall keeping quality and helps in the maintenance of the mitochondrial structure within the plant cell (Dwivedi *et al.*, 2018).

However, citric acid when used alone failed to maximize the vase life and recorded the shortest vase life among all the treatments. This could have happened due to the high pH of the vase solution caused by leaching out of substrate from the flower stems. Therefore, citric acid must be used in combination with a biocide and a sugar source for more effective results.

4.7.7 Vase solution uptake

Table 4.20 showed that the vase solution uptake of cut spikes had no significant effect caused by the application of various vase solutions. In the first year, highest vase solution update was recorded in T_8 (cane sugar 2% + commercial bleaching powder 0.005%) (72.80 ml) while the lowest was found in T_4 (cane sugar 10%) (31.80 ml).

During the second year of study, T_8 (cane sugar 2% + commercial bleaching powder 0.005%) (71.40 ml) recorded the highest while the lowest was found in T_4 (cane sugar 10%) (30.20 ml).

The mean data of the two years study showed that T_8 (cane sugar 2% + commercial bleaching powder 0.005%) (72.10 ml) recorded the highest while the lowest was found in T_4 (cane sugar 10%) (31.00 ml).

The obtained results might be due to the combination of sugar and biocides in the vase solution. Sugar acts as a good source of carbon and supplies necessary food to the cut stems, however it also creates favourable condition for the growth of microorganisms that accumulates at the base of the stem. This will create a barrier and block the uptake of water by the vascular tissues due to bacterial plugging. Hence, the addition of commercial bleaching powder has suppressed microbial growth and increase uptake of the vase solution. These results were in accordance with Arunesh *et al.* (2020) in gerbera and Asrar (2012) in snapdragon.

4.8 Benefit cost ratio of vase life solutions

4.8.1 Economics of vase life solutions

The possibility of the treatment to be adopted also depends on the economic, therefore the study on the cost and return have to be studied.

Table 4.20 Increase in spike length, vase life and vase solution uptake as influenced by different using locally available preservatives

Treatments	Increase in spike length (cm)			Vase life (Days)			Vase solution uptake (ml)		
	2021	**2022**	**Pooled**	**2021**	**2022**	**Pooled**	**2021**	**2022**	**Pooled**
T_1	7.30	7.04	7.17	5.40	5.40	5.40	63.00	60.60	61.80
T_2	6.64	6.22	6.43	6.00	6.00	6.00	33.60	32.20	32.90
T_3	5.44	5.30	5.37	4.60	4.40	4.50	69.80	68.00	68.90
T_4	4.62	4.34	4.48	6.00	5.80	5.90	31.80	30.20	31.00
T_5	5.82	5.54	5.68	7.20	7.20	7.20	56.20	53.60	54.90
T_6	2.32	2.28	2.30	5.00	5.00	5.00	48.20	46.60	47.40
T_7	6.78	6.46	6.62	6.40	6.40	6.40	48.20	46.40	47.30
T_8	7.08	6.58	6.83	5.60	5.60	5.60	**72.80**	**71.40**	**72.10**
T_9	**7.46**	**7.10**	**7.28**	6.20	6.40	6.30	66.60	64.20	65.40
T_{10}	4.82	4.66	4.74	**7.60**	**7.60**	**7.60**	64.40	63.00	63.70
SEm±	1.99	1.75	1.87	0.76	0.53	0.66	11.07	10.14	10.56
CD at 5%	NS	NS	NS	2.31	1.62	2.00	NS	NS	NS

Economics was worked out on the basis of the total blooming period, incremental benefit of shelf life over control and the cost of each treatment per scape.

The benefit cost ratio was calculated by finding the ratio of incremental benefit of shelf life over control upon the cost of each treatment per scape. The results were presented in the Table 4.21. The B:C ratio revealed that, most of the treatments were not economically viable. In comparison to control, B:C ratio of T_5 (commercial bleaching powder 0.005%) recorded the highest (3.60) which was followed by T_{10} (citric acid 0.05% + cane sugar 2% + commercial bleaching powder 0.005%), but the value (0.81) was recorded to be less than one which was similar with the rest of the treatments and therefore, could not qualify as an economical practice for vase life solution.

Among all the treatments, commercial bleaching powder 0.005% was more economical than other treatments. It was observed that combinational treatment T_{10} (citric acid 0.05% + cane sugar 2% + commercial bleaching powder 0.005%) extended the vase life (9.40 days), but was found economically not effective as compared to the individual treatment of T_5 (commercial bleaching powder 0.005%) which recorded a total blooming period of 9.00 days. Both the treatments showed negligible differences. Hence, it can be concluded that use of commercial bleaching powder 0.005% as a locally available vase life preservative was economically more capable to extend the vase life of gladiolus as the benefit cost returns were recorded to be the highest in this treatment. Similar finding were reported by Sravanthi in gerbera cv. Stanza (2019).

Table 4.21 Influence of different locally available preservatives on the economics

Treatments	Total blooming period (Days)	Incremental benefit of shelf life over control	Cost of treatment per scape (₹)	B:C
T_1	7.20	0.00	0.00	0.00
T_2	7.80	0.60	2.00	0.30
T_3	6.20	-1.00	1.40	-0.71
T_4	7.60	0.40	4.00	0.10
T_5	9.00	1.80	0.50	**3.60**
T_6	6.80	-0.40	6.00	-0.07
T_7	8.20	1.00	6.40	0.16
T_8	7.40	0.20	1.30	0.15
T_9	8.00	0.80	3.30	0.24
T_{10}	9.40	2.20	2.70	0.81

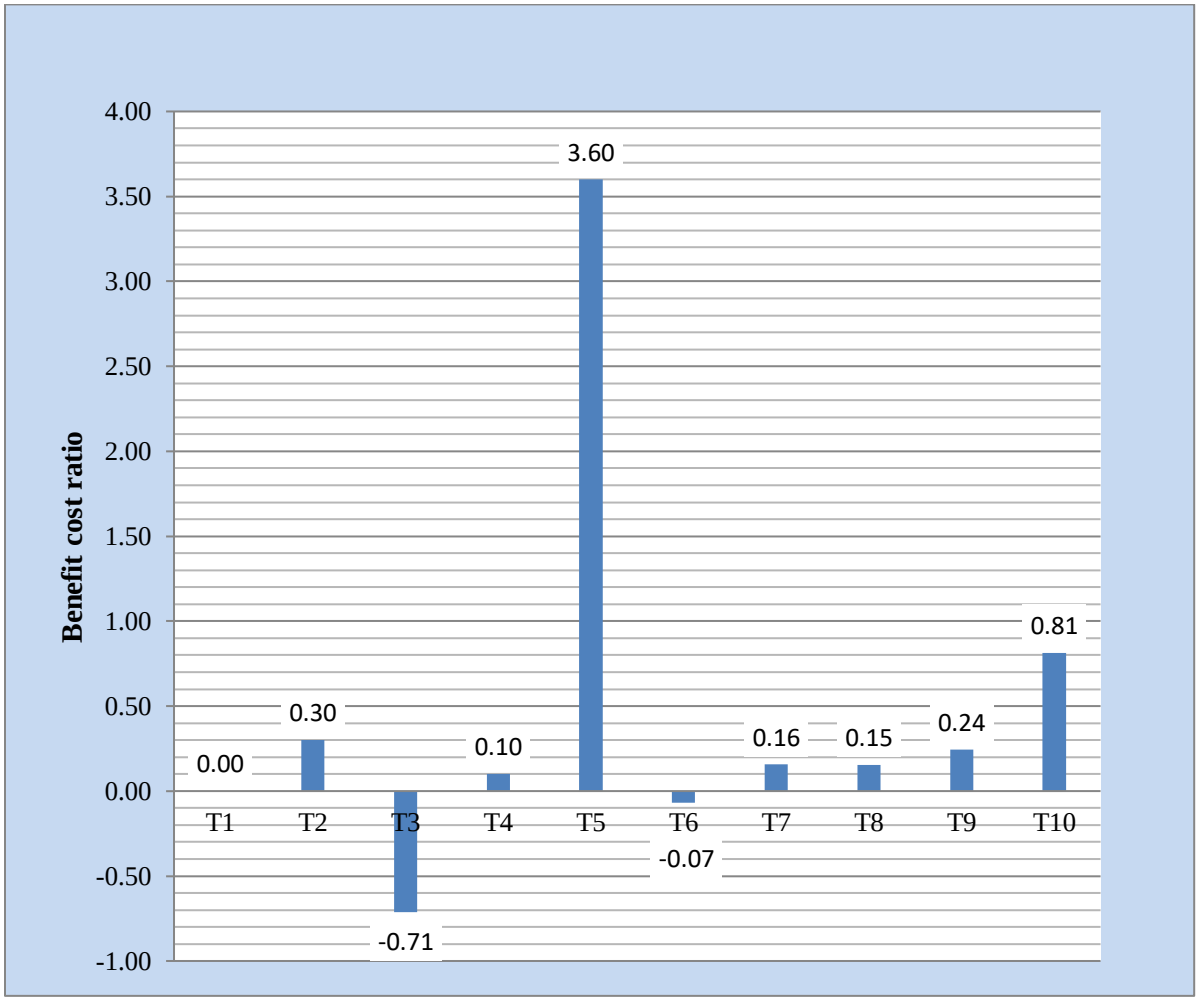

Fig. 4.2: Influence of different locally available preservatives on the Benefit cost ratio for vase-life studies.

CHAPTER V

SUMMARY AND CONCLUSIONS

SUMMARY AND CONCLUSION

The present investigation entitled "**Integrated nutrient management and vase life of Gladiolus (*Gladiolus grandiflorus* L.)**" was carried out in the Experimental farm, Department of Horticulture, School of Agricultural Sciences and Rural Development (SASRD), Nagaland University, Medziphema campus, Nagaland during 2021 to 2022. The investigation was undertaken with the following objectives.

1. To study the effect of different sources of nutrients and their combination on growth, flowering and corm characters.
2. To study the effect of integrated nutrient management (INM) on nutrient uptake by the plants.
3. The study the vase life using locally available preservatives.
4. To study the economics for different treatments.

The findings from the investigation have been summarized below:

5.1 Growth characters

The effect of various treatments on the mean values of growth characters showed different variations. The treatment T_2 (100 ml activated EM m^{-2}) recorded the earliest sprouting of the corms (6.83 days), the highest no. of leaves per plant (7.73) and the longest leaf length (46.16 cm). The tallest plant height (108.09 cm) and the maximum leaf area at spike emergence (125.32 cm^2) was recorded in T_6 (50% RDF + 50% IEM). The largest girth of plant base was obtained by T_5 (50% RDF + 50% EM) (6.23 cm).

5.2 Flowering parameters

The results showed significant effect on the flowering parameters. T_2 (100 ml activated EM m^{-2}) recorded the minimum days taken for spike initiation (68.48 days), the minimum days taken for first floret opening (74.24 days), the highest no. of spikes per plant (1.03) and the minimum days to harvesting of spikes (7.91 days). T_3 (500 ml activated IEM m^{-2}) had the longest spike length (89.62 cm), the highest no. of florets per spike (10.47) and the maximum floral diameter (9.97 cm). The maximum rachis length (33.66 cm) was obtained by T_0 (Control)

5.3 Corm and cormel characters

The findings from the experiment shows that the highest no. of corms per plant (1.76) was given by T_3 (500 ml activated IEM m^{-2}). The highest corm diameter (4.90 cm), maximum weight of corm per mother plant (25.93 gm), maximum no. of cormels per plant (15.73) and the maximum weight of cormels per mother corm (14.07 gm) was obtained in T_5 (50% RDF + 50% EM).

5.4 Quality parameters

It is observed that T_6 (50% RDF + 50% IEM) obtained the highest self life (11.00 days) and the longest vase life (9.35 days).

5.5 Plant nutrient uptake and soil fertility

For the soil fertility status, the maximum available nitrogen content (961.71 kg ha^{-1}), available phosphorus content (61.96 kg ha^{-1}), available potassium content (516.50 kg ha^{-1}) and the maximum EC value (0.66 dSm^{-1}) was obtained in T_2 (100 ml activated EM m^{-2}). The maximum pH value of 6.47 was reported in T_7 (50% RDF + 50% Jeevamrutha). T_5 (50% RDF + 50% EM) had the maximum soil organic carbon (2.81%). The maximum nitrogen content (4.33%) in leaves was

reported in T_2 (100 ml activated EM m^{-2}), maximum phosphorus content (0.011%) was observed in T_3 (500 ml activated IEM m^{-2}) and the maximum potassium content (2.24%) was observed in T_1 (100% RDF). In the corms, the highest nitrogen content (3.08%) was reported in T_1 (100% RDF). T_3 (500 ml activated IEM m^{-2}) had the maximum corm phosphorus content (0.016%) and the maximum potassium content (2.02%) was observed in T_6 (50% RDF + 50% IEM).

5.6 Benefit cost ratio of cultivation

The most profitable treatment for cultivating gladiolus was attained by T_3 (500 ml activated IEM m^{-2}) with net return of ₹ 676,653 and B:C ratio of 2.46.

5.7 Vase life parameters

It was observed that T_{10} (citric acid 0.05% + cane sugar 2% + commercial bleaching powder 0.005%) recorded the minimum requirement of time for basal floret opening (2.10), the maximum basal floret size (9.99 cm), the longest blooming period (9.60 days) and vase life (7.60 days). The shelf life of first floret was maximum (2.40 days) for T_1 (control) and T_5 (commercial bleaching powder 0.005%). T_9 (Lime juice 1% + cane sugar 2% + commercial bleaching powder 0.005%) (7.28 cm) recorded the maximum increase in spike length. T_8 (cane sugar 2% + commercial bleaching powder 0.005%) (72.10 ml) recorded the highest vase solution uptake.

5.8 Benefit cost ratio of vase life solutions

The B:C ratio revealed that, most of the treatments were not economically viable. In comparison to control, B:C ratio of T_5 (commercial bleaching powder 0.005%) recorded the highest (3.60).

Conclusion

From the result of these experiments, it can thus, be concluded that:

1. The application of effective microorganisms (EM) as in T_2 (100 ml activated EM m^{-2}) and T_5 (50% RDF + 50% EM) recorded the best results in growth, flowering and corm characters of gladiolus.

2. Integrated application of organic liquid input is recommended over lone application of inorganic fertilizers in order to retain the available nitrogen, phosphorus, potassium, soil organic carbon, EC and pH value and improve the soil fertility status after harvest, thereby, promoting better yield with sustainable use of resources.

3. The use of commercial bleaching powder 0.005% as a locally available vase life preservative was economically viable. Therefore, the study recommends the use of commercial bleaching powder 0.005% as an ideal vase life concentration for the vase life of gladiolus cv. Candyman.

4. The most profitable treatment for cultivating gladiolus was attained by T_3 (500 ml activated IEM m^{-2}) with net return of ₹ 676,653 and B:C ratio of 2.46.

Future line of work

Based on the results drawn from the present work, it is evident that there is promising scope for the utilization of organic liquid fertilizers on the following aspects for promoting sustainable horticulture.

1. In order to increase yield with the incorporation of organic liquid fertilizers, a standardized concentrate for similar horticulture crop can be initiated.
2. It is suggested to study more combination of dicot and monocot plants that can thrive well together under suitable organic integrated nutrient system.
3. Explore more on the economic profitability of organic liquid fertilizers for other high value horticulture crop.
4. The macronutrients were found to be retained more with the use of effective microorganism (EM) in comparison with other organic inputs, which indicates that EM can enhance the process of soil reclamation. So, the use of EM is suggested for soil and its health related studies.

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Appendix - A
Cost of cultivation (₹ ha^{-1})

(A) Fixed cost		
1	Planting material @ ₹ 3 / corm	₹ 200000
2	Ploughing 2 times @ ₹ 2000	₹ 4000
3	Land preparation by 10 men @ ₹ 500/ men	₹ 5000
4	Planting by 10 men @ ₹ 500/ men	₹ 5000
5	Intercultural activities 4 times by 10 men @ ₹ 500/ men	₹ 15000
6	Irrigation	₹ 3000
7	Harvesting, grading and packing by 20 men @ ₹ 500/ men	₹ 10000
8	Transportation and marketing charges	₹ 2000
9	Miscellaneous	₹ 1000
	Total	₹ 245000

(B) Treatment cost		
T0	Control (Untreated)	0
T1	100% RDF (400:200:200 kg/ha)	
	Cost of N through urea @ ₹ 90/ kg = Rs 36000	
	Cost of P_2O_5 through SSP @ ₹ 83/ kg = ₹ 16,600	
	Cost of K_2O through MOP @ ₹ 50/ kg = ₹ 10,000	₹ 62600
T2	EM (50 L EM/ha) 3 times @ ₹ 595/ Ltr	₹ 89250
T3	IEM (250 kg IEM/ha) 3 times @ ₹ 40/ kg	₹ 30000
T4	Jeevamrutha (500 L/ha) 2 times @ ₹ 10/ Ltr	₹ 10000
T5	50% RDF + 50% EM	₹ 75925
T6	50% RDF + 50% IEM	₹ 46300
T7	50% RDF + 50% Jeevamrutha	₹ 36300

Treatment	**Total cost of cultivation (₹)**	**Gross income (₹)**	**Net return (₹)**	**Benefit cost ratio**
Control (Untreated)	225000	583336.3	358336.3	1.59
100% RDF (40:20:20 gm m^{-2})	287600	402779.8	115179.8	0.40
EM (100 ml activated EM m^{-2})	254750	666670.0	411920.0	1.62
IEM (500 ml activated IEM m^{-2})	243000	625003.1	382003.1	1.57
Jeevamrutha (50 ml m-2)	228000	541669.4	313669.4	1.38
50% RDF + 50% EM	271175	597225.2	326050.2	1.20
50% RDF + 50% IEM	265300	625003.1	359703.1	1.36
50% RDF + 50% Jeevamrutha	257800	402779.8	144979.8	0.56