EFFECT OF VARIOUS NUTRIENT SOURCES ON THE GROWTH, FLOWERING, YIELD AND VASE LIFE OF *Gladiolus primulinus* cv. CANDYMAN

Thesis

submitted to

NAGALAND UNIVERSITY

in partial fulfilment of requirements for the Degree

of

Doctor of Philosophy

in

HORTICULTURE

by

NINI R. KUOTSU

Admn. No. Ph-152/13 Regn. No. 590/2014

Department of Horticulture

School of Agricultural Sciences & Rural Development

Nagaland University, Medziphema Campus– 797106

Nagaland

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Dedicated to my Loving Family

STUDENT'S DECLARATION

I, Nini R. Kuotsu, 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 has not been submitted by me for any research degree to any other university/institute.

This is submitted to Nagaland University for the degree of Doctor of Philosophy in Horticulture.

Date: **(NINI R. KUOTSU)**
Place:

....
Supervisor

NAGALAND UNIVERSITY
Medziphema Campus
School of Agricultural Sciences and Rural Development
Medziphema – 797106, Nagaland

Dr. Rokolhuü Keditsu
Assistant Professor
Department of Horticulture

CERTIFICATE – I

This is to certify that the thesis entitled "**Effect of various nutrient sources on the growth, flowering, yield and vase life of *Gladiolus primulinus* cv. Candyman**" submitted to Nagaland University in partial fulfilment of the requirements for the degree of Doctor of Philosophy in the discipline of Horticulture is the record of research work carried out by Ms. Nini R. Kuotsu Registration No. 590/2014 under my personal supervision and guidance.

The results 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.

Dated:
Place: ……………………………

Dr. ROKOLHUÜ KEDITSU
Supervisor

NAGALAND UNIVERSITY
Medziphema Campus
School of Agricultural Sciences and Rural Development
Medziphema – 797 106, Nagaland

CERTIFICATE – II

VIVA VOCE ON THESIS OF DOCTOR OF PHILOSOPHY IN HORTICULTURE

This is to certify that the thesis entitled "**Effect of various nutrient sources on the growth, flowering, yield and vase life of *Gladiolus primulinus* cv. Candyman**" submitted by Ms. Nini R. Kuotsu, Admission No. Ph-152/13 Registration No. 590/2014 to the NAGALAND UNIVERSITY in partial fulfilment of the requirements for the award degree of Doctor of Philosophy in Horticulture has been examined and approved by the Advisory Board and External Examiner on ....

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

Members	Signatures
1. Dr. Rokolhuü Keditsu (Supervisor)	....
2. .... (External Examiner)	....
3. Dr. S.P Kanaujia	....
4. Dr. C.S Maiti	....
5. Prof. S.K Sharma	....

Head
Department of Horticulture

Dean
School of Agricultural Sciences
& Rural Development

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THANK YOU

Date: *(Nini R. Kuotsu)*

Place:

CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

LIST OF APPENDICES

ABBREVIATIONS

%	Percent
±	plus or minus
$^{-1}$	Per
½	Half
@	at the rate of
CBR	Cost Benefit Ratio
CD	Critical Difference
cfu	colony formation unit
cm	Centimetre
Cu	Copper
cv.	Cultivar
DAT	Days After Planting
E	East
et al.	et alia (and others)
etc	etcetera
Fe	Iron
Fig	Figure
FYM	Farm Yard Manure
g	gram
ha	hectare
i.e.	that is
ICAR	Indian Council of Agricultural Research
INM	Integrated Nutrient Management
I.U.	International Unit
K	Potassium
kg	Kilogram
lb	Pound
L	Litre
m	Metre
Max	maximum
Min	minimum
mg	miligram
min.	minute
ml	millilitre
Mn	Manganese
MoP	Murate of Potash
MT	Metric tonnes
N	Nitrogen
NE	North East
NER	North East Region
Ni	Nickle
No.	number
NU	Nagaland University
^{0}C	Degree Celsius

P	Phosphorus
Pb	Lead
pH	negative logarithm of hydrogen ion activity of a soil
ppm	parts per million
PSB	Phosphate Solubilising Bacteria
PSM	Phosphate Solubilising Micro organism
q	Quintal
RBD	Randomized Block Design
RDF	Recommended Dose of Fertilizer
RH	Relative Humidity
₹	Rupees
S	South
S	Sulphur
SASRD	School of Agricultural Science and Rural Development
SEm±	Standard Error Mean
SSP	Single Super Phosphate
t	Tonnes
TSS	Total Soluble Solids
viz.	namely
VAM	Vesicular Arbuscular Mycorrhiza
Var	Variety
VC	Vermicompost
w.r.t	with respect to
W	West
Zn	Zinc

ABSTRACT

The present experiment on the "Effect of various nutrient sources on the growth, flowering, yield and vase life of *Gladiolus primulinus* cv. Candyman" were carried out in the Experimental Farm, Department of Horticulture, School of Agricultural Sciences and Rural Development, Nagaland University, Medziphema Campus during 2014-15 and 2015-16. The experiments were laid out in Randomized Block Design with 14 treatments and 3 replications. The corms were planted at a spacing of 25 × 30 cm in plot size of 1.5 m^2. The treatments are T_0 (Control), T_1 (FYM 40 t ha^{-1}), T_2 (Pig manure 35 t ha^{-1}), T_3 (Vermicompost 10 t ha^{-1}), T_4 (NPK 100% RDF *i.e.* 200:200:200 kg NPK ha^{-1}), T_5 (*Azospirillum* + Phosphotica), T_6 (50% NPK + 50% FYM), T_7 (50% NPK + 50% Pig manure), T_8 (50% NPK + 50% Vermicompost), T_9 (50% NPK + *Azospirillum* + Phosphotica), T_{10} (75% NPK + *Azospirillum* + Phosphotica), T_{11} (50% NPK + 25% FYM + *Azospirillum* + Phosphotica), T_{12} (50% NPK + 25% Pig manure + *Azospirillum* + Phosphotica) and T_{13} (50% NPK + 25% Vermicompost + *Azospirillum* + Phosphotica). Pooled results revealed that integrated application of T_{11} (50% NPK + 25% FYM + *Azospirillum* + Phosphotica), recorded significantly higher plant height (108.55 cm) and number of leaves $plant^{-1}$ (9.63) while T_{12} recorded significantly higher leaf area (130.56 cm^2), minimum days to spike emergence (68.72 days) and full opening of first floret (78.36 days), maximum spike length (88.76 cm) and rachis length (48.84 cm), more diameter of floret (10.33 cm), number of florets $spike^{-1}$ (15.58), durability of whole spikes (19.42 days), number of spikes $plant^{-1}$ (1.48), number of spikes $plot^{-1}$ (29.67), number of spikes $hectare^{-1}$ (197788), corm diameter (6.91 cm), number of corms $plant^{-1}$ (1.53), corm weight $plant^{-1}$ (99.52 g), weight of corms $plot^{-1}$ (1.99 kg), yield of corms (13.27 t ha^{-1}), number of cormels $plant^{-1}$ (14.38), weight of cormels $plant^{-1}$ (5.01 g), weight of cormels $plot^{-1}$ (0.100 kg) and yield of cormels (0.664 t ha^{-1}). The same treatment performed the best in vase life attributes *viz*. maximum fresh

weight of 65.37 g, highest water uptake (21.41g) and maximum water balance ratio (1.265) on the 3rd day of vase life. Maximum days to drooping of 1st and 5th floret (4.86 and 8.46 days), highest number of florets to remain open at a specific time (6.34) and maximum vase life (12.51 days) were also exhibited with T_{12}. Nitrogen and phosphorus content (2.92% and 0.41%) in index leaves were also highest with T_{12} while maximum potassium content (2.13%) was recorded with T_{11}. The highest soil organic carbon content (2.16%), pH (4.88), dehydrogenase activity (9.88 TPF µg g^{-1} hr^{-1}), bacterial count (144×10^4 cfu g^{-1}) and fungal count (35×10^4 cfu g^{-1}) was recorded with T_1. Highest available N (284.7 kg ha^{-1}) and available K (154.4 kg ha^{-1}) in soil after harvest was obtained with T_6 while highest available P (23.4 kg ha^{-1}) was recorded with T_7. T_{12} (50 % NPK + 25 % Pig manure + *Azospirillum* + Phosphotica) exhibited the highest profit (₹15,11,939) and highest cost benefit ratio (1:2.01). Treatment T_{12} was found to be statistically at par with treatment T_{11} in growth, flowering, yield and vase life parameters too.

(NINI R. KUOTSU)

CHAPTER I
INTRODUCTION

INTRODUCTION

Flowers are considered as the symbol of grace and elegance which possess a charm and allure that continues to captivate people around the globe. Floriculture has attained the status of one of the most important high value agricultural industry in many developing as well as under-developed countries of the world. Floriculture is a fast emerging and highly competitive industry and is getting attention globally due to change in the lifestyle of people, concern for environment and conscious efforts towards greening and better purchasing ability of the people. In India, floriculture is taking strong roots, which is emerging as a reliable floriculture supplier to the world. From the symbols of aesthetics and love, flowers have transformed into an industry, generating both income as well as employment. There has been a considerable increase in production, trading and consumption of flowers owing to its marked aesthetic importance and high economic value. The world floral industry is growing at the rate of 10% per annum. In India, the total area under flower crops in 2015-16 was 278 „000‟ ha with a production of 1656 „000‟ MT of loose flowers and 528 „000‟ MT of cut flowers. The flower production in Nagaland is estimated to be around 1.48 „000‟ MT from an area of 0.07 „000‟ ha during 2015-16 (Ministry of Statistics & Programme Implementation, 2016). India has exported 22,518.58 MT of floriculture products to the world for the worth of ₹ 479.42 crores in 2015-16 (APEDA, 2016).

Gladiolus is universally acclaimed prestigious flower. It has a great economic value as a cut flower and is known as queen amongst the bulbous flowers. Commercial cultivation of gladiolus is ever increasing due to its vivid colour, shape, size and long durability of spike in holding solution. It occupies the fourth place in international cut flower trade (Bhattacharjee & De, 2010). It has second rank after tulip among the bulbous flowers in India (Singh *et al.,* 2012). The powerful sentiments these flower can express are a perfect complement to their classic beauty and long- lasting freshness. Flower and corm of some gladiolus are used as food in many countries (Khan, 2009). Momin (2006) reported that income from gladiolus flower production is six times that returns from rice.

The name Gladiolus (*Gladiolus sp.)* popularly known as „Glad" or „Sword Lily" or „Corn Lily" is derived from the Latin word "*gladius"* meaning „sword" from the shape of its leaves. The modern cultivars and hybrids have originated from South Africa and are taxonomically identified as *Gladiolus grandiflorus* Andrews belonging to family *Iridaceae* and subfamily *Ixioideae*. The genus *Gladiolus* comprising 260 species (Ranjan *et al.*, 2010; Goldblatt & Manning, 1998) is a very popular bulbous commercial flower. It is known for its beautiful spikes as well as long vase life. The plant comes to flowering at 60-100 days after sowing depending on the cultivar and growing conditions. Gladioli contribute the most important item for aesthetic, economic and social appeal. The fascinating spike bears a large number of florets with varying sizes and forms with smooth ruffle of deeply crinkled sepals. Florets open sequentially from the base of the rachis and extension of longevity of these florets helps in maintaining the economic value of these flowers for a longer time. The stem of gladiolus is herbaceous and the leaves are narrowly linear, flattened at the sides and sheathing at the base. The bases of old leaves are thin and dry, which cover the corm and are called husks. They overlap each other and meet to form a point at the top. Daughter corms are produced on the top of mother corm which itself shrivels and dies. The bud development occurs on the upper surface of the daughter corm from which the new plant grows the following year. While the new daughter corm is forming on the top of old one and small new corms called cormels or cormlets are produced from the bases which are used for asexual propagation. One mother corm generally produces one daughter corm of standard size and few cormels.

Gladiolus corms undergo dormancy, which has physiological importance as it allows overcoming unfavourable environmental conditions. Cold storage of corms at 4-5 ºC for 3 to 4 months is widely followed practice for breaking dormancy and to cultivate gladiolus throughout the year (Padmalatha *et al.*, 2013).

Gladiolus is cultivated in most of the tropical and subtropical countries of the world. The major gladiolus producing countries are the United States (Florida and California), Holland, Italy, France, Poland, Bulgaria, Brazil, India, Australia and Israel. In India, the area under bulbous crop is about 3500 ha of which gladiolus occupies more than 1200 ha with an annual production of more than 150 million spikes. The main gladiolus growing places are suited to the north Indian plains. It is grown in the plains as well as hills up to elevation of 2400 m from mean sea levels (Singh *et al.*, 2012). The North Eastern Region of India, due to its peculiar physiographic, distinctive weather has the agro climatic advantage of tropical and temperate regions to grow varieties of floriculture crops in addition to rich genetic diversity. Nagaland has the suitable agro-climatic conditions which clearly indicate that wide range of ornamental crops can be grown, which can improve the economic conditions of the growers due to its higher income per unit area. Realizing the potential of this sector, many budding entrepreneurs are taking up floriculture.

Gladiolus is an all-time favorite for the cut-flower industry as it occupies a leading position among cut flowers due to its elegant appearance and spikes of different hues and having long vase life (Anderson *et al.*, 2012; Sajjad *et al.*, 2014). However, flower crops especially bulbous plants are very much responsive to fertilizer and are highly capable of exhausting huge nutrients from native soil thus require higher amount of fertilizer in balance proportion for ensuring maximum flower production. Fertilizer requirements of gladiolus like other crops, has vital role in growth, spike quality, corm and cormel production. The cut spikes to sustain floret longevity in an acceptable condition after harvest, is the criterion for describing the keeping quality of the flower which largely depends on the food materials supplied during growth as well as food sources in vase solution. Apart from quality spike production, multiplication of planting material is the present day need because the cut flower trade is lagging behind over the recent years, owing to the unavailability of sufficient quality propagating material at large scale (Barman *et al.*, 2005). One of the most effective means to improve the yield in terms of good quality spikes, corms and cormels in a sustainable production system is by adopting proper nutrient management practices by making judicious use of inorganic fertilizers, manures, composts and biofertilizers alone or in combination to get quality products without environmental hazard.

The organic manures play an important role in crop production owing to their twin utility for nutritive as well as non nutritive values. It acts on the soil physically, chemically and biologically in many beneficial ways. Physically, organic matter promotes formation of soil crumbs that make the soil friable and thereby facilitate the proper movement of air and water and absorption of rainwater while chemically it adds organic compound to the soil while going under decomposition. A good amount of nutrients, both macro and micro, are added to the soil through organic manures. Biologically, organic manures provide food for the beneficial soil microorganisms. The richness of soil in organic matter helps in alteration of physico-chemical (Aiswath *et al.*, 2003) and biological properties (Peterson *et al.*, 1982) to suit uninterrupted growth of plants. The improvement in physiochemical properties also aids in promoting the root growth and hastening the nutrient absorption by crop plants (Chandra *et al.*, 2010). This result in better vegetative growth and flowering in gladiolus and also provide congenial environment for growth and development of corms and cormels.

Biofertilizers are microbial inoculants of selective microorganisms like bacteria, algae, fungi, etc. which help in improving soil fertility by way of accelerating biological nitrogen fixation from atmosphere, solubilization of the insoluble nutrients already present in soil, decomposing plant residues, stimulating plant growth and production. They improve vegetative growth, flowering and corm production by producing phyto-hormones, enhancing the uptake of plant nutrient by plant roots and thus help in sustainable crop production through maintenance of soil productivity. To maximize the beneficial plant growth response it is to identify the best strains of microorganisms, verify their compatibility and combined efficiency before using them in crop production system as a potential component for sustainable systems of horticulture and floriculture (Chaudhary, 2010; Kumari *et al*., 2013). The process consumes less energy and provides cheap nutrients to agriculture without polluting the nature. The use of organic soil amendments and microbial culture along with the judicious use of chemical fertilizers can improve biological and physico-chemical properties of the soil moreover improving the nutrient uptake efficiency. During the current decade, microbial culture proved to be an important component of integrated nutrient application in agriculture and therefore seems a viable potential for efficient use of microorganisms for maximizing crop production. Application of microbes is an integral part of environment friendly sustainable organic agriculture (Bloemberg *et al*., 2000).

In the quest to attain good quality spike, corms and cormels production in gladiolus, the continuous and indiscriminate application of chemical fertilizers has created a disproportion of nutrients which adversely affected the soil structure and health (Younis *et al*., 2013). The recent crisis and hike in the prices of inorganic fertilizers further warranted towards the use of organic manures in flower crops (Waheeduzzama *et al*., 2007). At present, there is an urgent need to standardize agro techniques which are most suitable for local climatic and edaphic conditions. Due to energy crisis, problems associated in using chemical fertilizers and poor purchasing power of marginal and small farmers, it is imperative to strategies for using alternative or supplementary nutrient sources like organic manures or wastes and biofertilizers to their maximum potential with proper technology to meet the problems associated with chemical fertilizers for improving the soil fertility while obtaining desirable produce. However, information regarding organic and inorganic nutrient sources as well as their integrated use in gladiolus cultivation in Nagaland condition is extremely lacking. Thus, there is immense need to generate sufficient information on various parameters.

Keeping in view the above facts an investigation entitled **"Effect of various nutrient sources on the growth, flowering, yield and vase life of *Gladiolus primulinus* cv. Candyman"** was carried out with the following objectives:

1. To study the effect of various nutrient sources on the growth, flowering, yield and vase life of gladiolus.
2. To study the response of various nutrient sources on the soil fertility status and plant nutrition behaviour of gladiolus.
3. To study the benefit cost ratio of various treatments for production of gladiolus.

CHAPTER II
REVIEW OF LITERATURE

REVIEW OF LITERATURE

Gladiolus is a heavy feeder crop as such nutrition is one of the important aspects in increasing the yield and quality of corms and spikes. Variation in soil fertility and plant nutrition is the single most important factor that dictates both yield and quality in addition to influencing soil health. Achieving a balance between crop nutrient requirements and nutrient reserves in the soil is essential for maintaining high flower yield and soil fertility, besides safeguarding environmental concerns. Such an objective becomes further difficult to accomplish due to shrinking *per capita* land availability, more so in the developing world. Nutrient management, especially on integrated basis is an approach that seeks to both increase quality of production and protects the environment for posterity. It relies on nutrient application and conservation, new technologies to increase nutrient availability to plants and the dissemination of knowledge between farmers and researchers (Palm *et al*., 2001). In the past, nutrient management has been driven by the need to maximizing production. But now, nutrient management that is sustainable involves maximizing production, preventing on-site degradation and minimizing off-site involvement of applied nutrients (Tagaliavini & Maragoni, 2002).

Organic amendments such as manures, compost, biosolids and humic substances provide a direct source of carbon for soil microorganisms as well as an indirect source via increased plant growth and plant residue return (Bunemann *et al*., 2006). Organic and integrated production systems offer alternatives to conventional production systems (Curl *et al*., 2002; Peck *et al*., 2005) irrespective of soil and crop type. However, integrated production method is yet to attain the same widespread farmer‟s acceptance as organic production methods. In this chapter, efforts have been made to highlight the results accrued chronologically on the above mentioned important issues relation to gladiolus quality production.

2.1. Organic manures as the source of nutrients

Manures applied to soil improve its quality by altering the chemical and physical properties, increase organic matter content, water holding capacity, overall diversity of microbes, provide macro- and micronutrients essential for plant growth and suppress diseases which indirectly contributes to plant growth enhancement (Scheurell & Mahaffe, 2004; Heather *et al*., 2006). Certain microorganisms present in compost and compost extracts such as *Trichoderma*, *Rhizobacteria* and fluorescent *Pseudomonas* are known to stimulate plant growth (Sylvia, 2005). These microbes benefit plants through different mechanisms of action including the production of secondary metabolites such as antibiotics and hormone-like substances, the production of siderospores, antagonistic to soil-borne root pathogens, phosphate solubilization and nitrogen fixation.

Swine, cattle, and poultry manures are valuable resources as fertilizers and soil amendments. However, several studies have documented that manure and inorganic fertilizer applications are significant sources of excessive soil nitrogen (N) and phosphorus (P), resulting in increased leaching of nitrate-N (NO_3-N) and runoff losses of P if not properly managed. Qian and Schoenau (2000) also found that manure applications significantly increased N and P supply rates in soil not otherwise fertilized. Hassandokht and Kashi (2000) studied the effects of farmyard manure and nitrogen application on the quantity and quality of potato crop. Potatoes cv. Aula and Moren were given 0, 20 or 30 t FYM ha^{-1} and 120, 160 or 200 kg N ha^{-1} as urea. Tuber yield increased with increasing FYM rate (17.76, 22.66 and 25.66 t ha^{-1}, respectively), while yield from the N rates as listed was 17.79, 24.99 and 23.00 t ha^{-1}.

Asrey *et al.* (2002) studied the influence of organic manures and flower preservatives on postharvest vase life of gladiolus cut flower. The soil application of cotton cake followed by treatment of spikes with 150 ppm 8-hydroxyquinoline resulted in the longest vase life (13.41 days) over the control (8.56 days). Silver nitrate at 90 ppm also enhanced the vase life of cut flowers harvested from plots treated with cotton cake, vermicompost and farmyard manure. The NPK fertilizers were less effective than the organic amendments. Castro *et al.* (2002) studied the effect of organic fertilization in the culture of the gladiolus. The treatments consisted of (i) standard chemical fertilizer, (ii) poultry manure at 10 t ha^{-1}, (iii) hog manure at 10 t ha^{-1}, (iv) bovine manure at 10 t ha^{-1}, and (v) urban waste compost at 10 t ha^{-1}. All organic fertilizers provided satisfactory results and can, therefore, be used as substitutes to chemical fertilizers, with the urban waste compost providing the highest economic efficiency.

Meng *et al*. (2005) also determined that manure added to a soil did not result in greater N_2O emissions than a treatment with an N-containing fertilizer, but manure conferred greater benefits for soil fertility and the environment. Recent studies tend to support the assertion that manures are more environmentally sustainable than inorganic fertilizers (Sharpley *et al*., 2001; Tabbara, 2003; Loecke *et al*., 2004). John *et al.* (2007) studied the response of organic manure and inorganic fertilizer on tulip. The result revealed that the maximum value in terms of plant height, stem thickness, wrapper leave area bulb number/m^2 and their weight were recorded with highest level of 60 t ha^{-1} organic manure tested in the study. Gupta *et al*. (2008) studied the effect of different level of Vermicompost, NPK and FYM on performance of gladiolus. Among the three treatment *i.e.* (T_1) Vermicompost (125 g/m^2), (T_2) NPK (75 g/m^2) and (T_3) FYM (2.5 kg/m^2), (T_3) FYM (2.5 kg/m^2) treatment was recorded with best result of plant growth, flowering and corm yield parameters and the same was considered to be the treatment for growing a successful crop.

Nayak *et al*. (2009) conducted a six year field study to investigate the effects of swine manure application on P accumulation in the soil profile and found that nutrients from inorganic fertilizer are more susceptible to leaching to tile drains than nutrients from manure; however, P from manure was determined to increase in the surface soil by two to six times higher than the agronomic.

A variety of pot gerbera seedlings derived from *in vitro* culture was grown in seven different media; six seedlings were fertilized with aged cow manure and /or pig manure, while one medium contained no organic fertilizer. Beginning one week after transplanting, the plants grown in media with farmyard manure were treated with either organic fertilizer, in the form of pig manure extract or with chemical fertilizer. The plants on the medium without farmyard manure were treated with only chemical fertilizer. Plant growth was recorded at two weeks interval from 4-20 weeks after transplanting. The average number of leaves, plant height, canopy width and flower number per pot varied significantly by treatment. All treatments with chemical fertilizer showed the best performance with maximum values in leaf and flower number. Meanwhile some media which were treated with pig manure extract also performed well. The results from this research revealed a potential for growing pot gerbera using organic fertilizers alone like pig manure (Suwaree *et al*., 2009)

Yassen and Khalid (2009) studied the influence of organic manures on yield and mineral content of onion. All organic fertilizer treatment *i.e.* mixture of FYM and chicken manure, overcame the control treatment (recommended NPK) and improved the vegetative growth characters, essential oils, and NPK content. Gladiolus responds well to balanced nutrition for maximum flower production and better growth. Application of VAM and *Azospirillum* in gladiolus may be introduced in order to secure better quality traits and increasing shelf life of flower. Kumar *et al*. (2012) reported that application of bio-fertilizers in combination was proved to enhance the vase life (10.02 days) of gladiolus spike with application of VAM along with vermicompost.

2.2. Inorganic fertilizers as source of nutrients

Nitrogen is considered to be most crucial among all the fertilizers because it is a constituent of protein and nucleic acid, which is helpful in plant growth (Haque & Jakhro, 2001). Kumar and Chattopadhyay (2001) observed that the *G. grandiflorus* cv. Tropic Sea supplied with different levels of N (40, 50 and 60 g/m^2) at 2 splits (3 and 6 leaf stages) as side dressing, P_2O_5 (10, 20 and 30 g/m^2) and K_2O at 20 g/m^2, in a field experiment in West Bengal, India, during 1990-93. The fertilizer combination of N at 50 g/m^2, P at 10 g/m^2 and K at 20 g/m^2 resulted in the highest spike weight, numbers of flowers $spike^{-1}$, flower diameter, number of open flowers at a time, size and weight of corms, and number of corms.

Hatibarua *et al.* (2002) studied the effect of nitrogen doses (5, 10, 20, 30 and 40 g/m^2) on post harvest life of cut spikes of gladiolus cv. Dhanvantari. In general, increasing N levels markedly improved the characters studied. Nitrogen at 20 to 40 g/m^2 produced bigger diameter of fully open third florets, more life number of florets $spike^{-1}$, and higher effective useful life and vase life of spikes. Singh *et al.* (2002) determined the effects of N (0, 25, 50 and 75 g/m^2), P (0, 20 and 30 g/m^2) and K (0 and 20 g/m^2) on the N, P and K content of the leaves of gladiolus (*G. grandiflorus*) cv. Sylvia in a field experiment conducted in Hisar, Haryana, India. N, P and K content in the leaves of gladiolus increased with increasing rates of N, P and K fertilizers. P application increased the N status in the leaves of the plant. N and K application resulted in the increase in leaf P content although the increase was not significant. Leaf K content increased significantly with the application of N and K fertilizers. The effects of P on K content of the leaves were not significant.

Sehrawat *et al.* (2003) conducted an investigation to find out the optimum N, P and K rates for the cultivation of gladiolus cv. Happy End in Haryana, India, during 1997-98. Four N rates (0, 20, 40, 60 g/m^2) three P rates (0, 15 and 30 g/m^2) and/or two K rates (0 and 10 g/m^2) were given. The average leaf number per plant and plant height were highest with 60 g N, 30 g P and 15 g K/m^2. The corm production, duration of flowering, spike and rachis length and number of florets were maximum with the application of 40 g N, 15 g P and 15 g K/m^2.

Khan and Ahmad (2004) studied the effects of various levels of NPK, applied after 30 and 45 days of planting, on plant growth and flowering characteristics of *Gladiolus hortulanus* cv. Wind Song, in pot experiments as a means of achieving better management, production and ascertaining NPK utilization. Plant height (cm), number of leaves, leaf length (cm) and spike length (cm) was maximum with 10:10:5 g NPK pot^{-1} whereas spike emergence, opening of first and last floret, corm diameter and corm weight was maximum with 5:5:5 g NPK pot^{-1}. The number of florets per spike was the maximum with 10:5:5 g NPK pot^{-1}. High N application rate combined with moderate P and K rates enhanced vegetative growth characteristics while moderate rates of NPK exhibited more pronounced effect on floral characteristics and corm development of gladiolus. Selvaraj (2004) conducted an experiment under poly house conditions in Ooty, Tamil Nadu, India to evaluate the effect of different NPK levels (50:50:50, 50:50:100, 50:100:50: 50:100:100, 100:50:50, 100:50:100, 100:100:50 and 100:100:100 kg ha^{-1}) on the vegetative and flowering characteristics of gladiolus cv. Eurovision. NPK at 100:100:100 kg ha^{-1} recorded the highest values for plant height (106.3 cm), number of florets $spike^{-1}$ (13) and spike length (58.4 cm). The untreated control recorded the lowest values for these parameters.

Baboo *et al.* (2006) reported that in gladiolus, the highest number of florets $spike^{-1}$ (15.7), spike length (58.8 cm) and rachis length (44.7 cm) were obtained with 250 kg N ha^{-1}. On the other hand, 300 kg N ha^{-1} gave the highest number of corms (2.2), corm diameter (6.3 cm), corm weight (42.1 g), cormel weight (5.0 g) and number of cormels (19.6). P at 125 kg ha^{-1} gave the maximum number of days to flowering (114.7), number of florets $spike^{-1}$ (15.9), spike length (59.7 cm) and rachis length (45.5 cm).

Ocampo *et al*. (2012) noticed that the gladiolus supplied with 80-80-80 kg ha^{-1} NPK showed greater height; stem diameter, leaf area, dry matter and quality parameters such as length of inflorescence, number and size flowers $plant^{-1}$. N had the greatest influence on this response. The higher net income was with 80-80-40 kg ha^{-1} and the lowest with 0-80-40 of N, P and K. These results indicate that in warm weather NPK fertilization can improve the income of gladiolus producers. Khan *et al*. (2012) study conducted at the centre of Bangladesh Agricultural Research Institute (BARI) during the period from November 2006 to May 2008 to determine the optimum rate of N and K for better growth and yield of corm and cormel of gladiolus. The treatment combination N_{150} K_{200} kg ha^{-1} produced the longest plant (42.1 cm), the broadest leaf (1.93 cm), the maximum percentage of spikes (88.1%), and corm (97.6%), the heaviest and the largest corm (19.5 g and 4.11 cm, respectively), cent percent flowering sized corm, and the highest corm number and cormel yield (1,20,000 and 1.66 t ha^{-1}, respectively). The corm produced from this treatment combination also showed better performances in the next year in respect of plant emergence (100%), florets $spike^{-1}$ (13.1), spike and rachis length (82.2 cm and 45.4 cm, respectively), flower stick weight (57.1 g) and percentage of flower sticks (113%).

2.2. Response of Biofertilizers

Selosse *et al*. (2004) reported that the inoculation with fixative bacteria increased the absorption potential of plant and dry material in *Epipactis* plants. Increase in fresh weight of leaves due to the inoculation might be attributed to biological fixation of nitrogen and solubilization of phosphorus in root portion of plants resulting in absorption of more nutrients and its utilization. Moreover, *Azospirillum* had a role in nitrogen fixation and also involved in the production of indole-3-acetic acid (IAA), gibberellic acid (GA) and cytokinin like substances which enhanced the growth of plants. Phosphorous solubilizing bacteria helped in solubilization and mobilization of phosphorus in soil. The correlation value (0.96) showed a strong positive correlation between chlorophyll contents in leaves and fresh weight of leaves.

Dubey and Mishra (2005) observed that the combined inoculation of gladiolus corms with *Azotobacter* + PSB was found best for corn weight, corms plant^{-1}, cormel plant^{-1}, cormel weight and increased propagation coefficient. Yadav *et al.* (2005) reported that the application of *Azotobacter* and PSB significantly increase the spike length but the magnitude of increase was found lower in comparison to nitrogen. Among different biofertilizers, *Azotobacter* was found more effective in improving the quality of spikes.

Dubey *et al.* (2010) revealed that the combined inoculation of gladiolus corms with AZT+PSB was found best for days to flowering (114.59 days), first floret diameter (9.08 cm), florets remaining open (6.46) and days to last floret opening (128.90 days) among all the bio-fertilizer(s) treatments. Kumar and Haripriya (2010) concluded that the increase in fresh weight of leaves might be attributed to the nutrient accumulation in the leaves. Some bacteria in the inoculated treatments not only fix the nitrogen, but also solubilized the phosphorus in the soil, activated the plant growth hormones, natural enzymes, antibiotics and different compounds such as volatile gases, that enhanced the vegetative growth.

Ahmad *et al.* (2013) assess the effect of different bio-fertilizer on growth and flower quality characteristics of gladiolus *(Gladiolus grandiflorus L.)*. The present results have shown that all the vegetative and reproductive growth accomplished successfully by application of biofertilizers. However, the treatment containing *Azospirillum* (T_4) gained highest values in terms of plant height, florets spike^{-1}, spike length, florets fresh weight and earlier sprouting than rest of the treatments. The role of biofertilizers in cormels production and nutrient uptake, T_4 had also superiority with more cormels plant^{-1} and played leading role in nutrient (NPK) absorption than the control one. So, in this experiment biofertilizer has been identified as an alternative to chemical fertilizer in order to increase soil fertility and crop production in sustainable farming.

Sonmez *et al.* (2013) observed that the highest mean contents of nitrogen (1.97%), iron (160 ppm) and manganese (128 ppm) in leaves were obtained in chicken manure application, the highest mean contents of potassium (2.01%), calcium (1.80%) and magnesium (0.25 ppm) were determined in waste mushroom compost application. The highest mean contents of phosphorus (0.30%), zinc (25.3 ppm) and copper (9.29 ppm) in leaves were found with peat, control and farmyard manure applications, respectively. The highest mean contents of phosphorus (0.83%), potassium (1.47%), calcium (0.57%), manganese (73 ppm) and zinc (67.3 ppm) in corms were obtained in farmyard manure applications. The highest mean contents of iron (17.6 ppm) and magnesium (0.20%) in corms were obtained in peat and waste mushroom compost applications, respectively. Application of organic fertilizers increased macro and micro nutrient contents in leaves and corms of hybrid *Gladiolus sp.*

2.3. Combination effect of organic, inorganic and biofertilizers

Generally chemical fertilizers are applied for quick result to get more and more production but their unscrupulous use not only rob the soil, its texture and structure and nutrients status but also creates threat to soil health. Integrated Nutrients Management (INM) including use of organic manure and biofertilizers along with appropriate dosage of fertilizer is cost effective method to achieve more yield and better quality crop (Janakiram *et al.*, 2013).

Gangadharan and Gopinath (2000) studied the effect of organic and inorganic fertilizers on gladiolus. The combination 10 t vermicompost ha^{-1}+80% of the recommended dose of NPK *i.e.* 100: 60: 60 kg ha^{-1} resulted in the maximum number of cormels $plant^{-1}$ and $hectare^{-1}$ (3.07 and 6, 82, 000, respectively), highest benefit: cost ratio (1.56: 1), gross (₹ 13, 16, 400) and net (₹ 8, 01, 779.03) income. Highest numbers of spikes $plot^{-1}$ and $hectare^{-1}$ were obtained with treatment combinations of 5 t sewage sludge ha^{-1} + 80% NPK and 10 t vermicompost ha^{-1}+60% NPK. The latter combination also resulted in the highest number of corms $plant^{-1}$ (2.67) and $hectare^{-1}$ (2, 46, 666). Pushpalatha *et al*. (2000) revealed that the cost of cultivating gladiolus $acre^{-1}$ amounted to ₹ 2, 87, 974 and ₹ 2, 71, 816 in the urban and rural districts of Bangalore (Karnataka, India), respectively. The major cost components were the planting material and labour in weeding revealing the high capital and labour intensive nature of the crop. The high rate of return of 1.46 to 1.45 $₹^{-1}$ of investment showed the economic feasibility of gladiolus cultivation in the two districts. Unavailability of labour and storage facilities and exploitation by middlemen were the major constraints faced by the growers in the production and marketing of gladiolus.

Dahiya *et al*. (2001) mentioned that increments in nitrogen level increased growth of tuberose and the treatments comprising *Azospirillum* as inoculant have a significant effect on the plant height. This increase in plant height was due to the presence of readily available form of nitrogen. *Azospirillum* improved plant macro and micro nutrient absorption. Similarly, it was observed that seeds inoculated with *Azospirillum* improved growth factors such as plant height. Shankar and Dubey (2005) studied the response of NPK and FYM alone and in combination on gladiolus. The leaf breadth, weight of cormels $plots^{-1}$, dry weight of plant and yields of cormels was found maximum in the treatment NPK@ 40:20:20 g/m^2 + FYM @ 5 kg/m^2; N in two splits (at planting and 60 DAP). Zaghloul and Moghazy (2001) studied the response of some gladiolus cultivars to organic manure and NPK fertilizers on gladiolus. The best results were obtained with the combined application of chicken manure at 60 m^3 $feddan^{-1}$ + NPK at 300:300:150 kg $feddan^{-1}$ [1 feddan=0.42 ha]. Maeder *et al*. (2002) reported enhanced soil fertility and higher biodiversity in organic than conventional plots and concluded this may render organic systems less dependent on external inputs. In general, the bacterial population was higher than the fungal population at both the surface as well as the sub- surface soil depths.

Sasani *et al*. (2003) studied the effect of levels of inorganic fertilizers with and without organic manures on yield of potato in North Gujarat. The treatment where the potato crop received 25% more dose of NPK than the recommended dose (*i.e.* 220:110:220 kg NPK ha^{-1}) along with FYM at 25 t ha^{-1} recorded the maximum tuber yield of 533.3 q ha^{-1} and 388.5 q ha^{-1} during 2001-02 and 2002-03, respectively. This treatment also recorded the highest net returns of ₹ 69 990 ha^{-1} over the same level of inorganic fertilizers without FYM (₹ 55 570 ha^{-1}). Application of FYM increased the potato yield at all levels of applied fertilizers.

Chettri and Thapa (2004) studied the effect of integrated nutrient management with farm yard manure on potato (*Solanum tuberosum*). Maximum dry matter production, tuber bulking rate and tuber yield (270.8 q ha^{-1}) of potato were obtained with 100% of the recommended dose of N, P and K along with 10 t FYM ha^{-1}. Application of 75% of the recommended dose of N, P and K in conjunction with 10 t FYM ha^{-1} significantly increased the dry matter production, tuber bulking rate and tuber yield compared to N, P and K applied singly, even at higher dose.

Ahmed *et al.* (2004) studied the effect of urea, DAP and FYM on growth and flowering of Dahlia (*Dahlia variabilis*). The treatments comprised a control (T_0), 20 g urea/m^2 (T_1), 40 g (DAP)/m^2 (T_2), 4 kg FYM/m^2 (T_3), T_1+T_2 (T_4), and T_1+T_2+T_3 (T_5). The greatest plant height, highest number of branches $plant^{-1}$, highest number of flowers and largest flower size was recorded in T_5. Patil *et al*. (2004) studied the effect of integrated nutrient management on the growth and yield of onion (cv. N-2-4-1) seed. Significantly higher values of all growth attribute parameters were recorded with the treatment (T_2) fertilizer combination of 120:60:60 N: P_2O_5 : K_2O kg ha^{-1}+20 t FYM ha^{-1} over all the other treatments, closely followed by NPK application at RDF as per soil test.

Shankar and Dubey (2005) conducted an investigation in Horticultural nursery, IGAU, Raipur, Madhya Pradesh, India, during winter season of 2000-2001. The experiment was laid out on a randomized block design with five treatments and five replications. Results indicated that the growth characteristics such as plant height, number of leaves $plant^{-1}$, leaf area, fresh weight of plant, weight of corm, diameter of corm and yield of corms were influenced by the treatment 400 kg N, 200 kg P_2O_5, and 200 kg K_2O ha^{-1} with N in three splits, which was found to be superior over all other treatments. The leaf width, weight of cormels $plant^{-1}$, dry weight of plant and yield of cormels were found maximum in 400 kg N, 200 kg P_2O_5 and 200 kg K_2O ha^{-1} + 50 t farmyard manure ha^{-1} with N in two splits and it was found to be superior for these traits over other treatments.

Treatments with bacterial inoculation provided balance nutrients for gladiolus plants and efficient uptake of nitrogen and phosphorus through roots is due to interaction between nitrogen fixing and phosphate solubilizing bacteria. Therefore inoculation with the bio-fertilizers *Azotobacter*, phosphate solubilizing bacteria, VAmycorrhiza and farmyard manure application enhanced vegetative and floral qualities of gladiolus compared with control treatment. Application of 120:65:62.5kg ha^{-1} NPK + phosphobacteria + *Azospirillum* showed better results with respect to days to sprouting, fresh weight and dry weight $plant^{-1}$. This was due to better availability of nutrients for the production of the bulbs (Srivastava & Govil, 2005; Singh *et al*., 2006). Godse *et al.* (2006) evaluated the effect of organic manure and biofertilizers with reduced doze of inorganic fertilizer on gladiolus. The results revealed that plants receiving vermicompost 8 t ha^{-1} +Azotobacter and PSB @ 25 kg ha^{-1} each+80% RDF significantly increased growth, yield and quality attributes of gladiolus *viz.*, plant height, number of leaves, number of spikes ha^{-1}, number of corms $plant^{-1}$, weight of corms ha^{-1}, length of spike and number of florets $spike^{-1}$ when compared with RDF and other treatments.

Dalve *et al.* (2009) reported that the growth parameters like plant height and number of leaves, flowering parameters like days required for emergence of spikes, days required for first pair of florets, days required for 50% flowering, yield contributing characters like number of florets $spike^{-1}$, number of spike $plant^{-1}$, corms and cormels $plant^{-1}$ and $hectare^{-1}$ were positively influenced by the application of both the biofertilizers in combination with nitrogen and it was maximum under 75% N + 100% PK+ *Azotobacter* + *Azospirillum* and at par with the treatment 100% NPK+ *Azotobacter* + *Azospirillum*. Thus, there was 25% saving of nitrogenous a fertilizer which was replaced by the biofertilizers. Dongardive *et al.* (2009) studied the influence of organic manure and biofertilizers on yield and yield contributing parameters of corms and cormels in gladiolus cv. White Prosperity at Satpuda Botanical Garden, College of Agriculture, Nagpur (M.S.) during the year 2005-2006. The data indicated that, the yield in terms of number of corms and weight of corms and cormels $plant^{-1}$, weight of corm and cormels $hectare^{-1}$ and diameter of corms were found to be highly influenced by the treatment where RDF (500:200:200 NPK kg ha^{-1}) applied. The treatment RDF (500:200:200 NPK kg ha^{-1}) produced highest corm yield of 33.70 q ha^{-1} with 16.23 g $plant^{-1}$ yield of cormels. The treatment of vermicompost 8 t ha^{-1}+ (*Azotobacter* 5 kg ha^{-1}) + PSB 5 kg ha^{-1} also showed significant results were producing corm yield of 32.80 q ha^{-1} and cormels yield weighing 15.36 g $plant^{-1}$. Thus, significantly the maximum corm and cormels yield were obtained in the treatment where RDF

(500:200:200 NPK kg ha^{-1}) was applied and in the treatment of vermicompost 8 t ha^{-1} respectively as compared to other treatments.

The application of *Azospirillum* + 75% N+ 200 kg P_2O_5 + 200 kg K_2O was found to be superior over other combination of treatment in respect of significantly highest vase life of spike during both the years under study. Longest vase life might be attributed to the better over all food and nutrients of spike under these treatments.VAM improve vase life as reported by Kathiresan and Venkatesha (2002) in gladiolus while similar findings were observed by Kumar *et al*. (2003) in China aster, Bhatia *et al*. (2004) in carnation and Mittal *et al*. (2010) in African marigold. Basil and Singh (2010) conducted an experiment to find out the effect of bio-fertilizers and vermicompost in tuberose. Treatments comprised two bio-fertilizers (*Azotobacter* and *Azospirillum*), two levels of vermicompost (10 t ha^{-1} and 20 t ha^{-1}), four combinations of bio-fertilizers and vermicompost and a control. Among the different treatments, the treatments of *Azospirillum*+ vermicompost (10 t ha^{-1}) recorded maximum value for the parameters namely number of leaves on 90 days after planting, length of spike, length of rachis , number of florets $spike^{-1}$, number of spike $plant^{-1}$ and yield of spike ha^{-1}.

Nakhro and Dkhar (2010) reported an increase in microbial counts in response to fertilization. Soil microbial population increased in organically amended plots compared to inorganic and control plots which may be due to the addition of organic amendments that might have large impact on the size and activity of microbial population. Long term stubble retention, reduced tillage systems and manuring have been shown to increase microbial biomass carbon and microbial activity in soil.

Rajhansa (2010) investigated the effect of integrated nitrogen management on growth, yield and flower quality of gladiolus cv. Candyman. The result indicated that the T_3 [50% N (Urea) +50% N (FYM) +P and K @ 20 g/m^2 each] performed better in growth character namely, days to sprout, numbers of sprouts, number of leaves plant^{-1}, girth of plant base, width of leaf, height of the plant up to tip of leaf, days to spike emergence, number of opened fresh floret at a time, number of florets spike^{-1}, days to harvesting of spike, vase life of cut spikes, diameter of corm, weight corm^{-1}, total weights and number of corms plot^{-1}, weight of cormels plot^{-1} and yield of corms and cormels.

Swaroop and Janakiram (2010) carried out an experiment at the Research Farm of Floriculture, Division of Floriculture and Landscaping, IARI, New Delhi in gladiolus. They recorded maximum plant height, number of floret spike^{-1}, yield of corm and number of cormels plant^{-1} with the application of 75% RDF+ 1 kg/m^2 FYM+ 300 g/m^2 vermicompost, components like length of leaf, length of spike, length of rachis, vase life and yield of spike were influenced by the application of 75% RDF+ 1 kg/m^2 FYM+ 300 g/m^2 vermicompost+ 2 g plant^{-1} each of *Azospirillum* and PSB.

Rai and Yadav (2011) in their experiment on influence of inorganic and organic nutrient sources on soil enzyme activities concluded that all the integrated nutrients of RDF + 10 kg N ha^{-1} through each of FYM, carpet waste, press-mud, digested sludge and poultry manure showed greater urease activity than other treatments at different days of incubation. Highest and significant urease (300 μg urea hydrolyzed g^{-1} h^{-1}) activity was recorded at 30 days after incubation in the treatment receiving full doses of RDF + 85 kg carpet waste ha^{-1} followed by treatments of RDF + 2 t FYM and RDF + 1 t press-mud significantly superior over absolute control. Similarly maximum build-up of dehydrogenase (74.5 μg TPF g^{-1} day^{-1}) and alkaline phosphatase (90.7 μg pNP produced g^{-1} h^{-1}) was found in the soil treated with FYM and with press-mud at 30 and 120 days after incubation respectively. Kabir *et al*., 2011 reported that poultry litter performed the best in respect of flower characters and flower yield followed by cow dung and vermicompost in tuberose and treatment T_1 (100% RDF) and T_{10} (control) recorded less spike yield.

Jha *et al*. (2012) conducted an experiment on gladiolus variety 'Candyman' at Horticulture Farm, Department of Horticulture, IGKV Raipur (C.G.) during the rabi season of 2010-11 to study the effect of FYM and vermicompost in combination with various doses of inorganic fertilizer. Under the combinations of various levels of vermicompost, FYM and organic fertilizer, the treatment receiving 75% RDF+FYM 10 t ha^{-1} recorded better in days to sprouting, number of sprouts, number of leaves $plant^{-1}$, girth of plant base, width of leaf, height of the plant, days to spike emergence, diameter of corm, weight $corm^{-1}$, total corm weights $plot^{-1}$ and number of corms $plant^{-1}$. However, length of the spike, number of florets $spikes^{-1}$, vase life of cut spikes were found maximum with the application of 75% RDF+Vermicompost 3 t ha^{-1}. Whereas, treatments with FYM 10 t ha^{-1} and Vermicompost only 3.0 t ha^{-1} showed significantly minimum leaves $plant^{-1}$, diameter of corm, weight $corm^{-1}$, total corms weight $plot^{-1}$ and number of corms $plant^{-1}$.

Chaudhary *et al*. (2012) conducted an experiment on effect of INM on gladiolus and reported that the maximum microbial biomass (885 μg g^{-1}) and dehydrogenase activity (7.97 μg TPF g^{-1} h^{-1}) was found with the application of 75% RDF + 10 t FYM and vermicompost + 2 g $plant^{-1}$ each of *Azospirillum* and PSB followed by 50% RDF + 10 t each of FYM and vermicompost + 2 g $plant^{-1}$ each of *Azospirillum* and PSB as compared to control where it was only (219 μg g^{-1} and 2.29 μg TPF g^{-1} h^{-1} of microbial biomass and dehydrogenase activity respectively).

Keditsu (2012) conducted a field experiment on response of gerbera to inorganic fertilization versus organic manuring showed that as much as 50% of RDF, if substituted with organic manures (25% RDF with Cocopit and 25% RDF with Pig manure) out of 100% RDF, produced the best response on floral characteristics, flower yield in addition to leaf nutrient composition and available pool of nutrients in soil. These results were far superior to exclusive use of inorganic fertilizers. Study, hence, advocated the possibility of dual manuring having bipolar nutrient release pattern in order to extend nutrient dynamics in soil.

An investigation was carried out by Chaudhary *et al*. (2013) to study the combined effect of integrated nutrient management on vegetative growth and flowering characters of gladiolus cv. Snow Princess with the application of *Azospirillum*, PSB, vermicompost and FYM with and without 100, 75 and 50% recommended dose of NPK. The result showed that plant height was maximum with application of 75% RDF + 20 t ha^{-1} FYM, while number of florets remaining open at a time was recorded maximum under 100% RDF + 20 t ha^{-1} FYM ha^{-1}. Days to first floret opening and number of days for 50% plant to sprout were earliest under treatments 75% RDF + FYM 10 t ha^{-1} + vermicompost 10 t ha^{-1} and vermicompost 20 t ha^{-1} respectively. The application of FYM 20 t ha^{-1} produced maximum number of leaves. The components like diameter of third florets, length of rachis, fresh weight of plant and vase life of spike in plain water were maximum with 50% RDF (60:40:40 kg ha^{-1} NPK) + 10 t ha^{-1} each of FYM and vermicompost; whereas days to first floret opening was minimum with 75% RDF (90:60:60 kg/ha NPK) + 10 t ha^{-1} each of FYM and vermicompost. Application of integrated nutrients, *i.e.* 50% RDF (60:40:40 kg ha^{-1} NPK) + 10 t ha^{-1} each of FYM and vermicompost + 2g $plant^{-1}$ each of *Azospirillum* and PSB produced significantly maximum length of spike, number of florets $spike^{-1}$, duration of flowering and yield of corms. The dry weight of plant was found maximum with the application of with 75% RDF (90:60:60 kg ha^{-1} NPK) + 10 t ha^{-1} each of FYM and vermicompost + 2 g $plant^{-1}$ each of *Azospirillum* and PSB.

Gladiolus corms were inoculated with *Azospirillum* and VAM alone and in combination of nitrogen, phosphorus and potash including application of 10 t

FYM ha^{-1} in each treatment. The effect of INM was investigated on days taken for initiation of spike and opening of first floret, number and size of spike and spike floret and flowering duration during both years *i.e.* 2011-12 and 2012-13. Earliest spike initiations, first opening of floret, highest length and diameter of spike and highest number of spike $plant^{-1}$ were observed with T_8 (*Azospirillum* + 75% N + 200 kg P_2O_5 + 200 kg K_2O) during 2011-12 and 2012-13, respectively. The treatment combination T_8 showed highest number of floret $spike^{-1}$ (17.26 and 16.53 in 2011-12 and 2012-13, respectively). The duration of flowering was found to be enhanced maximum with the treatment T_8 (*Azospirillum* + 75% N + 200 kg P_2O_5 + 200 kg K_2O) being 15.16 days in 2011-12 and 15.30 days in 2012-13, respectively (Singh *et al*., 2014).

Zhen *et al*. (2014) investigated the dynamic impacts on soil microbial count, biomass, basal respiration, community structure diversity, and enzyme activity using six different treatments [no fertilizer (CK), N fertilizer (N), N fertilizer + bacterial fertilizer (NB), manure compost (M), manure compost + bacterial fertilizer (MB), and bacterial fertilizer (B)] in the plowed layer (0–20 cm) of potted soil during various crop growth stages in a temperate cropland of eastern China. The Shannon index displayed the result that adding manure compost significantly increased the amount of cultivable microorganisms and microbial biomass, thus enhancing soil respiration and enzyme activities, the highest value was with the MB treatments, whereas N treatment showed the lowest value. However, B and NB treatments minimally increased the amount of cultivable microorganisms and microbial biomass, with no obvious influence on community structure and soil enzymes. These findings indicated that the application of manure compost plus bacterial fertilizers can immediately improve the microbial community structure and diversity of degraded cropland soils.

Basoli *et al*. (2015) investigated on the impact of integrated nutrient management on growth and flowering of gladiolus (*Gladiolus hybrida*) cv.

Novalux at Model Floriculture Center, Govind Ballabh Pant University of Agriculture and Technology, Pantnagar, during 2010-11 and 2011-12. The experiment consisted of 3 replications and 25 treatments consisting of biofertilizers (Azotobacter, PSB and KSB), different levels of inorganic fertilizers and their combinations. Application of 3/4th NPK + Azotobacter + PSB + KSB was found most effective in enhancing the plant height (112.84 cm), bud emergence (7.31 days), days taken to spike emergence (87.28 days), size of florets (10.22 cm), length of spikes (109.27 cm), rachis length (52.6 cm), chlorophyll content (70.98 SPAD), photosynthetic rate (17.73 µmol/m^{225}). However, maximum number of leaves and days taken for opening of first floret were obtained when plants were fertilized with 3/4th NPK + Azotobacter + KSB. Treatment 3/4th NPK + PSB + KSB resulted in maximum stomatal conductance of spikes.

Singh *et al*. (2015) investigated the effect of INM on per cent increase in spike length, per cent opening floret spike^{-1}, number of floret opened at specific time, drooping of floret and vase life during both years *i.e*. 2011-12 and 2012-13. The per cent increase in spike length, per cent opening floret spike^{-1}, number of floret opened at specific time were highest at all the stage of observation with T_8 (*Azospirillum* + 75% N+ 200 kg P_2O_5 + 200 kg K_2O) during 2011-12 and 2012-13, respectively. The same treatment combination was found to be superior in respect of reduced drooping of floret and extended vase life (12.50 and 13.00 days in 2011-12 and 2012-13, respectively).

Imchalemla (2016) conducted two experiments on the effect of integrated nutrient management on lilium var. Bridisi. The experiments were carried out in the Experimental Farm, Department of Horticulture, School of Agricultural Sciences and Rural Development, Nagaland University, Medziphema Campus during 2012-13, 2013-14 and 2014-15. The experiments were laid out in Randomized Block Design with 14 treatments and 3 replications. The bulbs were planted at a spacing of 25 × 25 cm in plot size of 1 m^2. The treatments consisted of T_0 (Control), T_1 (AMF), T_2 (NPK 100% *i.e.* 300:250:300 kg NPK ha^{-1}), T_3 (Vermicompost 10 t ha^{-1}), T_4 (FYM 20 t ha^{-1}); T_5 (Poultry manure 10 t ha^{-1}), T_6 (NPK 50%+ AMF 50%), T_7 (NPK 50%+ Vermicompost 50%), T_8 (NPK 50% + FYM 50%), T_9 (NPK 50% + Poultry manure 50 %), T_{10} (AMF 50% + Vermicompost 50%), T_{11} (NPK 50% + AMF 50% + FYM 50%), T_{12} (NPK 50%+ 50% AMF + Poultry manure 50%) and T_{13} (Richspray 19:19:19). The result of the pooled data depicted that treatment combination of 50% RDF + 50% AMF + FYM 10 t ha^{-1} (T_{11}) recorded better performance with regard to plant growth, flowering, yield, vase life, plant nutrient concentration of NPK and soil available NPK. The highest benefit cost ratio was also recorded with the same treatment.

Suseela *et al*. (2016) experimented on tuberose using inorganic fertilizers in combination with different organic nutrient sources (FYM, Neem cake, poultry manure and vermicompost). The number of leaves, leaf area index and total chlorophyll content $plant^{-1}$ at all stages of plant growth are significantly increased by application of recommended dose of fertilizers 50% in combination with poultry manure 50% (T_7), recorded less number of days to 50% flower spike emergence, recorded significantly less number of days for sprouting and 50% sprouting of bulbs. Spike length, number of florets, number of spikes $clump^{-1}$, $plot^{-1}$ and $hectare^{-1}$ were significantly influenced by the application of RDF 50% in combination with poultry manure 50% followed by RDF 50% in combination with poultry manure 25% and neem cake 25%. They concluded that application of 50% RDF along with poultry manure 50% was found promising for good growth and higher spike yield with best quality and that there is ample scope for substitution of inorganic fertilizers with organic manures.

CHAPTER III

MATERIALS & METHODS

MATERIALS AND METHODS

The present investigation entitled "Effect of various nutrient sources on the growth, flowering, yield and vase life of *Gladiolus primulinus* cv. Candyman" was carried out in the Experimental farm of Horticulture, Nagaland University, School of Agricultural Sciences and Rural Development, Medziphema Campus, Nagaland during 2014-2016.

3.1 General

3.1.1 Experimental site

The experimental farm of Horticulture, School of Agriculture Sciences and Rural Development is located at Medziphema. It is situated at an altitude of 304.8 m above the mean sea level and is positioned geographically at 20º 45‟43" N Latitude and 93º 53‟04" E longitudes, at the foot-hills of Nagaland.

3.1.2 Climate

The site of the experimental area enjoys sub-humid tropical climate with high humidity, moderate temperature and medium to high rainfall ranging from 200-250 cm. The temperature ranges from 10-35 °C. The meteorological data recorded from the month of September, 2014 to February, 2015 and September, 2015 to February, 2016 is presented in Fig. 3.1.

3.1.3 Soil

Soil samples were analyzed for pH, organic carbon, available nitrogen, phosphorus and potassium before starting of the experiment and the results obtained are presented in Table 3.1. While the Table 3.2 depicts the nutrient profile of the various source of organic manure used in the experiment.

Table 3.1: Initial soil fertility status of experimental plots

Parameter	Value	Status	Method employed
pH	4.75	Acidic	Digital pH meter (Single electrode meter)
Organic carbon (%)	1.74	High	Walkley and Black Method, (Piper, 1966)
Available N (kg ha^{-1})	240.8	Medium	The Alkaline – potassium permanganate method (Subbiah and Asija, 1956)
Available P (kg ha^{-1})	17.12	Medium	Bray and Kurtz method, 1945
Available K (kg ha^{-1})	219.4	Medium	Flame photometer (Hanway and Heidal,1952)

Table 3.2: Nutrient profiling of different organic manures

Organic manures	Nutrient concentration %		
	N	P	K
FYM	0.5	0.4	0.5
Pig manure	0.6	0.7	0.5
Vermicompost	2.0	1.0	0.7

3.1 Experimental details

3.1.1 Planting materials

Gladiolus primulinus cv. Candyman was used for the experiment. Healthy disease-free corms having diameter of 4-5 cm were procured from a nursery in Kalimpong (West Bengal). The size of corm for the second year of experiment was 3-4 cm in diameter.

3.1.2 Field preparation

The land was ploughed deeply and thoroughly harrowed to a workable tilth. The weeds and stubbles were removed. The individual plots measuring 1.20 m × 1.25 m × 0.20 m were prepared. Layout of the plot is shown in Fig 3.2.

3.1.3 Technical details

Design : RBD

Replication : 3

Treatments : 14

Plot size : 1.20 m × 1.25 m

Spacing : 25 cm × 30 cm

Period of Observation-

First experiment : September 2014 - February 2015

Second experiment : September 2015 February 2016

Treatments:

T_0- Control

T_1- FYM (40 t ha^{-1})

T_2- Pig manure (35 t ha^{-1})

T_3- Vermicompost (10 t ha^{-1})

T_4- NPK 100% RDF (200:200:200 kg NPK ha^{-1})

T_5- Biofertilizers (*Azospirillum* + Phosphotica)

T_6- 50% NPK + 50% FYM

T_7- 50% NPK + 50% Pig manure

T_8- 50% NPK + 50% Vermicompost

T_9- 50% NPK + Biofertilizers

T_{10}- 75% NPK + Biofertilizers

T_{11}- 50% NPK + 25% FYM + Biofertilizers

T_{12}- 50% NPK + 25% Pig manure + Biofertilizers

T_{13}- 50% NPK + 25% Vermicompost + Biofertilizers

3.1.4 Application of manures and fertilizers

The inorganic sources of N, P_2O_5 and K_2O as urea, SSP and MoP were applied, respectively. The required quantities of inorganic fertilizers were worked out and entire amounts of SSP and MoP were applied during the final land preparation while nitrogen was applied in three equal installments at 15, 30 and 45 days after sowing. For treatment consisting organic manures, the required amount was worked out on the basis of available nitrogen content in the organic sources and was applied to the respective plots. Manures were applied by incorporating into the soil 2 weeks prior to planting. Biofertilizers were inoculated to the corms before planting by corm dip method for 30 minutes and dried in the shade prior to planting.

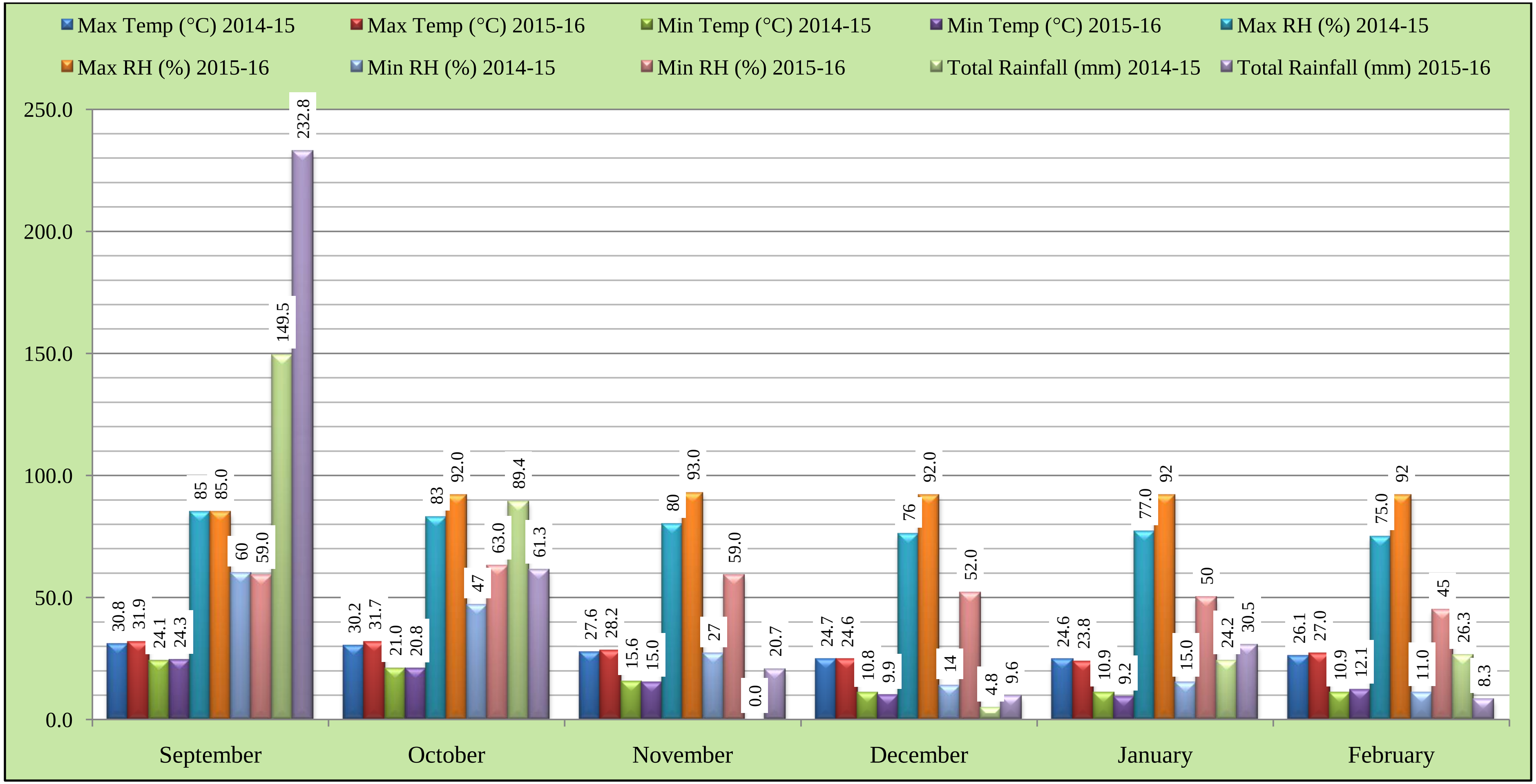


Fig. 3.1: Meteorological data recorded during the period of investigation (September-February, 2014-15 and 2015-16)

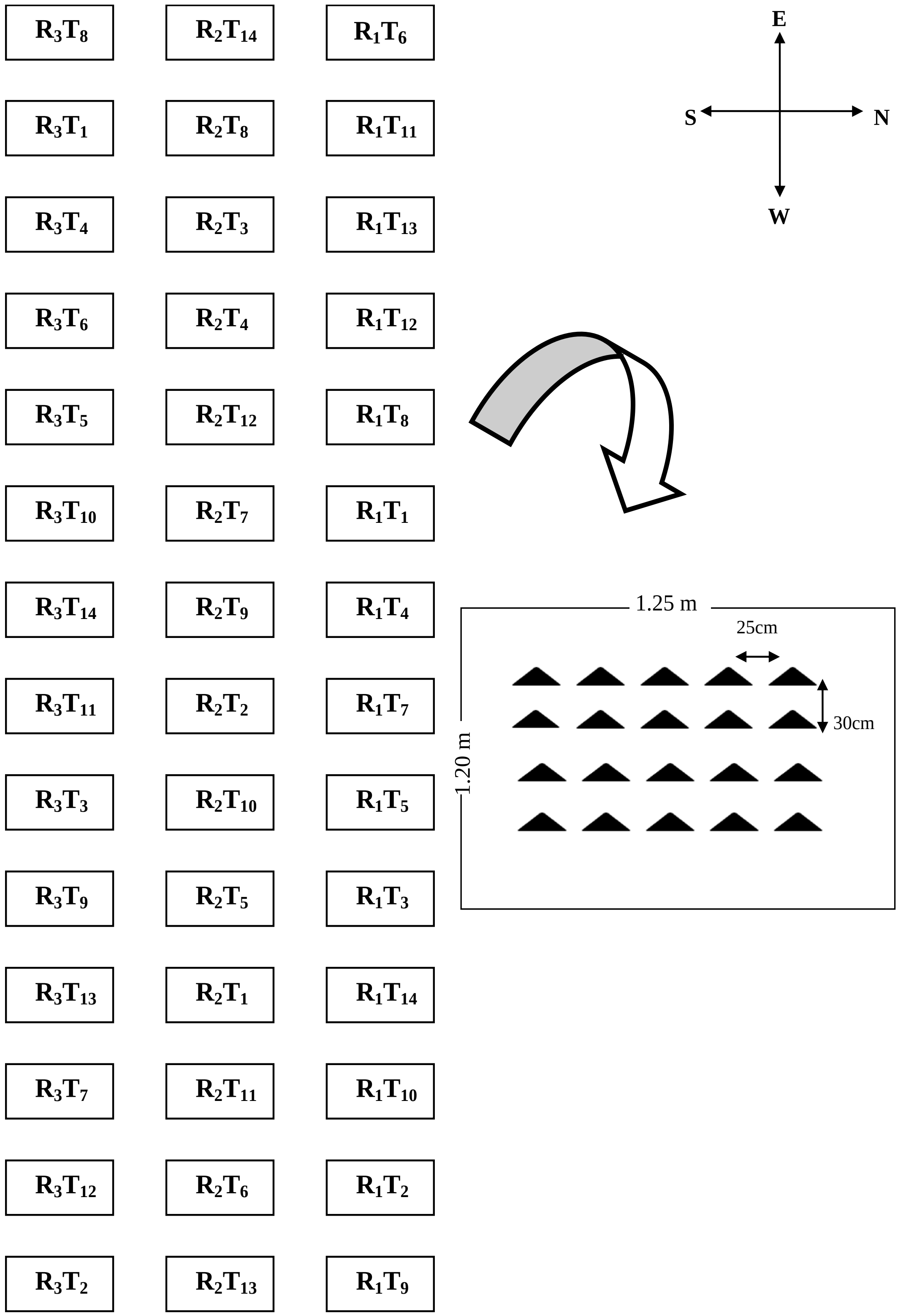


Fig. 3.2: Field layout of the experiment in Randomized Block Design

3.1.1 Planting

The corms were descaled prior to planting and dipped in 0.2% Bavistin solution for 15 minutes and dried under shade. Twenty numbers of corms were planted in each plot at a depth of 5-7 cm on the raised beds by maintaining a spacing of 25 × 30 cm.

3.1.2 Intercultural operations

When the corms started to emerge in the beds it was always kept under careful observation. After sprouting, various intercultural operations, like weeding, top dressing, irrigation was accomplished for better growth and development of gladiolus plants.

3.1.2.1 Irrigation and drainage

Light irrigation was given immediately after sowing, thereafter irrigation was provided with a watering can to the plots once immediately after sprouting of corms on every alternate day in the evening. Stagnant water was effectively drained out at the time of heavy rains.

3.1.2.2 Weeding

Weeding was done to keep the plots free from weeds, easy aeration of soil, which ultimately ensured better growth and development. The newly emerged weeds were uprooted carefully after the complete emergence of gladiolus seedlings whenever it was necessary. Breaking the crust of soil was done when needed.

3.2.6.3 Top dressing

Top-dressing of urea was done by applying on both sides of plant rows and mixed with the soil by hand. Earthing up was done with the help of khurpi immediately after top dressing of nitrogen fertilizer and irrigated.

3.2.7 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.

3.2.8 Harvesting of spikes

Flower spikes were harvested when the lower most mature floret showed signs of opening (bud-break stage). Harvesting was done during the cool morning hours using secateurs.

3.2.9 Lifting of corms and cormels

The maturity of corms is identified by browning of leaves and wilting of plants. The corms and cormels were lifted 60 days after flowering. The corms are lifted with the tools like digging fork, garden spade or khurpi with utmost care so as not to make any mechanical injury to the corms. The infected and injured corms and cormels, stone and pebbles were removed. The corms and cormels were separated and then graded according to the size. The corms are then dried in shade for one week.

3.2.10 Vase life studies

Three flower stalks from each of the plot were selected for vase life studies. They were cut at equal length of 75 cm and kept in conical flask containing a standard solution of 4 % Sucrose and 300 ppm of $Al_2(SO_4)_3$.

3.3 Sampling and observations recorded

Five plants were randomly selected from each plot and were tagged for the collection of field data for vegetative, floral, cormal and yield attributes while three random floral spikes from each plot were selected for post harvest studies.

3.3.1 Vegetative parameters

3.3.1.1 Days to sprouting

It was counted from the day of sowing till the day the corms sprouted and the mean values were expressed in days.

3.3.1.2 Leaves plant^{-1}

The leaves plant^{-1} was counted from the sample plants at the time of spike emergence and mean values were worked out.

3.3.1.3 Plant height

Plant height was measured from sample plants in centimeter from the attachment of the ground level up to the tip of the longest leaf at the time of spike emergence and the mean value was calculated.

3.3.1.4 Leaf area

The longest leaves of the sample plants were cut into smaller parts and the surface area was calculated in Leaf Area Meter and expressed in square centimetre.

3.3.2 Flowering attributes

3.3.2.1 Days to spike emergence

Days to spike initiation were recorded in five randomly selected plants of each plot from the date of sowing to spike initiation and the mean values were expressed in days.

3.3.2.2 Days to full opening of first floret

Days to full opening of first floret were recorded from the date of sowing to first floret opening and the mean values were expressed in days.

3.3.2.3 Florets spike^{-1}

Florets spike^{-1} was counted from the sample plants and their mean was recorded.

3.3.2.4 Days to 5th floret opening

It was recorded from the day of 1st floret opening till the opening of the 5th floret of the sample plants and their mean was recorded and expressed in days.

3.3.2.5 Spike length

Spike length was measured from the 4th leaf to the tip of the spike with measuring scale when the 5th floret opened and expressed in centimeter.

3.3.2.6 Rachis length

Rachis length refers to the length from the axils of 1st floret up to the tip of the inflorescence and it was expressed in centimeter.

3.3.2.7 Floret diameter

The diameters of 1st, 3rd and 5th florets were measured by using linear scale when the florets fully opened and the average was recorded and expressed in centimeter.

3.3.2.8 Durability of spikes

The day from the full bloom of the 1st floret till the day 70% of the florets wilted was recorded and expressed in days.

3.3.3 Yield parameters

3.3.3.1 Flower production

3.3.3.1.1 Spikes plant^{-1}

Spikes plant^{-1} was counted from five random plants in each replications and mean was recorded.

3.3.3.1.2 Spikes plot^{-1}

Spikes plot^{-1} was obtained from counting all spikes in a plot in each replication and mean was recorded.

3.3.3.1.3 Spikes hectare^{-1}

The projected yield of spikes hectare^{-1} was computed from spikes plot^{-1}.

3.3.3.2 Corm and cormel production

3.3.3.2.1 Corm diameter

The diameter of each of the corm from the 5 sample plants was measured with the help of vernier calliper and their mean was recorded and expressed in centimeter.

3.3.3.2.2 Corms plant^{-1}

Corms plant^{-1} was obtained by taking 5 sample plants from each plot and the average was recorded.

3.3.3.2.3 Weight of corm plant^{-1}

Corms of the five sample plants from each plot were weighted and the average was recorded and expressed in gram.

3.3.3.2.4 Weight of corms plot^{-1}

Total corm yield plot^{-1} was recorded by adding the total harvested corm in a plot and expressed in kilogram.

3.3.3.2.5 Yield of corms hectare^{-1}

Yield of corms hectare^{-1} was computed from plot yield by the following formula-

$$X = \text{Yield plot}^{-1} \text{ (kg)} \times \text{Area of the plot } (m^2)$$

The data obtained was converted to tonnes hectare^{-1}.

3.3.3.2.6 Cormels plant^{-1}

Cormels plant^{-1} was calculated from the number of cormels obtained from 5 sample plants and the average was recorded.

3.3.3.2.7 Weight of cormels plant^{-1}

Cormels collected from the five plants from each plot were weighted and averaged and the value obtained was expressed in grams.

3.3.3.2.8 Weight of cormels plot^{-1}

Total cormel yield plot^{-1} was recorded by adding the total harvested cormels in a plot and was expressed in kilogram.

3.3.3.2.9 Yield of cormels hectare^{-1}

Weight of cormels hectare^{-1} was calculated using the method similar to that of weight of corms hectare^{-1} and was expressed in tonnes hectare^{-1}.

3.3.4 Vase life attributes

Three spikes were harvested from each plot when the first floret was half open and brought to the laboratory for post harvest studies at room temperature. The spikes were given a uniform cut of 75 cm and kept in a standard solution of Sucrose (4%) and of $Al_2 (SO_4)_3$ (300 ppm) for further post harvest studies. The various vase life parameters were recorded at every two days interval and the average values of the three spikes for every parameter were recorded.

3.3.4.1 Fresh weight of spike

The individual spike was weighted and the value was recorded in grams.

3.3.4.2 Water uptake

Water uptake was recorded as the weight of the vase solution without the flower at two days interval and expressed in grams.

3.3.4.3 Water loss

Water loss was recorded as the weight of the vase solution along with the flower at two days interval and expressed in grams.

3.3.4.4 Water balance ratio

Water balance ratio was calculated by dividing the water uptake with water loss.

3.3.4.5 Days to drooping of 1st and 5th floret

The days to drooping of the 1st and 5th floret were recorded from the first day of vase life till the day the florets drooped and the mean was expressed in days.

3.3.4.6 Florets remaining open at a specific time

The maximum number of florets to remain open at a specific time during vase life was counted.

3.3.4.7 Vase life

Vase life was counted from the first day of the flowers in vase solution till the day when 70% of the florets withered and expressed in days.

3.3.5 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 samples were thoroughly brushed and grounded using Willey Grinding Machine and sieved to obtained homogenous samples for determination of NPK contents. The result, thus, obtained was represented in terms of percentage on dry weight basis.

3.3.5.1 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 DISTYL-EM, the digested samples are heated by passing steam and the ammonia librated due to the addition of 40% NaOH is dissolved in 4% boric acid. The boric acid consisting of ammonia is 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.

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

3.3.5.2 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 Molybdophoshoric 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 Soil Sampling and Analysis

The soil samples were collected at random from five places near the base of the plant in each experimental plot after harvesting at a depth of 15 cm with the help of screw type auger. The collected soil samples were mixed and reduced into 500 g and then dried under shade ground and sieved for analysis of the soil parameters.

3.3.6.1 Organic carbon

Organic carbon was determined by Walkley and Black Rapid Titration Method as described by Piper (1966) and expressed in percentage.

3.3.6.2 Soil pH

The pH of the soil was determined in 1:2 soil water suspensions using digital pH meter.

3.3.6.3 Available nitrogen

Available nitrogen was determined by the alkaline permanganate method as suggested by Subbiah and Asija (1956) and expressed in kg ha^{-1}.

3.3.6.4 Available phosphorus

Available phosphorus (P_2O_5) in the soil was determined by Bray‟s Method (Bray & Kurtz, 1945) and expressed in kg ha^{-1}.

3.3.6.5 Available Potassium

The available potassium (K_2O) was determined by ammonium acetate method (Hanway & Heidal, 1952) and expressed in kg ha^{-1}.

3.3.6.6 Dehydrogenase activity

The activity of DHA is determined in air-dried soil samples as per the method described by Casida *et al. (*1964). Soil sample of 10 g was mixed with 0.1 g $CaCO_3$ and then, the mixture is distributed to 3 screw cap tubes each with 3 g. To each test tube 0.5 ml of 3% 2,3,5- triphenyltetrazolium chloride (TTC) and 1.25 ml of distilled water was added and mixed thoroughly with gentle tapering and incubated at 37 ^{0}C for 24 hours. After 24 hours incubation, the soil suspension was filtered through glass funnel equipped with absorbent cotton. Methanol was used to extract soil suspension until the cotton plug‟s colour became white and final volume was made up to 50 ml. Intensity of reddish colour was measured by using spectrophotometer at a wavelength of 485 nm (Spectrascan 2600, Thermo Scientific, USA). The concentration of triphenylformazan (TPF) in the supernatant was determined against a standard graph prepared using known concentrations of TPF. Dehydrogenase activity was expressed in µg (TPF) g^{-1} (dw) soil h^{-1}.

3.3.6.7 Soil microbial population

The soil sample were also analyzed for soil microbial biomass in form of fungal count and bacterial count using rose bengal agar and nutrient agar medium respectively, enumerated by soil dilution plate method (Wolum, 1982). The soil microbial population was expressed in cfu g^{-1}.

3.3.7 Benefit cost ratio

Treatment-wise economics were carried out by calculating the cost of cultivation based on prevailing rates input and output (Appendix – I). Gross income was calculated by yield multiplied by whole sale rate of gladiolus spikes @ Rs. 8 $spike^{-1}$. Net income was estimated by deducting the total cost of cultivation (fixed cost + treatment cost) from gross income of the particular treatment. Benefit cost ratio was also worked out by the relationship given below-

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

3.3.8 Statistical analysis

The data collected from experiments were subjected to analysis of variance technique (ANOVA) for Randomized Block Design (Panse and Sukhatme, 1989) and the treatment variance was tested against error variance by applying Fischer Snedecor „F‟ tests of probability at 5 percent level. For comparison among treatment contrasts, Standard Error of Mean will be computed as-

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

Then, Critical Difference (CD) at 5% level of significance will be computed as-

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

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

CHAPTER IV
RESULTS & DISCUSSIONS

RESULTS AND DISCUSSIONS

The results of the present investigation "Effect of various nutrient sources on the growth, flowering, yield and vase life of *Gladiolus primulinus* cv. Candyman" related to the impact of various nutrient sources on growth, floral characters, spike yield and corms production, nutrient content, soil health and fertility status are embodied and explained in this chapter. The results enumerating from the present studies are discussed using probable causes and effects of analysis in the light of available relevant literature under the following major heads.

1. Growth characters
2. Flowering parameters
3. Yield and yield attributing characters
4. Vase life parameters
5. Plant nutrition and soil fertility
6. Benefit cost ratio

4.1 Response of various sources of nutrient on growth characters

The progressive data recorded on growth studies *viz*. days to sprouting, plant height, number of leaves per plant and leaf area as affected by various treatments, have been considered and described below in the light of treatments at progressive stages of crop.

4.1.1 Days to sprouting

The data pertaining to days to sprouting as influenced by different treatments has been presented in Table 4.1. In general, the corms of the second year of experiment took more time to sprouting as compared to the first year of experiment which may be due to the slight difference in the size of corms. The corms of the first year experiment were slightly larger than those of the second year hence, they required lesser days to sprouting than the smaller corms of the second year. The variation in the days to sprouting ranged from 6.93 days to 7.34 days in 2014-15 and 8.33 days to 8.95 days in 2015-16. The variations during both the seasons of experimentation under different treatments were quite marginal and could not reach the level of significance.

This may be because in bulbous crops the variation in time to sprouting is known to depend on food materials stored within the bulb. The corms of gladiolus store food from the previous season‟s growth which is used to sustain the plant for its initial growth and development. The present result is in conformity with the reports of Gagbhiye (2013) and Sharma *et al*. (2003) who reported that sprouting of corms in gladiolus depends upon the stored food materials in the corm and not the external nutrition. This is in corroboration with the findings of Kumar *et al*. (2013) who in their experiment on nutrient management in potato showed that the emergence of potato plants did not vary significantly among the different nutrient management practices and biofertilizers used during all the three years under the study. This was mainly due to the fact that the bulbous crops had enough food to nourish the young sprouts for emergence. Further, the effect of applied nutrients would only be estimated after their absorption through well established root system that comes later on.

4.1.2 Plant height

The different treatments produced significant response on plant height to varying proportions during both the seasons of 2014-15 and 2015-16 including pooled data analysis (Table 4.1). The data on plant height were recorded at spike initiation stage. Results revealed that the application of (T_7) 50% NPK through inorganic fertilizers along with 50% pig manure exhibited the tallest plant height (115.30 cm) with 41.86% magnitude of increase over control in the first season of experiment. It was at par with T_{12} (50% RDF + 25% Pig manure + Biofertilizers) (112.23 cm), T_{11} (50% RDF + 25% FYM + Biofertilizers) (110.90 cm), T_6 (50% RDF + 50% FYM) (106.23 cm). All these treatments recorded significantly greater plant height over all other nutrient sources. The minimum plant height (81.28 cm) was noted in control which was at par with T_5 (Biofertilizers) (91.00 cm).

Significantly tallest plants were recorded in plots that received integrated nutrient sources of 50% RDF + 25% FYM + Biofertilizers (T_{11}) which measured 106.20 cm, in the year 2015-16. It was at par with treatment T_{12} (50% NPK + 25% Pig manure + Biofertilizers) (103.01 cm), T_6 (50% NPK + 50% FYM) (101.11 cm), T_7 (50% NPK + 50% Pig manure) (100.30 cm), T_{13} (50% NPK + 25% Vermicompost + Biofertilizers) (99.47 cm), T_4 (100% NPK) (97.81 cm) and T_8 (50% NPK + 50% Vermicompost) (96.82 cm) while the lowest plant height (80.48 cm) was obtained in control.

The perusal of two year pooled data revealed that the treatment T_{11} (50% NPK + 25% FYM + Biofertilizers) emerged as the tallest plant (108.55 cm) which was at par with T_7 (50% NPK + 50% Pig manure) (107.80 cm) and T_{12} (50% NPK + 25% Pig manure + Biofertilizers) (107.63 cm) while control recorded the least effective treatment (80.88 cm) which was significantly lower than all the other treatments. Use of only organic sources (100% RDN) of nutrients *viz.* FYM, Pig

Table 4.1: Effect of various sources of nutrients on days to sprouting of corms and plant height in *Gladiolus primulinus* cv. Candyman

Treatments	Days to sprouting			Plant height (cm)		
	2014-15	**2015-16**	**Pooled**	**2014-15**	**2015-16**	**Pooled**
T_0	6.97	8.50	7.73	81.28	80.48	80.88
T_1	7.34	8.57	7.95	97.20	94.67	95.93
T_2	7.29	8.95	8.12	98.37	96.13	97.25
T_3	7.29	8.67	7.98	92.53	90.54	91.54
T_4	6.97	8.89	7.93	101.20	97.81	99.51
T_5	7.13	8.49	7.81	91.00	89.33	90.17
T_6	7.25	8.82	8.04	106.23	101.11	103.67
T_7	7.22	8.88	8.05	**115.30**	100.30	107.80
T_8	7.01	8.87	7.94	99.47	96.82	98.15
T_9	7.23	8.76	7.99	92.00	89.63	90.82
T_{10}	**6.93**	8.47	**7.70**	99.93	97.77	98.85
T_{11}	7.17	**8.33**	7.75	110.90	**106.20**	**108.55**
T_{12}	7.29	8.57	7.93	112.23	103.01	107.62
T_{13}	7.23	8.56	7.90	99.96	99.47	99.71
SEm ±	0.45	0.52	0.34	3.38	3.31	2.37
CD at 5%	NS	NS	NS	9.82	9.64	7.73

manure, Vermicompost or Biofertilizers recorded non significant values among themselves however they were significantly inferior to those obtained with integrated use of 50% RDNPK through inorganic sources and 50% RDN through organic sources with or without biofertilizers during both the years. These findings indicated that gladiolus crop required high amount of nutrients for its proper growth and 100% replacement of nutrients through organic sources was unable to supply plant nutrients adequately keeping space with the requirement during its growth period. It might be attributed to slow mineralization rate of organic matter at initial growth stages and high N requirement during the period of formation of new corm. This is in confirmation with the findings of Kumar *et al*. (2013) in their experiment on potato.

On the contrary, the rise in the height of plant in the integrated nutrient management might be because of the readily available form of nutrients. Plant height may be attributed to the presence and synthesis of gibberellins in organic manures. Gibberellins cause both cell elongation and division that stimulated elongation and resulted in increased plant height. These findings were in conformity with the findings of Shankar *et al.* (2010) and Prakash *et al.* (2015) in gladiolus. Moreover, application of biofertilizers in addition to organic manures and inorganic fertilizers might have increased the absorption of the macro and micro nutrients of plant. This might be due to fact that combined application of biofertilizers enhance the rate of mineralization of plant nutrients in soil and thus help in better nutrition of the crop that reflected in increasing plant height (Mondal *et al*., 2005; Sarkar *et al*., 2007). Inoculation of seeds with bio-fertilizers enhanced growth factors such as plant height, fresh and dry weight of leaves in tuberose plants as opined by Wang *et al*. (1995). Ahmad *et al*. (2013) showed that biofertilizers caused an increase in plant height through enhancement of nitrogen content and photosynthesis rate.

4.1.3 Leaves plant^{-1}

The variation in leaves plant^{-1} was significantly influenced by different sources of nutrients (Table 4.2). The data showed that the highest leaves plant^{-1} (9.78) in the first year of experiment was obtained in T_{11} (50% NPK + 25% FYM + Biofertilizers) which was statistically at par with T_{12} (50% NPK + 25% Pig manure + Biofertilizers) (9.53), T_6 (50% NPK + 50% FYM) (9.53), T_7 (50% NPK + 50% Pig manure) (9.46), T_{13} (50% NPK + 25% Vermicompost + Biofertilizers) (9.17) and T_{10} (75% NPK + Biofertilizers) (9.01). The lowest leaves plant^{-1} was noted in control (8.21).

In the second year, T_{12} (50% NPK + 25% Pig manure + Biofertilizers) gave the highest leaves (9.50) which was at par with T_{11} (50% NPK + 25% FYM + Biofertilizers) (9.48). Control registered the lowest leaves plant^{-1} (8.04) followed by T_5 (Biofertilizers) (8.43).

Data when analyzed on pooled basis revealed that T_{11} (50% NPK + 25% FYM + Biofertilizers) produced maximum leaves plant^{-1} (9.63) followed by T_{12} (50% NPK + 25% Pig manure + Biofertilizers) (9.52), T_7 (50% NPK + 50% Pig manure) (9.44) and T_6 (50% NPK + 50% FYM) (9.42) which also showed statistically non significant response when compared among themselves. The treatment showing statistically most inferior response (8.12) could be adjudged as T_0 followed by T_5 (Biofertilizers) (8.48), T_3 (Vermicompost 10 t ha^{-1}) (8.57) and T_1 (FYM 40 t ha^{-1}) (8.68). The plots treated solely with organic nutrient source (T_1, T_2 and T_3) recorded lower values than the plots receiving combined nutrient sources (T_6, T_7, T_8, T_{11}, T_{12}, and T_{13}) showing that although organic manures are the source of all nutrients, crop response is more evident in the presence of chemical fertilizers with or without biofertilizers. The magnitude of increase with respect to number of leaves of T_6 over T_1 is 8.53% and that with T_{11} over T_1 is 10.94% depicting that combined application of manure with inorganic fertilizer is better than its sole application while the combination of manure with inorganic fertilizer and biofertilizers in optimum dose is more effective than manure with inorganic fertilizer alone in influencing the number of leaves.

These results need to be looked in the light of an increased availability of nutrient element in the treatment combination of organic and inorganic sources to constitute chlorophyll which led to better number of leaves over control and other lone treatments. Increase in number of leaves may be due to increased nutrient availability especially nitrogen, as it is a constituent of protein, component of protoplasm and also increased chlorophyll content in leaves. All the factors contributed to cell multiplication, cell elongation and differentiation, which have resulted in better photosynthesis and ultimately respective growth. Dubey *et al.* (2008) and Singh (2005) reported that the profound effect of nitrogen fertilization on anatomical structure of gladiolus resulted production of more number of leaves. Similar findings were also reported by Gangadharan and Gopinath (2000) in gladiolus cv. White Prosperity. *Azotobacter* and PSB in combination with RDF has reported to increase the plant height and number of leaves in gladiolus (Godse *et al*., 2006). Increase in plant height and number of leaves with the application of biofertilizers in combination with inorganic fertilizers was also reported in other flower crops by Kukde *et al.,* 2006 in tuberose cv. Single and Warade *et al.* (2007) in Dahlia.

4.1.4 Leaf area

The leaf area of the plant also plays an important role in photosynthetic activity as it intercepts more of radiant energy from sunlight. Different sources of fertilizers also largely influenced the leaf area as the variations differed significantly. As depicted in Table 4.2, during 2014-15, the highest leaf area (136.70 cm^2) was observed with T_{12} (50% NPK + 25% Pig manure + Biofertilizers) which was statistically at par with T_{11} (50% NPK + 25% FYM +

Biofertilizers) (130.40 cm^2), T_7 (50% NPK + 50% Pig manure) (130.00 cm^2) and T_6 (50% NPK + 50% FYM) (124.99 cm^2) while the lowest leaf area (92.45 cm^2) was recorded in control followed by T_5 (Biofertilizer) (99.78 cm^2) and T_9 (50% NPK + Biofertilizers) (100.56 cm^2).

During 2015-16, T_{11} (50% NPK + 25% FYM + Biofertilizers) recorded the highest leaf area measuring 128.30 cm^2 which showed at par values with T_{12} (50% NPK + 25% Pig manure + Biofertilizers) (124.42 cm^2), T_7 (50% NPK + 50% Pig manure) (122.40 cm^2), T_{13} (50% NPK + 25% Vermicompost + Biofertilizers) (120.20 cm^2) and T_6 (50% NPK + 50% FYM) (118.63 cm^2). On the contrary, the lowest leaf area (87.48 cm^2) was noted in control which differed significantly from all the rest of the treatments.

On the basis of two year mean data on leaf area, maximum value (130.56 cm^2) was recorded in T_{12} (50% NPK + 25% Pig manure + Biofertilizers). However, differences between the treatment effects of T_{12}, T_{11} (50% NPK + 25% FYM + Biofertilizers) (129.35 cm^2), T_7 (50% NPK + 50% Pig manure) (126.20 cm^2), T_{13} (50% NPK + 25% Vermicompost + Biofertilizers) (122.05 cm^2) and T_6 (50% NPK + 50% FYM) (121.81 cm^2) were found at par. Among the organic treatments, T_1 (FYM 40 t ha^{-1}) recorded the maximum leaf area (109.74 cm^2) however it was at par with T_2 (Pig manure 35 t ha^{-1}) (105.62 cm^2) and T_3 (Vermicompost 10 t ha^{-1}) (103.81 cm^2) which were significantly higher than control and biofertilizer treatments alone. On the other hand, the treatments consisting of 50% inorganic fertilizers and 50% organic manures recorded at par values among themselves as well as those treatments which consisted of 50% inorganic fertilizers with 25% organic manures and biofertilizers but significantly higher than those treatments containing 100% fertilizers through individual nutrient sources. Significantly lower leaf area (89.96 cm^2) was obtained in control.

Table 4.2: Effect of various sources of nutrient on the leaves plant^{-1} and leaf area of gladiolus cv. Candyman

Treatments	Leaves plant^{-1}			Leaf area (cm^2)		
	2014-15	**2015-16**	**Pooled**	**2014-15**	**2015-16**	**Pooled**
T_0	8.21	8.04	8.12	92.45	87.48	89.96
T_1	8.83	8.52	8.68	112.89	106.59	109.74
T_2	8.89	8.53	8.71	111.07	100.16	105.62
T_3	8.69	8.46	8.57	108.56	99.06	103.81
T_4	8.93	8.68	8.81	116.78	112.25	114.52
T_5	8.54	8.43	8.48	99.78	98.26	99.02
T_6	9.53	9.31	9.42	124.99	118.63	121.81
T_7	9.46	9.42	9.44	130.00	122.40	126.20
T_8	8.98	8.78	8.88	121.33	117.56	119.45
T_9	8.72	8.71	8.72	100.56	99.59	100.08
T_{10}	9.01	8.83	8.92	116.37	112.73	114.55
T_{11}	**9.78**	9.48	**9.63**	130.40	**128.30**	129.35
T_{12}	9.53	**9.50**	9.52	**136.70**	124.42	**130.56**
T_{13}	9.17	8.91	9.04	123.89	120.20	122.05
SEm ±	0.27	0.24	0.18	5.08	3.60	3.11
CD at 5 %	0.78	0.70	0.59	14.75	10.46	10.16

It is evident from the present investigation that the various nutrient sources and their combinations have differential positive effect on the growth attributes such as plant height, leaf number and leaf area of gladiolus. The combined application of chemical fertilizers, organics and biofertilizers has been found to influence morphological characters better than the sole application of the different nutrient sources in the present investigation. These growth parameters are influenced by a number of intrinsic and extrinsic environmental factors apart from management practices.

Increase in vegetative growth might be due to better flow of macro and micro nutrients along with plant growth substances into the plant system in the plots applied with manures, biofertilizers and half of the recommended dose of fertilizer. In addition to improving the soil physical properties, the growth promoting substances present in organic matter might have resulted in increased cell division and elongation leading to enhanced leaf expansion, thus leading to increase in the leaf area which in turn improved the overall performance of the plant. On the other hand, the decrease in vegetative parameters of other treatments might be due to unavailability of sufficient nutrients at critical stages to plant for its luxuriant growth. The observed results are in agreement with the findings of Reshma *et al.* (2013) in flower crops. Kumar *et al.* (2011) reported that combined application of chemical fertilizers, biofertilizers and biostimulants showed a significant influence on growth of gladiolus cv. Sancerre. Similar findings were also reported by Srivastava and Govil (2007) in gladiolus cv. American Beauty.

4.2 Flowering parameters

The commercial value of a flower crop depends mainly on its specific quality attributes. In gladiolus, floral characters like days to spike initiation and basal floret opening decide the availability of flowers to the market demand. Flower characters like spike length, rachis length, florets spike^{-1} and diameter of floret decides the value of flower spike. In the present investigation, the flower characters were significantly influenced by the use of various nutrient sources.

4.2.1 Days to spike emergence

The data recorded for emergence of spike is incorporated in Table 4.3. The perusal of the data of 2014-15 indicated that T_{11} (50% RDF+ 25% FYM + Biofertilizers) registered the minimum requirement of time for spike emergence *i.e.* 67.56 days which was at par with T_{12} (50% NPK + 25% Pig manure + Biofertilizers) (67.70 days). However, this trait was delayed most (77.63 days) with control which showed at par values with T_3 (Vermicompost 10 t ha^{-1}) (75.19 days), T_1 (FYM 40 t ha^{-1}) and T_2 (Pig manure 30 t ha^{-1}) (74.84 days), T_5 (Biofertilizers) (74.28 days) and T_4 (100% NPK) (73.34 days).

In 2015-16, the minimum days to spike emergence (69.75 days) was noted in T_{12} (50% NPK + 25% Pig manure + Biofertilizers) which was at par with T_{11} (50% RDF+ 25% FYM + Biofertilizers) (70.20 days). Control took the maximum days to spike emergence (79.23 days) followed by T_5 (Biofertilizers) (77.40 days).

Pooled analysis of the two years data indicated that the minimum days to spike emergence (68.72 days) was recorded in T_{12} (50% NPK + 25% Pig manure + Biofertilizers) which was at par with T_{11} (50% RDF+ 25% FYM + Biofertilizers) (68.88 days), T_{13} (50% NPK + 25% Vermicompost + Biofertilizers) (71.10 days), T_{10} (75% NPK + Biofertilizers) (72.00 days) and T_6 (50% NPK + 50% FYM) (72.69 days). The least responsive treatment was recorded with control (78.43 days) followed by T_3 (Vermicompost @ 10 t ha^{-1}) (76.06 days).

The earliness in spike emergence in INM might be ascribed to easy uptake of nutrients and simultaneous transport of growth promoting substances like cytokinin. An adequate supply of phosphorus in the early stages of growth is important for laying down the primordial for reproductive parts of the plant and helps in early maturity of crops. Ultimately, this has resulted in a better sink for quick mobilization of photosynthates and early transformation of plant parts from vegetative to reproductive phase. The result of present investigation is in close conformity with the findings of Parolekar *et al*. (2012) in tuberose; Pathak and Kumar (2009) in gladiolus.

4.2.2 Days to full opening of 1st floret

The time needed for full opening of 1st floret was significantly influenced by different sources of nutrients as presented in Table 4.3. In the first year of experiment, the minimum days (77.05 days) to opening of 1st floret was observed with T_{11} 5(0% NPK + 25% FYM + Biofertilizers) which was found to be at par with T_{12} (50% NPK + 25% Pig manure + Biofertilizers) (77.13 days), T_{13} (50% NPK + 25% Vermicompost + Biofertilizers) (78.86 days) and T_{10} (75% NPK + Biofertilizers) (79.71 days), T_9 (81.25 days), T_7 (50% NPK + 50% Pig manure) (73.09 days), T_6 (50% NPK + 50% FYM) (82.21 days) and T_8 (50% NPK + 50% Vermicompost) (82.73 days) where as T_0 required the maximum days for full opening of 1st floret (89.89 days) followed by T_1 (FYM 40 t ha^{-1}) and T_3 (Vermicompost (10 t ha^{-1}) (86.19 days), T_2 (Pig manure @ 35 t ha^{-1}) (85.74 days) and T_4 (100% NPK) (85.01 days).

Similar result was obtained in the second year, T_{12} (50% NPK + 25% Pig manure + Biofertilizers) recorded the minimum days to full opening of 1st floret (79.59 days) which was statistically at par with T_{11} (50% NPK + 25% FYM + Biofertilizers) (79.77 days), T_{13} (50% NPK + 25% Vermicompost + Biofertilizers) (80.06 days), T_{10} (75% NPK + Biofertilizers) (82.87 days), T_9 (50% NPK + Biofertilizers) (83.63 days), T_6 (50% NPK + 50% FYM) (85.17 days), T_8 (50% NPK + 50% Vermicompost) (85.23 days), T_7 (50% NPK + 50% Pig manure) (85.51 days). Control recorded the maximum days to 1st floret opening (90.10 days) followed by T_5 (Biofertilizers) (88.04 days), T_1 (FYM 40 t ha^{-1}) (87.82

Plate 3. Spike initiation stage and full opening of 1st floret

Plate 4. General view of experimental site at flowering stage of *Gladiolus primulinus* cv. Candyman

days), T_3 (Vermicompost @ 10 t ha^{-1}) (87.76 days), T_2 (Pig manure @ 35 t ha^{-1}) (87.45 days) and T_4 (100% NPK) (86.41 days).

Similar trend of result was obtained in the pooled analysis of the two years data. T_{12} (50% NPK + 25% Pig manure + Biofertilizers) recorded the least days (78.36 days) to full opening of 1^{st} floret which showed at par values with T_{11} (50% NPK + 25% FYM + Biofertilizers) (78.41 days) and T_{13} (50% NPK + 25% Vermicompost + Biofertilizers) (79.46 days), T_{10} (75% NPK + Biofertilizers) (81.29 days) and T_9 (50% NPK + Biofertilizers) (82.44 days). On the contrary, the maximum days (90.00 days) to full opening of the 1^{st} floret was observed in control followed by T_5 (Biofertilizers) with 87.06 days.

Among different treatments, application of 50% recommended dose of fertilizers in combination with 25% of either FYM or Pig manure + Biofertilizers (either T_{11} or T_{12} respectively) recorded significantly less days to spike emergence and full opening of the first floret. This might be due to application of organic manures which led to improved soil texture by making soil loose thereby increasing the water holding capacity which encouraged early growth and development of corms and indirectly helped in early emergence of spike. The readily available nutrients from 50% RDF might have helped in building up of nutrition in corms, which might have improved the early vegetative growth of the plant which in turn had indirectly helped in early emergence of spike. Another probable reason for early heading and flowering in the plots which have received integrated nutrient treatments containing organic manures, inorganic fertilizers and biofertilizers might be that the hormones which enhanced early heading and flowering was secreted by *Azospirillum* and phosphotica. This result is in agreement with the findings of Srivastava *et al*., 2014 in tuberose and Dubey *et al*., 2008 in gladiolus who reported that application of biofertilizers would have helped

Table 4.3: Days to spike emergence and full opening of 1st floret as influenced by various nutrient sources

Treatments	Days to spike emergence			Days to full opening of 1st floret.		
	2014-15	**2015-16**	**Pooled**	**2014-15**	**2015-16**	**Pooled**
T_0	77.63	79.23	78.43	89.89	90.10	90.00
T_1	74.85	76.99	75.92	86.19	87.82	87.00
T_2	74.85	76.92	75.88	85.74	86.41	86.08
T_3	75.19	76.92	76.06	86.19	87.76	86.98
T_4	73.34	76.49	74.92	85.01	87.45	86.23
T_5	74.28	77.40	75.84	86.08	88.04	87.06
T_6	71.54	73.83	72.69	82.21	85.17	83.69
T_7	71.33	74.85	73.09	81.89	85.51	83.70
T_8	72.62	75.00	73.81	82.73	85.23	83.98
T_9	71.39	75.29	73.34	81.25	83.63	82.44
T_{10}	69.73	74.27	72.00	79.71	82.87	81.29
T_{11}	**67.56**	70.20	68.88	**77.05**	79.77	78.41
T_{12}	67.70	**69.75**	**68.72**	77.13	**79.59**	**78.36**
T_{13}	70.36	71.10	70.73	78.86	80.06	79.46
SEm ±	1.64	1.81	1.22	2.44	2.12	1.62
CD at 5%	4.75	5.27	3.99	7.08	6.18	5.27

in uptake of micronutrients and have provided essential plant growth promoting substances which resulted in early flowering.

INM might have role in supply of macro and micronutrients, enzymes and growth hormones and provide micronutrients such as Zn, Fe, Cu, Mn *etc*. in an optimum level which helped in proper flower development. Further, increase in absorptive surface area of the roots due to the combined use of different nutrient sources might have led to enhanced uptake and translocation of available water and nutrients like P, Zn, Fe, Mg and Cl, ultimately resulting in better sink for faster mobilization of photosynthesis and early transformation of plant parts from vegetative to reproductive phase. Similar results were reported by Tripathi *et al.* (2013) in tuberose and Narendra *et al*. (2013) in gladiolus. They also recorded that the time required to 80% spike initiation was found to be delayed in control treatment. RDF alone recorded maximum days for spike emergence and minimum leaves and leaf area index compared to RDF with organic manure combinations. Similar results were observed during both the years of study. This is in line with the findings of Suseela *et al.*, 2016. Singh *et al*. (2010) reported that biofertilizers, *Azotobacter* and *Pseudomonas* caused early spike initiation and basal floret opening in gladiolus. Godse *et al*. (2006) also observed early spike initiation with the use of biofertilizers in gladiolus. Similar results were reported by Kumar *et al*. (2011) in gladiolus by the use of combination of chemical fertilizers, biofertilizers and biostimulants.

4.2.3 Florets spike^{-1}

In gladiolus, the number of florets is an important criterion for the suitability of the cultivar for cut flower and bedding purposes. The data relating to florets spike^{-1}, embodied in Table 4.4, revealed that the integrated application of nutrients produced maximum florets spike^{-1} and was significantly higher than the sole application of the nutrient sources. In the first year of experiment, application of T_{12} (50% NPK + 25% Pig manure + Biofertilizers) resulted in higher number of florets spike^{-1} (15.61) which was at par with treatment T_{11} (50% RDF+ 25% FYM + Biofertilizers) (15.21), T_7 (50% NPK + 50% Pig manure) (15.16), T_6 (50% NPK + 50% FYM) (15.02) and T_{13} (50% NPK + 25% Vermicompost + Biofertilizers) (15.00),T_8 (50% NPK + 50% Vermicompost) (14.81) and T_4 (100% NPK) (14.64). Whereas the minimum florets (12.00) was noted in the plot where only biofertilizers was applied followed by control (12.89).

Similar trend was followed during the second year of study, where T_{12} (50% NPK + 25% Pig manure + Biofertilizers) recorded the highest number of florets (15.55) which was at par with T_{11} (50% RDF+ 25% FYM + Biofertilizers) (15.20), T_7 (50% NPK + 50% Pig manure) (15.10), T_6 (50% NPK + 50% FYM) (15.00) and T_{13} (50% NPK + 25% Vermicompost + Biofertilizers) (14.67). The lowest number of florets (11.24) was recorded in control which was at par with T_5 (Biofertilizers) (12.46).

The pooled data produced no different response to what was obtained through seasonal analysis. T_{12} (50% NPK + 25% Pig manure + Biofertilizers) gave the highest number of florets (15.58) which was statistically at par with T_{11} (50% RDF+ 25% FYM + Biofertilizers) (15.21), T_7 (50% NPK + 50% Pig manure) (15.13), T_6 (50% NPK + 50% FYM) (15.01) T_{13} (50% NPK + 25% Vermicompost + Biofertilizers) (14.84), T_4 (100% NPK) and T_8 (50% NPK + 50% Vermicompost) (14.53), while minimum number of florets (12.07) was obtained in control which was inferior to all the other treatments under study.

Maximum florets spike^{-1} was obtained by the application of T_{12} (50% NPK + 25% Pig manure + Biofertilizers) and other integrated treatments which might be due to fast release of nutrients and increased levels of both macro and micronutrients and more absorption area. Increased plant growth and leaf area with these treatments might have resulted in the production of more photosynthates which might have consequently led to the production of more florets spike^{-1}. These results were also found to be in conformity with the findings of Suseela *et al*. (2016).

4.2.4 Days to 5th floret opening

Data in respect to days to 5th floret opening highlighted in Table 4.4 revealed that the minimum days to 5th floret opening was recorded in T_{12} (50% NPK + 25% Pig manure + Biofertilizers) in both the years under study and also in the pooled data analysis (6.09, 6.14 and 6.11 days) respectively. However, the various sources of nutrient failed to exert any significant influence on days to 5th floret opening.

4.2.5 Spike length

Different INM oriented treatments produced significant response on length of spikes to varying proportions during both the seasons of experiment and also on the pooled data. It is clear from the data presented in Table 4.5 that the length of spike was significantly influenced by various treatments. Length of spike ranged from 62.00 cm to 88.76 cm among the various treatments in the pooled analysis of the two years under study. In the first year (2014-15), the longest length of spike (90.11 cm) was recorded in with T_{12} (50% NPK + 25% Pig manure + Biofertilizers) while the least spike length (63.95 cm) was observed in control. T_{12} was at par with T_{11} (50% RDF+ 25% FYM + Biofertilizers) (89.59 cm), T_{13} (50% NPK + 25% Vermicompost + Biofertilizers) (82.90 cm), T_7 (50% NPK + 50% Pig manure) (89.47 cm) and T_6 (50% NPK + 50% FYM) (85.72 cm).

In the second year of experiment, the maximum length of spike (87.41 cm) was observed with T_{12} (50% NPK + 25% Pig manure + Biofertilizers) followed by T_{11} (50% RDF+ 25% FYM + Biofertilizers) (84.42 cm) and T_7 (50% NPK + 50%

Table 4.4: Florets spike^{-1} and days to 5th floret opening as influenced by various nutrient sources

Treatments	Florets spike^{-1}			Days to 5th floret opening		
	2014-15	**2015-16**	**Pooled**	**2014-15**	**2015-16**	**Pooled**
T_0	12.89	11.24	12.07	6.99	6.99	6.99
T_1	13.80	13.58	13.69	6.78	6.62	6.70
T_2	14.18	13.66	13.92	6.43	6.75	6.59
T_3	13.25	13.14	13.19	6.70	6.85	6.77
T_4	14.64	14.41	14.53	6.29	6.34	6.31
T_5	12.00	12.46	12.73	6.89	6.90	6.90
T_6	15.02	15.00	15.01	6.37	6.57	6.47
T_7	15.16	15.10	15.13	6.12	6.38	6.25
T_8	14.81	14.24	14.53	6.27	6.44	6.36
T_9	13.82	13.31	13.57	6.75	6.74	6.74
T_{10}	14.37	14.27	14.32	6.39	6.45	6.42
T_{11}	15.21	15.20	15.21	6.12	6.22	6.17
T_{12}	**15.61**	**15.55**	**15.58**	**6.09**	**6.14**	**6.11**
T_{13}	15.00	14.67	14.84	6.18	6.41	6.30
SEm ±	0.42	0.56	0.35	0.27	0.41	0.24
CD at 5%	1.23	1.61	1.14	NS	NS	NS

Pig manure) (84.21 cm), whereas control exhibited the minimum spike length (60.03 cm).

Similar trend was followed in the pooled analysis for both the seasons, where (50% NPK + 25% Pig manure + Biofertilizers) was significantly better in improving the length of spike (88.76 cm) than most of the other treatments however it was at par with T_{11} (50% RDF+ 25% FYM + Biofertilizers) (87.00 cm), T_7 (50% NPK + 50% Pig manure) (86.84 cm), T_6 (50% NPK + 50% FYM) (84.25 cm), T_{13} (50% NPK + 25% Vermicompost + Biofertilizers) (80.94 cm) and T_{10} (75% NPK + Biofertilizers) (80.02 cm). The least effective treatment was noted as control (62.00 cm) which differed significantly from the rest of the treatments.

The increased spike length in the INM oriented treatments was probably due to the better vegetative growth whose result was later manifested through the improved reproductive characters. These results were similar to the works of Tripathi *et al.* (2012) who found that spike length was increased with the application of vermicompost and trichocompost along with ¼ RDF fertilizers. Moghadam and Shoor (2013) who concluded that the treatment of *Azospirillum sp.* + phosphate solubilizing bacterium + vermicompost + NPK (25% of recommended dose) enhanced the quality of flowers and multiplied the flower yield of *Petunia hybrid* flower.

4.2.6 Rachis length

Rachis lengths of as affected by various nutrient sources are depicted in Table 4.5. Rachis length ranged from 31.94 cm to 48.84 cm among the various treatments during both the years under study. The maximum rachis length (47.97 cm) in the year 2014-15 was observed in T_{12} (50% NPK + 25% Pig manure + Biofertilizers) which was at par with T_{11} (50% NPK + 25% FYM + Biofertilizers) (47.30 cm) while control noted the shortest rachis length (33.71 cm).

Similarly, in the second year, T_{12} (50% NPK + 25% Pig manure + Biofertilizers) recorded the maximum rachis length (49.72 cm) which was at par with T_{11} (50% NPK + 25% FYM + Biofertilizers) (49.17 cm) and T_7 (50% NPK + 50% Pig manure) (47.10 cm), T_6 (50% NPK + 50% FYM) (47.06 cm) and T_{13} (50% NPK + 25% Vermicompost + Biofertilizers) (44.00 cm) while T_0 recorded the minimum rachis length (30.16 cm) which was at par with T_5 (Biofertilizers) (36.53 cm).

Data when analyzed on pooled basis followed almost the same pattern of response where T_{12} (50% NPK + 25% Pig manure + Biofertilizers) recorded maximum rachis length with a value of 48.84 cm which was at par with T_{11} (50% NPK + 25% FYM + Biofertilizers) (48.23 cm), T_7 (50% NPK + 50% Pig manure) (47.16 cm) and T_6 (50% NPK + 50% FYM) (46.54 cm). The most inferior treatment pertaining to rachis length (31.94 cm) was recorded in control which was statistically lower than all the other treatments.

Combined application of organic and inorganic nutrient sources in combination with the biofertilizers in optimum proportion might have enhanced the availability of nutrients in the soil which increased the synthesis of amino acids and chlorophyll formation and in return carbohydrate formation which ultimately resulted in the better growth and length of spike and rachis. Results indicated that the dose of organic manures can be replaced up to 50% with the addition of biofertilizers which can either improve or maintain the performance of crops as compared to the sole treatment of organic manures. However, the sole treatment of biofertilizer in the absence of organic manures does not produce significant effect over the control. This might be due to the low availability of organic substrates for the activity of microbial population as well as competition from soil native microorganisms. The present result is in close collaboration with the findings of Mohammadi (2011) and Ros *et al*. (2003).

Table 4.5: Spike length (cm) and rachis length (cm) as influenced by various sources of nutrients

Treatments	Spike length (cm)			Rachis length (cm)		
	2014-15	**2015-16**	**Pooled**	**2014-15**	**2015-16**	**Pooled**
T_0	63.95	60.03	62.00	33.71	30.16	31.94
T_1	73.80	75.71	74.76	40.91	38.73	39.82
T_2	74.53	73.25	73.89	41.37	40.00	40.68
T_3	72.76	71.83	72.30	40.17	37.13	38.65
T_4	81.27	77.68	79.47	44.17	41.83	43.00
T_5	72.22	70.96	71.59	39.77	36.53	38.15
T_6	85.72	82.79	84.25	46.02	47.06	46.54
T_7	89.47	84.21	86.84	47.22	47.10	47.16
T_8	79.96	78.60	79.28	44.44	43.83	44.14
T_9	73.86	73.62	73.74	40.57	37.08	38.82
T_{10}	81.35	78.69	80.02	44.26	42.21	43.23
T_{11}	89.59	84.42	87.00	47.30	49.17	48.23
T_{12}	**90.11**	**87.41**	**88.76**	**47.97**	**49.72**	**48.84**
T_{13}	82.90	78.99	80.94	44.67	44.00	44.33
SEm±	2.69	3.62	2.25	1.88	2.33	1.50
CD at 5%	7.82	10.52	7.36	5.46	6.77	4.88

4.2.7 Diameter of floret

A good flower size, an indicator of efficient culmination of utmost exploitation of available resources to their optimum, was significantly influenced by the various treatments under study. The diameter of floret, being one of the most important characters of gladiolus is greatly influenced by nutrient uptake, better mobilization and solubilisation of phosphate. Results of the influence of various nutrient sources on floret diameter, thus obtained are depicted in Table 4.6.

Diameter of floret was maximum (10.54 cm) with the application of T_{11} (50% NPK + 25% FYM + Biofertilizers) in 2014-15 which was statistically at par with T_{12} (50% NPK + 25% Pig manure + Biofertilizers) (10.53 cm), T_7 (50% NPK + 50% Pig manure) (10.30 cm) and T_6 (50% NPK + 50% FYM) (10.25 cm) whereas the minimum diameter of floret was noted in control (9.21 cm) followed by T_5 (Biofertilizers) (9.35 cm) and T_1 (FYM 40 t ha^{-1}) (9.67 cm).

In 2015-16, T_{12} (50% NPK + 25% Pig manure + Biofertilizers) gave the largest diameter of floret (10.13 cm) which was at par with T_6 (50% NPK + 50% FYM) and T_7 (50% NPK + 50% Pig manure) both of which measured 10.12 cm and T_{11} (50% NPK + 25% FYM + Biofertilizers) (10.11 cm). The least diameter (8.78 cm) of floret was noted in the control plot.

The pooled data analysis of both years revealed that T_{12} (50% NPK + 25% Pig manure + Biofertilizers) recorded higher diameter of floret (10.33 cm) and was at par with T_{11} (50% NPK + 25% FYM + Biofertilizers) (10.32 cm). On the contrary, the lowest floret diameter was registered in control and T_5 (Biofertilizers), 8.99 cm and 9.15 cm respectively.

Significant increase in floral characters could be attributed to the rapid absorption of nutrient elements by the plant and their translocation in the floral parts. The increase in floral characters due to application of organic and inorganic fertilizers increased the vegetative growth and healthy green leaves which in turn was manifested in higher assimilate synthesis thus leads to production of more food material, which in turn might have been utilized for better development of size and weight of flowers. Similarly, Bhalla *et al*. (2006) emphasized that increase in number of florets and size of floret in gladiolus was due to the improved uptake and absorption of the nutrients by the use of biofertilizers. Dubey *et al*. (2010) reported that significant improvement in flower quality of gladiolus were recorded with the inoculation of *Azotobacter* + PSB, which might be due to increased availability of nitrogen and better mobilization, solubilization of phosphate and better uptake of micronutrients like Zn, which is a precursor of auxin ultimately improved plant growth and flower spike. Similar results were reported by Srivastava and Govil (2007) in gladiolus cv. White Prosperity. Kumar *et al*. (2011) in gladiolus cv. Sancerre reported that biofertilizers increased the plant height and number of leaves which ultimately resulted in increased flower attributes like spike length, rachis length and number of florets. The beneficial effect of biofertilizers which enhanced nutrient availability to plants resulting in increased flower quality of gladiolus was reported by Godse *et al*. (2006).

On the other hand, the reason behind the lowest mean diameter of florets in the spikes of control plots and the plots receiving individual nutrient sources may be due to uptake of essential nutrients in less than required amount leading to flaccidity and de plasmolysis of cells in turn leading to reduced size of cells and that of petals. Moreover, in the spikes from INM treated plots, there may be adequate availability of carbohydrates which might have facilitated higher rate of respiration necessary for cell division, cell expansion and providing carbon skeleton for the tissue structure contributing to floret expansion, formation of cell constituents and thus caused increased floret size (Singh *et al*., 2005). Similar results were found by Mahesh *et al*. (2011) in gladiolus.

4.2.8 Durability of spike (days)

The observations pertaining to flowering duration were recorded and the mean data so obtained are presented in Table 4.6. From the table, it could be inferred that duration of flowering recorded from full bloom of first floret up to the stage till 70% florets wilt, was found more in T_{12} (50% NPK + 25% Pig manure + Biofertilizers) with 19.87 days at par with T_{11} (50% NPK + 25% FYM + Biofertilizers) and T_7 (50% NPK + 50% Pig manure) in the order of 19.72 and 19.66 days respectively in the first year of experiment. T_0 recorded the lowest durability (15.42) was at par with T_9 (50% NPK + Biofertilizers) (17.28) and T_5 (Biofertilizers) (16.97).

Almost similar trend of result was observed in the second season with T_{12} (50% NPK + 25% Pig manure + Biofertilizers) recording the longest durability of 18.97 days which was at par with T_7 (50% NPK + 50% Pig manure) (18.88) and T_{11} (50% NPK + 25% FYM + Biofertilizers) (18.84).

Pooled data analysis showed that the durability was highest in T_{12} (50% NPK + 25% Pig manure + Biofertilizers) (19.42 days) and it was at par with T_{11} (50% NPK + 25% FYM + Biofertilizers) (19.28 days), T_7 (50% NPK + 50% Pig manure) (18.84 days) and T_{10} (75% NPK + Biofertilizers) (18.37 days). The lowest durability of spikes was observed in control. Duration of flowering was reduced by almost a week in control grown plants (14.93 days).

The longer durability of whole spikes in INM might be due to optimum content of nutrients in the plant tissues and their continuous supply to the flowering spikes which might have improved the quality of the spikes and more number and longer durability of individual florets which in turn might have increased the self life of the spikes. Singh *et al*. (2008) and Dubey and Misra (2006) also found best growth and flowering characters in gladiolus with the combined application of nutrients.

Table 4.6: Diameter of floret (cm) and durability of spikes as influenced by various nutrient sources

Treatments	Diameter of floret (cm)			Durability of spikes (days)		
	2014-15	**2015-16**	**Pooled**	**2014-15**	**2015-16**	**Pooled**
T_0	9.21	8.78	8.99	15.42	14.44	14.93
T_1	9.67	9.31	9.49	17.55	16.54	17.04
T_2	9.79	9.31	9.55	17.89	16.63	17.26
T_3	9.71	9.11	9.41	17.51	16.46	16.98
T_4	10.18	9.68	9.93	18.83	17.86	18.35
T_5	9.35	8.95	9.15	16.97	16.00	16.48
T_6	10.25	10.12	10.18	19.27	18.50	18.89
T_7	10.30	10.12	10.21	19.66	18.88	19.27
T_8	10.09	9.86	9.97	18.63	17.51	18.07
T_9	9.82	9.41	9.62	17.28	16.40	16.84
T_{10}	10.21	9.97	10.10	18.72	18.01	18.37
T_{11}	**10.54**	10.11	10.32	19.72	18.84	19.28
T_{12}	10.53	**10.13**	**10.33**	**19.87**	**18.97**	**19.42**
T_{13}	10.16	9.96	10.06	18.84	17.65	18.25
SEm±	0.33	0.27	0.21	0.67	0.69	0.48
CD at 5%	1.02	0.77	0.69	1.95	2.01	1.57

4.3 Yield

Yield is the manifestation of various yield components. Significantly higher yields were recorded with the application of integrated nutrient sources over the control and individual application of nutrient sources. The low yield in unfertilized treatment was due to their lower yield-attributing characters. Treatments applied with manures showed better system productivity. It might be owing to the direct and residual effect of manures which become pronounced in the productivity during crop cycle because of improvement of soil parameters overtime.

4.3.1 Flower production

Table 4.7 showed that the number of spikes plant^{-1}, plot^{-1} and hectare^{-1} are significantly influenced by the application of various sources of nutrient.

4.3.1.1 Spikes plant^{-1}

It can be inferred from the data in Table 4.7 that the spikes plant^{-1} was also significantly influenced by combined application of inorganic fertilizers, organic manures and bio-fertilizers. Highest spikes plant^{-1} (1.50) was recorded in T_{12} (50% NPK + 25% Pig manure + Biofertilizers) which was at par with T_{11} (50% NPK + 25% FYM + Biofertilizers) (1.49) in the first year. The lowest spikes plant^{-1} (1.18, 1.27 and 1.28) respectively was recorded in T_0 (Control), T_5 (Biofertilizers) and T_9 (50% NPK + Biofertilizers).

Similarly, in 2015-16, T_{12} (50% NPK + 25% Pig manure + Biofertilizers) gave the highest spikes plant^{-1} (1.47) which showed at par values with T_{11} (50% NPK + 25% FYM + Biofertilizers) (1.45) and T_7 (50% NPK + 50% Pig manure) (1.43). The lowest spike plant^{-1} (1.11) was recorded in control which was significantly lower than all the rest of the treatments.

Pooled data of both the years depicted a similar trend, T_{12} (50% NPK + 25% Pig manure + Biofertilizers) gave the highest spike plant^{-1} (1.48) which was at par with T_{11} (50% NPK + 25% FYM + Biofertilizers) (1.47) and T_7 (50% NPK + 50% Pig manure) (1.46). Control recorded minimum spike plant^{-1} (1.15) which differed from other treatments significantly.

The increased spikes plant^{-1} might be due to continuous supply and uptake of nutrients with higher moisture content, conversion of non available nutrients to available forms by biofertilizers during different growth stages which stimulate more cell elongation and cell division lead to more number of leaves. Leaves are the main photosynthetic apparatus in plants, synthesizing various metabolites required for plant growth and development. Nitrogen being a constituent of chlorophyll might have increased the leaf area there by more synthesis of carbohydrates, which are utilized in building up of new cells then finally leads to more spike production. These results are in agreement with that of Pansuriya (2015) in gladiolus.

A thorough analysis of the data proved that a difference of 25% or 50% manures or compost in the INM treatments produced yield equivalent to that produced by half dose of NPK. The results are in accordance with the findings of Singh *et al*. (2008) who reported that the reduction to the tune of 25% in recommended dose of N, P and K could be made with the application of farmyard manure.

4.3.1.2 Spikes plot^{-1}

The spikes plot^{-1} was found significantly higher in almost all the INM treatments as compared to control. In 2014-15, treatment T_{12} (50% NPK + 25% Pig manure + Biofertilizers) recorded the highest spikes plot^{-1} (29.93) which was at par with T_{11} (50% NPK + 25% FYM + Biofertilizers) (29.73) and T_7 (50% NPK + 50% Pig manure) (29.67). The minimum spikes plot^{-1} (23.67) was obtained in control which was at par with T_5 (Biofertilizers) (25.40) and T_9 (50% NPK + Biofertilizers) (25.67).

In the year 2015-16, the highest spikes plot^{-1} (29.40) was recorded in T_{12} (50% NPK + 25% Pig manure + Biofertilizers) which was at par with T_{11} (50% NPK + 25% FYM + Biofertilizers) (29.00) and T_7 (50% NPK + 50% Pig manure) (28.67). Control recorded the minimum spikes plot^{-1} (22.20) which was significantly lower than the other treatments.

Similarly, in the pooled analysis, T_{12} (50% NPK + 25% Pig manure + Biofertilizers) (29.67) showed maximum spikes plot^{-1} and it was at par with T_{11} (50% NPK + 25% FYM + Biofertilizers) (29.37), T_7 (50% NPK + 50% Pig manure) (29.17), T_6 (50% NPK + 50% FYM) (28.67), T_{13} (50% NPK + 25% Vermicompost + Biofertilizers) (28.33), T_8 (50% NPK + 50% Vermicompost) (28.03), T_4 (100% NPK) (28.00) while significantly lower spike plot^{-1} was recorded in T_0 (22.93).

4.3.1.3 Spike hectare^{-1}

The projected yield of spike hectare^{-1} in the year 2014-15 was highest (1,99,566) in T_{12} (50% NPK + 25% Pig manure + Biofertilizers) followed by T_{11} (50% NPK + 25% FYM + Biofertilizers) (1,98,232), T_7 (50% NPK + 50% Pig manure) (1,97,788), T_6 (50% NPK + 50% FYM) (1,93,343), T_{13} (50% NPK + 25% Vermicompost + Biofertilizers) (1,91,121), T_4 (100% NPK), T_8 (50% NPK + 50% Vermicompost) (1,88,898) and T_2 (Pig manure @ 35 t ha^{-1}) (1,84,454) which were also statistically at par among themselves while the lowest yield was recorded in control (1,57,786), T_5 (Biofertilizers) (1,69,342) and T_9 (50% NPK + Biofertilizers) (1,71,120).

Similar result was obtained in the second year of experiment. T_{12} (50% NPK + 25% Pig manure + Biofertilizers) resulted in maximum spikes hectare^{-1} (1,96,010) which was followed by T_{11} (50% NPK + 25% FYM + Biofertilizers) (193343) and T_7 (50% NPK + 50% Pig manure) (191121) while control noted significantly lower reading than all the other treatments *i.e.* 1,48,007.

Pooled data revealed no differential result, T_{12} (50% NPK + 25% Pig manure + Biofertilizers) (1,97,788) recorded the highest spikes which was at par with T_{11} (50% NPK + 25% FYM + Biofertilizers) (1,95,787), T_7 (50% NPK + 50% Pig manure) (1,94,454), T_6 (50% NPK + 50% FYM) (1,91,120), T_{13} (50% NPK + 25% Vermicompost + Biofertilizers) (1,88,898), T_8 (50% NPK + 50% Vermicompost) (1,86,898), T_4 (100% NPK) (1,86,676) while the significantly lowest spikes hectare^{-1} (1,52,896) was recorded in control. The magnitude of increase was about 26% in T_{12} (50% NPK + 25% Pig manure + Biofertilizers) over that with control while over other treatments containing differential dose of pig manure *i.e.* T_7 (50% NPK + 50% Pig manure) and T_2 (Pig manure @ 35 t ha^{-1}) was 1.71% and 8.54% respectively. Similarly, the magnitude of increase in T_{11} (50% NPK + 25% FYM + Biofertilizers) was 2.44% and 11.52% over that of T_6 (50% NPK + 50% FYM) and T_1 (FYM @ 40 t ha-^{1}) while the magnitude of increase in T_{13} (50% NPK + 25% Vermicompost + Biofertilizers) was pronounced to be 1.07% and 8.97% over T_8 (50% NPK + 50% Vermicompost) and T_3 (Vermicompost @ 10 t ha^{-1}) respectively.

In this study the treatment, T_0 (control), T_1 (FYM 100 %), T_2 (Pig manure 100 %), T_3 (Vermicompost 100 %), T_4 (100% RDF), T_5 (Biofertilizer) and T_9 (50 % RDF+ Biofertilizer) recorded lesser spike yield than the other treatments. The reduction of spike yield may be due to poor initial vegetative growth as compared to the INM-based treatments leading to reduction in yield attributing characters. The increased spike yield could be due to increase in the yield attributing characters such as number of leaves, leaf area index and total chlorophyll content. The increased spike yield in the integrated nutrient treatments such as T_{12}, T_{11}, T_6, T_7 and T_{13} might be attributed to higher mineralization of various essential elements due to increased microbial activity and organic colloids resulting in better availability and uptake of these elements ultimately resulting in increased photosynthetic activity. The increased photosynthetic activity in turn would have

Table 4.7: Yield of spikes plant^{-1}, plot^{-1} and hectare^{-1} as influenced by various nutrient sources

T	Spikes								
	Plant^{-1}			Plot^{-1}			Hectare^{-1}		
	2014-15	**2015-16**	**Pooled**	**2014-15**	**2015-16**	**Pooled**	**2014-15**	**2015-16**	**Pooled**
T_0	1.18	1.11	1.15	23.67	22.20	22.93	157786	148007	152896
T_1	1.35	1.28	1.32	27.00	25.67	26.33	180009	171120	175564
T_2	1.38	1.35	1.37	27.67	27.00	27.33	184454	180009	182231
T_3	1.33	1.27	1.30	26.67	25.33	26.00	177787	168897	173342
T_4	1.42	1.38	1.4	28.333	27.67	28.00	188898	184454	186676
T_5	1.27	1.28	1.27	25.40	25.53	25.47	169342	170231	169786
T_6	1.45	1.42	1.43	29.00	28.33	28.67	193343	188898	191120
T_7	1.48	1.43	1.46	29.67	28.67	29.17	197788	191121	194454
T_8	1.42	1.39	1.40	28.33	27.73	28.03	188898	184898	186898
T_9	1.28	1.28	1.28	25.67	25.60	25.63	171120	170675	170897
T_{10}	1.35	1.37	1.36	27.00	27.33	27.17	180009	182231	181120
T_{11}	1.49	1.45	1.47	29.73	29.00	29.37	198232	193343	195787
T_{12}	**1.50**	**1.47**	**1.48**	**29.93**	**29.40**	**29.67**	**199566**	**196010**	**197788**
T_{13}	1.43	1.40	1.42	28.67	28.00	28.33	191121	186676	188898
SEm ±	0.05	0.05	0.03	0.92	0.99	0.68	6136	6641	4521
CD at 5%	0.13	0.15	0.11	2.68	2.90	2.21	17839	19307	14759

increased assimilation of photosynthates resulting in a higher C: N ratio. An increase in the higher C: N ratio might have helped in increasing number of spikes, florets spike^{-1}, spike weight and spike yield plot^{-1} in the integrated treatments as compared with the application of sole nutrient source. Efficacy of the inorganic fertilizers was pronounced when they are combined with organic manures was the probable remedy for this problem. Similar results were obtained by Suseela *et al*. (2016) who reported low flower yield with only chemical fertilizers.

4.3.2 Corm and cormel production

4.3.2.1 Diameter of corm

Diameter of corm was significantly influenced by the application of INM-oriented treatments as presented in the Table 4.8. Corm diameter ranged between 5.77 cm and 6.91 cm in the pooled data of the experiments. Treatment T_{11} (50% NPK + 25% FYM + Biofertilizers) (7.46 cm) recorded the highest corm diameter which was at par with T_{12} (50% NPK + 25% Pig manure + Biofertilizers) (7.36 cm), T_7 (50% NPK + 50% Pig manure) (7.35 cm) and T_6 (50% NPK + 50% FYM) (7.32 cm) in the first year of experiment. The lowest corm diameter was observed in control (6.28 cm), T_5 (Biofertilizers) (6.30 cm), T_3 (Vermicompost @ 10 t ha^{-1}) (6.83 cm) and T_9 (50% NPK + Biofertilizers) (6.86 cm).

In the second year, T_{12} (50% NPK + 25% Pig manure + Biofertilizers) (6.39 cm) performed the best among the treatments which was statistically at par with T_{11} (50% NPK + 25% FYM + Biofertilizers) (6.36 cm). Control exhibited the lowest corm diameter in the second year of experiment 5.25 cm which registered at par values with T_5 (Biofertilizers) (5.27 cm), T_9 (50% NPK + Biofertilizers) (5.30 cm), T_1 (FYM @ 40 t ha^{-1}) (5.42 cm), T_3 (Vermicompost @ 10 t ha^{-1}) (5.81 cm).

In pooled data analysis, T_{11} (50% NPK + 25% FYM + Biofertilizers) (6.91 cm) recorded the maximum corm diameter which was at par with T_{12} (50% NPK + 25% Pig manure + Biofertilizers) (6.88 cm), T_7 (50% NPK + 50% Pig manure) (6.85 cm) and T_6 (50% NPK + 50% FYM) (6.82 cm) while control recorded the least corm diameter (5.77 cm) which was at par with T_5 (Biofertilizers) (5.79 cm), T_9 (50% NPK + Biofertilizers) (6.08 cm) and T_1 (FYM @ 40 t ha^{-1}) (6.17 cm).

4.3.2.2 Corms $plant^{-1}$

The corms $plant^{-1}$ was significantly influenced by the various treatments under study which is presented in Table 4.8. In 2014-15, the maximum corms (1.55) was obtained in T_7 (50% NPK + 50% Pig manure) and T_{12} (50% NPK + 25% Pig manure + Biofertilizers) while the lowest corms $plant^{-1}$ was obtained in T_0 (1.20).

During 2015-16, the highest corms (1.51) was recorded in T_{12} (50% NPK + 25% Pig manure + Biofertilizers) and T_7 (50% NPK + 50% Pig manure) while the lowest was with control (1.22).

Similar result was depicted in the pooled data analysis. The highest corm yield was obtained in T_7 (50% NPK + 50% Pig manure) and T_{12} (50% NPK + 25% Pig manure + Biofertilizers) (1.53) which was at par with the rest of the treatments except T_0 (1.21), T_5 (Biofertilizers) (1.30) and T_9 (50% NPK + Biofertilizers) (1.33).

4.3.2.3 Weight of corm $plant^{-1}$

The effect of various nutrient sources on weight of corm $plant^{-1}$ was significant. The data regarding weight of corm $plant^{-1}$ as influenced by various treatments is presented in Table 4.8. The perusal of the data revealed that weight

Table 4.8: Corm diameter (cm), corms plant^{-1} and weight of corms plant^{-1} (g) as influenced by various nutrient sources

T	Corm diameter (cm)			Corms plant^{-1}			Weight of corms plant^{-1} (g)		
	2014-15	**2015-16**	**Pooled**	**2014-15**	**2015-16**	**Pooled**	**2014-15**	**2015-16**	**Pooled**
T_0	6.28	5.25	5.77	1.20	1.22	1.21	82.07	72.66	77.37
T_1	6.91	5.42	6.17	1.45	1.40	1.42	98.19	87.68	92.93
T_2	7.00	5.97	6.49	1.45	1.33	1.39	93.77	94.22	93.99
T_3	6.83	5.81	6.32	1.40	1.41	1.41	97.87	84.41	91.14
T_4	7.27	6.16	6.71	1.48	1.43	1.46	98.67	96.78	97.72
T_5	6.30	5.27	5.79	1.35	1.24	1.30	79.30	75.91	77.60
T_6	7.32	6.32	6.82	1.48	1.43	1.45	99.75	98.35	99.05
T_7	7.35	6.35	6.85	**1.55**	1.51	1.53	100.16	**98.80**	99.48
T_8	7.17	6.18	6.68	1.50	1.42	1.46	99.80	96.20	98.00
T_9	6.86	5.30	6.08	1.37	1.30	1.33	88.40	83.80	86.10
T_{10}	7.11	6.00	6.56	1.48	1.42	1.45	99.48	93.49	96.48
T_{11}	**7.46**	6.36	**6.91**	1.52	1.50	1.51	100.27	98.39	99.33
T_{12}	7.36	**6.39**	6.88	**1.55**	**1.51**	**1.53**	**100.70**	98.36	**99.52**
T_{13}	7.34	6.30	6.82	1.53	1.48	1.51	100.10	97.71	98.90
SEm ±	0.22	0.24	0.16	0.06	0.06	0.04	3.64	4.20	2.78
CD at 5%	0.65	0.70	0.54	0.17	0.17	0.14	10.58	12.20	9.07

of corms differed significantly among the various treatments. Maximum weight of corm (100.70 g) was recorded with the application of T_{12} (50% NPK + 25% Pig manure + Biofertilizers) in the year 2014-15 followed by T_{11} (50% NPK + 25% FYM + Biofertilizers) (100.27 g). The lowest weight of corm was obtained in T_5 (Biofertilizers) (79.30 g) which was at par with control (82.07 g) and T_9 (50% NPK + Biofertilizers) (88.40 g).

In the year 2015-16, the highest corm weight was obtained in T_7 (50% NPK + 50% Pig manure) (98.80 g) which showed at par values with T_{11} (50% NPK + 25% FYM + Biofertilizers) (98.39 g) while T_0 recorded the lowest weight of corm plant^{-1} *i.e.* 75.91 g.

Pooled data analysis revealed that T_{12} (50% NPK + 25% Pig manure + Biofertilizers) produced the highest weight of corm (99.52 g) followed by T_7 (50% NPK + 50% Pig manure) (99.48 g) and they were at par with the rest of the treatments except T_0 (77.37 g) which registered the lowest reading and T_5 (Biofertilizers) (77.60 g).

4.3.2.4 Weight of corms plot^{-1}

In the first year, the weight of corms plot^{-1} was highest in T_{12} (50% NPK + 25% Pig manure + Biofertilizers) (2.02 kg**)** which was at par with T_{11} (50% NPK + 25% FYM + Biofertilizers) (2.01 kg). T_5 (Biofertilizers) noted the least corm weight plot^{-1} (1.59 kg plot^{-1}) which was at par with T_0 (1.64 kg) and T_9 (50% NPK + Biofertilizers) (1.77 kg) (Table 4.9).

Similar trend of result was obtained in the second year where T_{11} (50% NPK + 25% FYM + Biofertilizers) recorded the maximum weight of corms (1.98 kg) which was at par with T_6 (50% NPK + 50% FYM), T_7 (50% NPK + 50% Pig manure), T_{12} (50% NPK + 25% Pig manure + Biofertilizers) which gave equal weight of corms of 1.97 kg. The least corm weight was observed in T_0 (1.45 kg), T_5 (Biofertilizers) (1.52 kg), T_9 (50% NPK + Biofertilizers) (1.68 kg).

Mean data of the two years study showed that the highest weight of corms were obtained in T_{11} (50% NPK + 25% FYM + Biofertilizers) and T_{12} (50% NPK + 25% Pig manure + Biofertilizers) (1.99 kg) which were at par with T_6 (50% NPK + 50% FYM), T_7 (50% NPK + 50% Pig manure) and T_{13} (50% NPK + 25% Vermicompost + Biofertilizers) all of which has yielded 1.98 kg of corms plot^{-1}. Control recorded the minimum weight of 1.55 kg followed by T_5 (Biofertilizers) (1.56 kg) which differed from the rest of the treatments significantly.

4.3.2.5 Yield of corms hectare^{-1}

Projected yield of corms was found to be the maximum under those treatments receiving integrated sources of nutrients in both the years of study (Table 4.9). Treatment T_{12} (50% NPK + 25% Pig manure + Biofertilizers) recorded the highest corm yield (13.42 t ha^{-1}) and it was at par with T_{11} (50% NPK + 25% FYM + Biofertilizers) (13.37 t ha^{-1}), T_7 (50% NPK + 50% Pig manure) (13.36 t ha^{-1}), T_{13} (50% NPK + 25% Vermicompost + Biofertilizers) (13.35 t ha^{-1}). On the contrary, T_5 (Biofertilizers) recorded the lowest yield (10.57 t ha^{-1}) which was at par with T_0 (10.94 t ha^{-1}) and T_9 (50% NPK + Biofertilizers) (11.79 t ha^{-1}).

Similar trend in the result was observed in the second year where T_{11} (50% NPK + 25% FYM + Biofertilizers) with a yield of 13.13 t ha^{-1} recorded the maximum reading among all the treatments which was at par with T_6 (50% NPK + 50% FYM) and T_{12} (50% NPK + 25% Pig manure + Biofertilizers) both yielding 13.12 t ha^{-1}, T_7 (50% NPK + 50% Pig manure) (13.11 t ha^{-1}) and T_{13} (50% NPK + 25% Vermicompost + Biofertilizers) (13.03 t ha^{-1}). Here also control has registered the lowest value (9.69 t ha^{-1}).

Pooled analysis of the data of two years indicated that T_{12} (50% NPK + 25% Pig manure + Biofertilizers) and T_{11} (50% NPK + 25% FYM + Biofertilizers) projected the highest corm yields, 13.27 and 13.25 t ha^{-1}. The magnitude of increase in yield due to T_{12} and T_{11} over control (10.32 t ha^{-1}) was 28.59% and

Table 4.9: Weight of corms plot^{-1} (kg) and yield of corms (t ha^{-1}) as influenced by various nutrient sources

Treatments	Weight of corms plot^{-1} (kg)			Yield of corms (t ha^{-1})		
	2014-15	**2015-16**	**Pooled**	**2014-15**	**2015-16**	**Pooled**
T_0	1.64	1.45	1.55	10.94	9.69	10.32
T_1	1.96	1.75	1.86	13.09	11.69	12.39
T_2	1.88	1.88	1.88	12.50	12.56	12.53
T_3	1.96	1.69	1.82	13.05	11.26	12.15
T_4	1.97	1.94	1.95	13.16	12.91	13.03
T_5	1.59	1.52	1.55	10.57	10.12	10.35
T_6	2.00	1.97	1.98	13.30	13.12	13.21
T_7	2.00	1.97	1.98	13.36	13.11	13.23
T_8	2.00	1.92	1.96	13.31	12.83	13.07
T_9	1.77	1.68	1.72	11.79	11.17	11.48
T_{10}	1.99	1.87	1.93	13.27	12.47	12.87
T_{11}	2.01	**1.97**	1.99	13.37	**13.12**	13.25
T_{12}	**2.01**	1.97	**1.99**	**13.42**	13.12	**13.27**
T_{13}	2.00	1.95	1.98	13.35	13.03	13.19
SEm ±	0.08	0.08	0.06	0.56	0.56	0.37
CD at 5%	0.24	0.24	0.18	1.63	1.63	1.21

28.39% respectively. Conjunctive use of soil amendments, balanced chemical fertilizers and organic manures improves the soil physio-chemical and biological properties and thus produces sustainable crop yields (Hota *et al*., 2014).

4.3.2.6 Cormels plant^{-1}

An examination of the data (Table 4.10) revealed that during the year 2014-15 there was a significant difference in cormels plant^{-1} among the treatments. T_6 (50% NPK + 50% FYM) resulted in significantly higher cormels plant^{-1} (15.13) than the rest of the treatments except T_{12} (50% NPK + 25% Pig manure + Biofertilizers) (15.00), T_{11} (50% NPK + 25% FYM + Biofertilizers) (14.97) and T_7 (50% NPK + 50% Pig manure) (14.93) which showed at par values with each other. The lowest cormels plant^{-1} among the treatments were T_0 (11.57), T_5 (Biofertilizers) (12.70) and T_9 (50% NPK + Biofertilizers) (12.94).

Almost similar result was obtained during the second year of experiment where T_{11} (50% NPK + 25% FYM + Biofertilizers) (13.80) recorded the highest cormels plant^{-1} while the lowest was with T_0 (11.57).

In the pooled analysis of the experiments, treatment T_{11} (50% NPK + 25% FYM + Biofertilizers) and T_{12} (50% NPK + 25% Pig manure + Biofertilizers) showed significant increase in cormels plant^{-1} (14.38) followed by T_7 (50% NPK + 50% Pig manure) (14.34) and T_6 (50% NPK + 50% FYM) (14.32) which were also significantly at par. Here also the lowest reading was obtained in T_0 (11.57), T_5 (Biofertilizers) (12.06) and T_9 (50% NPK + Biofertilizers) (12.28).

4.3.2.7 Weight of cormels plant^{-1}

It is apparent from the data presented in Table 4.10 that weight of cormels was significantly influenced by the application of various treatments. The highest weight of cormels plant^{-1} was obtained in T_{12} (50% NPK + 25% Pig manure + Biofertilizers) in both the years of experiment as well as in pooled data analysis. In

Table 4.10: Cormels plant^{-1} and weight of cormels plant^{-1} (g) as influenced by various nutrient sources

Treatments	Cormels plant^{-1}			Weight of cormels plant^{-1} (g)		
	2014-15	**2015-16**	**Pooled**	**2014-15**	**2015-16**	**Pooled**
T_0	11.57	11.57	11.57	3.71	3.07	3.39
T_1	13.39	12.30	12.85	4.18	3.93	4.06
T_2	13.47	12.87	13.17	3.97	4.44	4.20
T_3	13.78	11.82	12.80	3.88	4.02	3.95
T_4	13.92	13.33	13.63	4.49	4.49	4.49
T_5	12.70	11.42	12.06	3.79	3.60	3.69
T_6	**15.13**	13.51	14.32	4.74	4.89	4.82
T_7	14.93	13.74	14.34	5.05	4.86	4.95
T_8	13.97	12.62	13.29	4.59	4.57	4.58
T_9	12.94	11.62	12.28	3.89	3.86	3.88
T_{10}	13.87	12.81	13.34	3.99	4.50	4.25
T_{11}	14.97	**13.80**	**14.38**	4.85	4.89	4.87
T_{12}	15.00	13.76	14.38	**5.06**	**4.95**	**5.01**
T_{13}	14.09	13.09	13.59	4.52	4.67	4.60
SEm ±	0.59	0.49	0.384	0.27	0.25	0.18
CD at 5%	1.71	1.44	1.25	0.77	0.73	0.60

Plate 5. Corms at harvest

Plate 6. Cormels at harvest

2014-15, T_{12} recorded the highest weight of cormels plant^{-1} (5.06 g) which was at par with T_7 (50% NPK + 50% Pig manure) (5.05 g), T_{11} (50% NPK + 25% FYM + Biofertilizers) (4.85 g). Control recorded minimum weight of cormels plant^{-1} (3.71 g).

During 2015-16, the maximum weight of cormels plant^{-1} was obtained in T_{12} (50% NPK + 25% Pig manure + Biofertilizers) (4.95 g) which was at par with T_6 (50% NPK + 50% FYM) and T_{11} (50% NPK + 25% FYM + Biofertilizers) both yielded 4.89 g, T_7 (50% NPK + 50% Pig manure) (4.86 g), T_{13} (50% NPK + 25% Vermicompost + Biofertilizers) (4.67 g), T_4 (100% NPK) (4.49 g) and T_2 (Pig manure @ 35 t ha^{-1}) (4.44). While the lowest weight of cormels (3.07 g) was registered in control which differed significantly from the rest of the treatments.

In pooled data analysis, similar result was recorded. T_{12} (50% NPK + 25% Pig manure + Biofertilizers) excelled better than the rest of the treatments with 5.01 g cormels plant^{-1} followed by T_7 (50% NPK + 50% Pig manure) (4.95 g) and T_{11} (50% NPK + 25% FYM + Biofertilizers) (4.87 g), T_{13} (50% NPK + 25% Vermicompost + Biofertilizers) (4.60 g), T_8 (50% NPK + 50% Vermicompost) (4.58 g) and T_4 (100% NPK) (4.49 g) which were at par with each other. Significantly lower weight of cormels plant^{-1} (3.39 g) was observed in control.

4.3.2.8 Weight of cormels plot^{-1}

Data embodied in Table 4.11 revealed that the treatments responded significantly to different nutrients applied. The maximum weight of cormels plot^{-1} was recorded in T_7 (50% NPK + 50% Pig manure) and T_{12} (50% NPK + 25% Pig manure + Biofertilizers) (0.101 kg) in 2014-15 which were at par with T_{11} (50% NPK + 25% FYM + Biofertilizers) (0.097 kg), T_6 (50% NPK + 50% FYM) (0.095 kg), T_8 (50% NPK + 50% Vermicompost) (0.092 kg), T_{13} (50% NPK + 25% Vermicompost + Biofertilizers) (0.091 kg) and T_4 (100% NPK) (0.090 kg). Control recorded the minimum weight of cormels plot^{-1} (0.074 kg) which was followed by T_5 (Biofertilizers) (0.076 kg), T_3 (Vermicompost @ 10 t ha^{-1}) and T_9 (50% NPK + Biofertilizers) (0.078 kg).

While in the 2015-16, T_{11} (50% NPK + 25% FYM + Biofertilizers) (0.099 kg) exhibited the maximum reading which was followed by T_6 (50% NPK + 50% FYM) and T_{12} (50% NPK + 25% Pig manure + Biofertilizers) (0.098 kg), T_7 (50% NPK + 50% Pig manure) (0.097 kg) and T_{13} (50% NPK + 25% Vermicompost + Biofertilizers) (0.093 kg). Control recorded the minimum value (0.061 kg) which was at par with T_5 (Biofertilizers) (0.072 kg).

Similar result was observed in the pooled analysis in which T_{12} (50% NPK + 25% Pig manure + Biofertilizers) gave the highest cormel weight (0.100 kg) and it was at par with T_7 (50% NPK + 50% Pig manure) (0.099 kg), T_{11} (50% NPK + 25% FYM + Biofertilizers) (0.098 kg), T_6 (50% NPK + 50% FYM) (0.096 kg), T_{13} (50% NPK + 25% Vermicompost + Biofertilizers) and T_8 (50% NPK + 50% Vermicompost) with both treatments yielding 0.092 kg. A significantly lower weight of cormels $plot^{-1}$ was observed in control (0.068 kg).

4.3.2.9 Yield of cormels ha^{-1}

The data on projected yield of cormels ha^{-1} in 2014-15 (Table 4.11) indicates that the projected yield was maximum under T_{12} (50% NPK + 25% Pig manure + Biofertilizers) (0.675 t ha^{-1}), T_7 (50% NPK + 50% Pig manure) (0.673 t ha^{-1}) and T_{11} (50% NPK + 25% FYM + Biofertilizers) (0.647 t ha^{-1}). The lowest yield was observed in control (0.495 t ha^{-1}) followed by T_5 (Biofertilizers) (0.505 t ha^{-1}).

Similar yield data was obtained in the year 2015-16 where the highest yield was recorded in T_{11} (50% NPK + 25% FYM + Biofertilizers) (0.660 t ha^{-1}) which was at par with T_6 (50% NPK + 50% FYM) (0.653 t ha^{-1}), T_7 (50% NPK + 50% Pig manure) (0.647 t ha^{-1}), T_{13} (50% NPK + 25% Vermicompost + Biofertilizers)

(0.623 t ha^{-1}) while the minimum projected yield was registered in control (0.410 t ha^{-1}) and T_5 (Biofertilizers) (0.480 t ha^{-1}).

Study conducted for 2 years revealed that the highest yield of cormels hectare^{-1} was with treatment combination of half dose of recommended fertilizers, a quarter dose of organic manure amended with biofertilizers. T_{12} (50% NPK + 25% Pig manure + Biofertilizers) with a yield of 0.664 t ha^{-1} was noted as the highest value and it was at par with T_7 (50% NPK + 50% Pig manure) (0.660 t ha^{-1}), T_{11} (50% NPK + 25% FYM + Biofertilizers) (0.653 t ha^{-1}), T_6 (50% NPK + 50% FYM) (0.642 t ha^{-1}), T_{13} (50% NPK + 25% Vermicompost + Biofertilizers) (0.613 t ha^{-1}), T_8 (50% NPK + 50% Vermicompost) (0.610 t ha^{-1}) and T_4 (100% NPK) (0.599 t ha^{-1}) while control noted the lowest yield (0.452 t ha^{-1}) which differed significantly from the rest of the treatments. The magnitude of increase in T_{12} over control was about 47%.

A noticeable rise in corm and cormels yield in INM especially in the plot treated with pig manures *i.e.* T_7 (50% NPK + 50% Pig manure) and T_{12} (50% NPK + 25% Pig manure + Biofertilizers) might be because of the more content and better availability of phosphorous which is particularly needed for growth of corms. The beneficial effect of pig manure in production of corms was more intense when corms were inoculated with biofertilizers in addition to chemical fertilizers that led the treated plants to store more carbohydrates through an effective photosynthesis process. As for the increment of corms weight, that could be a result of carbohydrates and nitrogen compound storage in the corms. Soluble nitrogen compounds and carbohydrates are translocated from the leaves to the corms. Corms play the role of a sink source for food storage as explained by Nazki and Arora (2000).

The enhanced availability of nitrogen and phosphorus by through the combined application of manures and fertilizers in the rhizosphere enhanced the weight and size of corms. Similarly, the increase in weight and size of cormels might be due to release of growth promoting hormones and enzymes by the microbes promoting vegetative growth and increase the photosynthetic and metabolic activities causing more transport and utilization of photosynthetic products (Khan & Zaidi, 2002). Hence, plant supplied with sufficient N and P continuously maintained vegetative growth leading to increase in photosynthetic area, which in turn resulted in more accumulation of assimilates and partitioning to the developing corms, which resulted in bigger size corms and number of corms and cormels. The present findings are in confirmation with Dubey and Misra (2005), Singh and Bijimol (2000) and Kathiresan and Venkatesha (2002) in gladiolus.

The leaf as a site of photosynthesis is responsible for variation in the yield. It was also influenced by different sources of nutrients. The increased leaf number and leaf area in the plots treated with INM might have increased the photosynthetic efficiency of the plant leading to the increased production. The treatments containing organic manure as a source of nutrients showed better result in corm and cormel production. This might be attributed to slow and sustained release of nutrients from manures which could help to release nitrogen at slower rate which is helpful for plant growth at later stages of the plant. These organic sources contain nitrogen in complex organic form which requires the mineralization process to be executed for bringing nitrogen in available form. This process is essentially a soil microbiological process carried out by the soil heterotrophic micro flora which is a slow process. As a result the entire nitrogen becomes available to the plants over an extended period of time. These results are in conformity with the findings of Singh *et al*. (2006) in rose and Kabir *et al*. (2011) in tuberose.

Table 4.11: Weight of cormels plot^{-1} (kg) and yield of cormels (t ha^{-1}) as influenced by various nutrient sources

Treatments	Weight of cormels plot^{-1} (kg)			Yield of cormels (t ha^{-1})		
	2014-15	**2015-16**	**Pooled**	**2014-15**	**2015-16**	**Pooled**
T_0	0.074	0.061	0.068	0.495	0.410	0.452
T_1	0.084	0.079	0.081	0.558	0.525	0.541
T_2	0.079	0.089	0.084	0.529	0.592	0.560
T_3	0.078	0.080	0.079	0.518	0.537	0.527
T_4	0.090	0.090	0.090	0.599	0.599	0.599
T_5	0.076	0.072	0.074	0.505	0.480	0.493
T_6	0.095	0.098	0.096	0.632	0.653	0.642
T_7	**0.101**	0.097	0.099	0.673	0.647	0.660
T_8	0.092	0.091	0.092	0.612	0.609	0.610
T_9	0.078	0.077	0.078	0.519	0.515	0.517
T_{10}	0.080	0.090	0.085	0.533	0.601	0.567
T_{11}	0.097	**0.099**	0.098	0.647	**0.660**	0.653
T_{12}	**0.101**	0.098	**0.100**	**0.675**	0.653	**0.664**
T_{13}	0.091	0.093	0.092	0.603	0.623	0.613
SEm ±	0.005	0.005	0.004	0.035	0.033	0.024
CD at 5%	0.015	0.015	0.012	0.103	0.097	0.079

Plate 7. Harvest maturity stage for vase life studies and senescence stage (70% floret wilting)

4.4 Vase life studies

The results on vase life as evident from the pre-harvest treatments exhibited significant variation among themselves in terms of vase life of cut spikes of *Gladiolus primulinus* cv. Candyman. The effect of different nutrient sources on the vase life of gladiolus in a standard solution was investigated in room temperature and the results envisaged that most of the attributes are significantly effected by different treatments.

4.4.1 Changes in fresh weight of spikes during vase life

The data related to changes in fresh weight of spikes presented in Table 4.12 indicated that the impact was quite apparent in different treatments. In general, there was a sharp increase in the fresh weight of spikes in all the treatments on the 3^{rd} day of vase life which gradually decreased thereafter. The cut spikes harvested from the plots receiving integrated nutrient treatments recorded the highest fresh weight during vase life during both the years of experiment and also in pooled analysis. In 2014-15, treatment T_{12} (50% NPK + 25% Pig manure + Biofertilizers) recorded the highest fresh weight (67.79 g) which was at par with T_{11} (50% NPK + 25% FYM + Biofertilizers) (66.45 g), T_7 (50% NPK + 50% Pig manure) (65.90 g) and T_6 (50% NPK + 50% FYM) (65.65 g) and it was observed on the 3^{rd} day of vase life and thereafter there was a decrease in fresh weight in all the treatments with the lowest fresh weight (43.27 g) recorded with control on the 9^{th} day followed by T_5 (Biofertilizers) (44.75 g).

A perusal of the data further showed that the highest fresh weight during the second year *i.e.* 2015-16 was registered on the 3^{rd} day with T_{12} (50% NPK + 25% Pig manure + Biofertilizers) (62.98 g) which was closely followed by T_{11} (50% NPK + 25% FYM + Biofertilizers) (62.94 g) and were also at par with each other. The least fresh weight was recorded in control (40.49 g) and T_5 (Biofertilizers) (43.11 g) which was recorded on the 9^{th} day.

Table 4.12: Influence of various nutrient sources on changes in fresh weight (g) during vase life

Treatments	1st Day			3rd Day			6th Day			9th Day		
	2014-15	**2015-16**	**Pooled**	**2014-15**	**2015-16**	**Pooled**	**2014-15**	**2015-16**	**Pooled**	**2014-15**	**2015-16**	**Pooled**
T_0	50.43	45.44	47.93	52.04	47.06	49.55	48.11	43.82	45.97	43.27	40.49	41.88
T_1	55.30	51.96	53.63	57.69	53.89	55.79	53.36	51.19	52.28	47.69	49.19	48.44
T_2	55.87	52.35	54.11	58.63	54.30	56.47	53.63	51.29	52.46	48.63	50.01	49.32
T_3	54.65	50.81	52.73	57.01	52.52	54.77	52.01	49.33	50.67	47.35	48.40	47.87
T_4	60.10	54.25	57.17	64.03	56.86	60.45	58.97	53.34	56.16	53.40	50.38	51.89
T_5	51.17	49.39	50.28	53.08	51.67	52.38	48.75	48.11	48.43	44.75	43.11	43.93
T_6	62.65	59.32	60.98	65.65	61.24	63.45	59.98	58.02	59.00	54.65	55.61	55.13
T_7	62.69	59.75	61.22	65.90	62.20	64.05	60.33	58.22	59.27	55.05	55.88	55.47
T_8	61.63	57.30	59.47	64.87	59.82	62.34	59.52	55.30	57.41	54.43	53.30	53.87
T_9	53.29	50.37	51.83	55.52	52.98	54.25	51.39	49.75	50.57	46.29	45.42	45.85
T_{10}	57.45	54.11	55.78	60.79	57.04	58.91	56.45	54.16	55.31	51.45	50.16	50.81
T_{11}	62.75	60.73	61.74	66.45	**62.98**	64.72	61.05	59.11	60.08	56.04	57.45	56.75
T_{12}	**64.04**	**60.85**	**62.45**	**67.79**	62.94	**65.37**	**62.53**	**59.43**	**60.98**	**57.37**	**57.48**	**57.43**
T_{13}	60.12	58.96	59.54	64.24	60.73	62.49	60.75	58.80	59.78	55.08	55.03	55.06
SEm±	2.80	2.70	1.94	2.88	2.79	2.01	2.67	2.80	1.93	2.93	2.53	1.94
CD at 5%	8.13	7.84	6.34	8.37	8.12	6.55	7.76	8.13	6.31	8.52	7.36	6.32

Similar result was observed in the pooled data analysis of the two years. The cut spikes harvested from the plots receiving integrated use of nutrient sources recorded the maximum vase life on the 3th day. T_{12} (50% NPK + 25% Pig manure + Biofertilizers) recorded the highest fresh weight (65.37 g) which showed at par readings with T_{11} (50% NPK + 25% FYM + Biofertilizers) (64.72 g), T_7 (50% NPK + 50% Pig manure) (64.05 g). The lowest fresh weight (41.88 g) was observed with control and T_5 (Biofertilizers) (43.93 g) on the 9th day which are also at par with each other.

According to the results, it is inferred that the pre harvest treatments had profound effect on the post harvest life of crop as the treatments which performed better in the field has also performed better in post harvest studies. The fresh weight might have increased as a result of the biological fixation of phosphorous and nitrogen in the portion of roots in the plants which resulted in better absorption of more nutrients and better utilization of them as well. In addition, *Azospirillum* plays a role in the fixation of nitrogen and is also a part of the production of GA, IAA and cytokinin like substances which improves the growth of plants. These results are on the same page with the results of Rajesh *et al.* (2006) who founded that applying bio-fertilizers like phosphate solubilizing bacterium and *Azospirillum* increased the fresh weight of flowers in carnation.

4.4.2 Water uptake

Table 4.13 proved that the water uptake of cut spikes was significantly affected by the applications of various nutrient sources. In general, water uptake was greatest on the 3rd day of vase life which gradually decreased in the following days of observation.

The water absorbed by each spike during vase life also responded similarly to the other post-harvest traits and it was found that during the first year of experiment, cut spikes which were harvested from the plots treated with a combination of 50% NPK + 25% Pig manure + Biofertilizers (T_{12}) consumed the highest amount of water spike^{-1} (21.93 g) on the 3th day. It was statistically at par with T_{11} (50% NPK + 25% FYM + Biofertilizers), T_6 (50% NPK + 50% FYM), T_7 (50% NPK + 50% Pig manure), T_{13} (50% NPK + 25% Vermicompost + Biofertilizers), T_4 (100% NPK), T_{10} (75% NPK + Biofertilizers) and T_8 (50% NPK + 50% Vermicompost). On the contrary, the minimum absorption of water (1.27 g) was observed with T_0 on the 9th day.

The second year investigation revealed similar trend in the result in which T_{12} (50% NPK + 25% Pig manure + Biofertilizers) recorded the highest water uptake (20.89 g) which was noted on the 3rd day followed by T_{11} (50% NPK + 25% FYM + Biofertilizers), T_7 (50% NPK + 50% Pig manure), T_{13} (50% NPK + 25% Vermicompost + Biofertilizers) and T_6 (50% NPK + 50% FYM) which were also at par with each other. The lowest water uptake was registered on the 9th day with control (1.27 g) and it was statistically at par with T_5 (Biofertilizers) (1.41 g).

According to the pooled analysis, T_{12} (50% NPK + 25% Pig manure + Biofertilizers) recorded 21.41 g on the 3rd day of vase life which was higher than all the other treatments however it was at par with T_{11} (50% NPK + 25% FYM + Biofertilizers) (21.26 g) and T_7 (50% NPK + 50% Pig manure) (20.94 g), T_6 (50% NPK + 50% FYM) (20.81 g) and T_{13} (50% NPK + 25% Vermicompost + Biofertilizers) (20.48 g). The minimum water uptake was observed on the 9th day with control (1.27 g) which was significantly lower than the other treatments.

The increase in water uptake may be attributed to more sink potential arising out of more number of florets spike^{-1} as well as larger size of florets. Increase in post-harvest attributes of cut spikes due to application of integrated nutrient sources could be attributed due to the presence of ethylene inhibitors or due to the presence of cytokinins in organic sources which delayed the senescence of flowers. These results are in corroboration with the findings of Chaudhary *et al*.

Table 4.13: Water uptake (g) of cut gladiolus spikes as influenced by various nutrient sources

T	Water uptake (g)								
	3rd Day			6th Day			9th Day		
	2014-15	**2015-16**	**Pooled**	**2014-15**	**2015-16**	**Pooled**	**2014-15**	**2015-16**	**Pooled**
T_0	15.33	11.32	13.33	2.78	2.05	2.41	1.27	1.27	1.27
T_1	18.34	15.38	16.86	3.04	2.72	2.88	1.52	1.46	1.49
T_2	18.00	15.79	16.90	3.11	2.79	2.95	1.48	1.41	1.44
T_3	17.55	14.82	16.19	2.86	2.46	2.66	1.45	1.40	1.42
T_4	20.44	16.87	18.66	3.53	3.08	3.31	1.67	1.63	1.65
T_5	16.47	13.14	14.80	2.99	2.10	2.54	1.41	1.42	1.42
T_6	21.67	19.96	20.81	3.86	3.16	3.51	1.85	1.68	1.77
T_7	21.35	20.54	20.94	3.90	3.29	3.60	1.85	1.70	1.78
T_8	19.49	18.66	19.07	3.67	3.10	3.39	1.82	1.64	1.73
T_9	17.59	15.32	16.45	3.16	2.50	2.83	1.39	1.47	1.43
T_{10}	20.33	17.54	18.94	3.66	3.07	3.37	1.70	1.64	1.67
T_{11}	21.92	20.60	21.26	3.91	3.37	3.64	1.85	1.68	1.77
T_{12}	**21.93**	**20.89**	**21.41**	**3.98**	**3.41**	**3.69**	**1.88**	**1.70**	**1.79**
T_{13}	21.05	19.90	20.48	3.78	3.16	3.47	1.80	1.64	1.72
SEm±	1.00	0.70	0.61	0.21	0.14	0.13	0.10	0.05	0.05
CD at 5%	2.91	2.03	1.99	0.60	0.41	0.41	0.27	0.15	0.18

1^{st} Day

3^{rd} Day

6^{th} Day

9^{th} Day

12^{th} Day

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

(2013) in gladiolus. Also, the increment in water absorption in the spikes harvested from INM treated plots might be due to the fact that the spikes may have greater area of xylem as well as more amounts of carbohydrates resulting in higher water absorption. These results are in accordance with Varu and Barad (2010) in tuberose.

4.4.3 Water loss

As far as water loss is concerned, it varied significantly with respect to different nutrient sources. A perusal of the data in Table 4.14 showed that the water loss in 2014-15 was the lowest in control (5.87 g) which was at par with T_5 (Biofertilizers) (6.48 g), T_3 (Vermicompost @ 10 t ha^{-1}) (14.59 g) and T_9 (50% NPK + Biofertilizers) (14.67 g) while it was the maximum in T_{12} (50% NPK + 25% Pig manure + Biofertilizers) which was recorded to be 17.22 g and was closely followed by T_{11} (50% NPK + 25% FYM + Biofertilizers) (17.06 g).

In 2015-16, similar trend in water loss on the 3rd day was observed. Similar result was obtained in the second year where the lowest water loss was recorded in control (5.55 g) which was found to be at par with T_5 (Biofertilizers) (5.68 g), T_3 (Vermicompost @ 10 t ha^{-1}) (5.84 g), T_9 (50% NPK + Biofertilizers) (5.91 g), T_2 (Pig manure @ 35 t ha^{-1}) (5.96 g) and T_1 (FYM @ 40 t ha^{-1}) (6.06 g). On the contrary, T_{12} (50% NPK + 25% Pig manure + Biofertilizers) exhibiting the greatest water loss of 16.89 g which was at par with T_{11} (50% NPK + 25% FYM + Biofertilizers) (16.84 g), T_7 (50% NPK + 50% Pig manure) (16.65 g), T_8 (50% NPK + 50% Vermicompost) (15.52 g) and T_{13} (50% NPK + 25% Vermicompost + Biofertilizers) (16.17 g).

Analysis of the pooled data showed that the lowest water loss was obtained on the 9th day with control (5.71 g) which was at par with T_5 (Biofertilizers), T_9 (50% NPK + Biofertilizers), T_3 (Vermicompost @ 10 t ha^{-1}) and T_2 (Pig manure @ 35 t ha^{-1}) (6.08g, 6.12 g, 6.17 g and 6.25 g) respectively while the highest water

Table 4.14: Water loss (g) of cut gladiolus spikes as influenced by various nutrient sources

T	Water loss (g)								
	3rd Day			6th Day			9th Day		
	2014-15	**2015-16**	**Pooled**	**2014-15**	**2015-16**	**Pooled**	**2014-15**	**2015-16**	**Pooled**
T_0	13.00	10.37	11.68	7.60	6.48	7.04	5.87	5.55	5.71
T_1	15.00	13.72	14.36	8.06	7.01	7.54	6.91	6.06	6.49
T_2	15.00	13.66	14.33	8.07	7.07	7.57	6.54	5.96	6.25
T_3	14.59	13.11	13.85	7.67	6.96	7.31	6.49	5.84	6.17
T_4	16.44	14.55	15.50	9.27	7.83	8.55	7.04	6.60	6.82
T_5	13.78	11.48	12.63	7.93	6.52	7.23	6.48	5.68	6.08
T_6	16.85	16.64	16.75	9.75	8.09	8.92	7.25	6.61	6.93
T_7	16.58	16.65	16.62	9.79	8.25	9.02	**7.27**	6.82	7.04
T_8	15.43	15.52	15.48	9.31	7.83	8.57	7.11	6.56	6.83
T_9	14.67	13.30	13.98	8.98	7.17	8.08	6.34	5.91	6.12
T_{10}	16.70	15.17	15.94	9.22	7.83	8.52	6.90	6.55	6.73
T_{11}	17.06	16.84	16.95	9.76	8.38	9.07	7.26	**6.83**	7.04
T_{12}	**17.22**	**16.89**	**17.06**	**9.81**	**8.49**	**9.15**	**7.27**	**6.83**	**7.05**
T_{13}	16.53	16.17	16.35	9.54	8.02	8.78	7.02	6.55	6.79
SEm±	0.74	0.43	0.42	0.45	0.46	0.32	0.39	0.28	0.24
CD at 5%	2.14	1.24	1.39	1.30	1.32	1.04	NS	0.81	0.78

loss (17.06 g) was noted with T_{12} (50% NPK + 25% Pig manure + Biofertilizers) and it was closely followed by T_{11} (50% NPK + 25% FYM + Biofertilizers) (16.95 g). Greater water loss in the integrated nutrient treatments might be due to more surface area for transpiration which has resulted from more number of florets and larger floret diameter.

4.4.1 Water balance ratio

The data encamped in Table 4.15 showed that the different nutrient management practices failed to exert significant effect on the water balance ratio under different treatments on all the days of observation.

During the vase life study of the first year, it was observed that the highest water balance ratio (1.293) was recorded on the 3rd day with T_{12} (50% NPK + 25% Pig manure + Biofertilizers) and it was statistically at par with T_{11} (50% NPK + 25% FYM + Biofertilizers) with 1.292 and T_7 (50% NPK + 50% Pig manure) with 1.291 and T_6 (50% NPK + 50% FYM) with 1.285 while the lowest was found in control and T_5 (Biofertilizers) (0.218) on the 9th day of vase life.

During the second year of study, T_{12} (50% NPK + 25% Pig manure + Biofertilizers) (1.236) followed by T_7 (50% NPK + 50% Pig manure) (1.236), T_{13} (50% NPK + 25% Vermicompost + Biofertilizers) (1.232) and T_{11} (50% NPK + 25% FYM + Biofertilizers) (1.223) noted the highest water balance ratio on the 3rd day. On the contrary, T_0 (0.230) followed by T_2 (0.237) registered the minimum reading.

The mean data of the two years study showed that the highest water balance ratio (1.263) was registered in T_{12} (50% NPK + 25% Pig manure + Biofertilizers) (1.265) which was at par with T_7 (50% NPK + 50% Pig manure) while the lowest ratio (0.224) was observed on the 9th day with control followed by T_2 and T_3 where

Table 4.15: Influence of various nutrient sources on the water balance ratio of cut gladiolus spikes

Treatments	Water balance ratio								
	3rd Day			6th Day			9th Day		
	2014-15	**2015-16**	**Pooled**	**2014-15**	**2015-16**	**Pooled**	**2014-15**	**2015-16**	**Pooled**
T_0	1.191	1.088	1.139	0.364	0.315	0.340	0.218	0.230	0.224
T_1	1.222	1.123	1.173	0.377	0.395	0.386	0.225	0.241	0.233
T_2	1.200	1.156	1.178	0.384	0.396	0.390	0.227	0.237	0.232
T_3	1.200	1.131	1.166	0.375	0.354	0.364	0.221	0.242	0.232
T_4	1.242	1.165	1.204	0.384	0.397	0.390	0.239	0.247	0.243
T_5	1.197	1.147	1.172	0.380	0.330	0.355	0.218	0.251	0.235
T_6	1.285	1.200	1.243	0.396	0.399	0.397	0.255	**0.256**	0.256
T_7	1.291	1.236	1.263	0.401	0.400	0.400	**0.258**	0.250	**0.254**
T_8	1.264	1.201	1.232	0.396	0.396	0.396	0.256	0.253	**0.254**
T_9	1.202	1.152	1.177	0.352	0.351	0.351	0.219	0.249	0.234
T_{10}	1.219	1.167	1.193	0.398	0.393	0.395	0.247	0.251	0.249
T_{11}	1.292	1.223	1.258	0.405	0.403	0.404	0.255	0.248	0.251
T_{12}	**1.293**	**1.236**	**1.265**	**0.406**	**0.404**	**0.405**	**0.258**	0.249	**0.254**
T_{13}	1.279	1.232	1.256	0.398	0.397	0.398	0.256	0.251	**0.254**
SEm±	0.070	0.057	0.045	0.027	0.029	0.020	0.015	0.013	0.010
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS

both the treatments registered a ratio of 0.232. The obtained results might also be due to the fact that higher water absorption maintained better water balance and flower freshness. These results were in accordance with Varun and Barad (2010) in tuberose and Mukesh *et al.* (2007) in gladiolus.

4.4.2 Days to drooping of 1st and 5th floret

A perusal of the data in Table 4.16 indicated that the various nutrient sources did not have significant effect on the days to drooping of 1st floret during 2014-15, 2015-16 and also in pooled data analysis. However, the maximum days to drooping of the 1st floret was observed in T_{12} (50% NPK + 25% Pig manure + Biofertilizers) (4.86 days) and the least requirement of days was recorded in control (4.04 days) in the pooled data.

The treatments showed non-significant effect on the days to drooping of 5th floret in 2014-15 however, T_{11} (50% NPK + 25% FYM + Biofertilizers) and T_{12} (50% NPK + 25% Pig manure + Biofertilizers) resulted in the maximum days to drooping of 5th floret (8.93) and T_0 recorded the least days (7.41) followed by T_9 (50% NPK + Biofertilizers (8.12) and T_5 (Biofertilizers) (7.89).

During 2015-16, T_{12} (50% NPK + 25% Pig manure + Biofertilizers) took significantly maximum days to drooping of 5th floret (7.99) which was statistically on par with the rest of the treatments except T_0 which has recorded the lowest days (6.52).

Pooled analysis of the two years data showed that T_{12} (50% NPK + 25% Pig manure + Biofertilizers) required the maximum days (8.46) to drooping of 5th floret which showed at par result with T_7 (50% NPK + 50% Pig manure), T_{11} (50% NPK + 25% FYM + Biofertilizers), T_6 (50% NPK + 50% FYM), T_{13} (50% NPK + 25% Vermicompost + Biofertilizers) and T_8 (50% NPK + 50% Vermicompost) while control took the least days (6.97) to drooping of the 5th floret which was found to be significantly lower than the rest of the treatments.

Table 4.16: Days to drooping of 1st and 5th floret during vase life

Treatments	1st floret			5th floret		
	2014-15	**2015-16**	**Pooled**	**2014-15**	**2015-16**	**Pooled**
T_0	4.04	4.03	4.04	7.41	6.52	6.97
T_1	4.86	4.31	4.58	8.17	7.20	7.69
T_2	4.86	4.40	4.63	8.40	7.30	7.85
T_3	4.78	4.20	4.49	8.00	6.95	7.47
T_4	5.08	4.44	4.76	8.67	7.64	8.15
T_5	4.71	4.12	4.41	7.89	6.81	7.35
T_6	4.94	4.52	4.73	8.88	7.93	8.41
T_7	5.16	4.52	4.84	**8.93**	7.96	8.45
T_8	4.92	4.48	4.70	8.73	7.91	8.32
T_9	4.67	4.14	4.40	8.12	6.93	7.52
T_{10}	4.92	4.40	4.66	8.23	7.74	7.99
T_{11}	5.16	4.52	4.84	8.91	7.97	8.44
T_{12}	**5.18**	**4.53**	**4.86**	**8.93**	**7.99**	**8.46**
T_{13}	4.84	4.50	4.67	8.85	7.92	8.38
SEm±	0.26	0.20	0.17	0.42	0.23	0.24
CD at 5%	0.76	0.59	0.54	1.21	0.68	0.78

The obtained results might also be due to a fact that higher water absorption maintained better water balance and flower freshness thus saving the florets from early wilting. These results were in accordance with Varun and Barad (2010). Similar results were reported by Mukesh *et al.* (2007) in gladiolus.

4.4.3 Florets remaining open at a time

The data embodied in Table 4.17 showed that the treatments had significant effect on the number of florets to remain open at a specific time. In 2014-15, the maximum florets to remain open at a specific time was recorded in T_{12} (50% NPK + 25% Pig manure + Biofertilizers) (6.98) which was found to be statistically at par with the plots receiving integrated nutrient management treatments including organic manures and vermicompost as a source of nutrients while control recorded minimum value (6.31) followed by T_9 (50% NPK + Biofertilizers) (6.35).

During 2015-16, T_7 (50% NPK + 50% Pig manure) and T_{12} (50% NPK + 25% Pig manure + Biofertilizers) showed maximum florets to remain open (5.70) which was at par with T_{11} (50% NPK + 25% FYM + Biofertilizers), T_8 (50% NPK + 50% Vermicompost), T_{13} (50% NPK + 25% Vermicompost + Biofertilizers) and T_4 (100% NPK) while T_0 resulted in the least florets to remain open (5.01).

Pooled data analysis showed that maximum florets to remain open at a specific time was given by T_{12} (50% NPK + 25% Pig manure + Biofertilizers) (6.34) followed by T_7 (50% NPK + 50% Pig manure), T_{11} (50% NPK + 25% FYM + Biofertilizers), T_6 (50% NPK + 50% FYM), T_{13} (50% NPK + 25% Vermicompost + Biofertilizers) and T_8 (50% NPK + 50% Vermicompost). The least florets to remain open was recorded in T_0 (5.66) which was found to be at par

with other treatments which received single source of nutrients and the integrated treatments with only chemical fertilizer and biofertilizers.

4.4.4 Vase life

Regarding vase life of cut spikes of gladiolus, it is evident from Table 4.17 that the different treatments varied significantly and it was found that plants grown using integrated nutrient sources resulted in highest number of days to drooping of 70% florets. The longest vase life of 12.99 days was observed in T_{12} (50% NPK + 25% Pig manure + Biofertilizers) followed by T_{11} (50% NPK + 25% FYM + Biofertilizers) (12.78 days), T_7 (50% NPK + 50% Pig manure) (12.60 days), T_6 (50% NPK + 50% FYM) (12.19 days), T_{13} (50% NPK + 25% Vermicompost + Biofertilizers) (12.15 days), T_4 (100% NPK) (11.99 days), T_8 (50% NPK + 50% Vermicompost) (11.95 days) and T_{10} (75% NPK + Biofertilizers) (11.79 days) which has exhibited appreciable duration for the character under observation and were also statistically at par with T_{12} (50% NPK + 25% Pig manure + Biofertilizers). Like most of the vegetative and floral attributes, plants grown in control had minimum days (9.78 days) to drooping of 70% florets and it was also at par with T_5 (Biofertilizers) (10.50 days), T_3 (Vermicompost @ 10 t ha^{-1}) (10.83 days) and T_9 (50% NPK + Biofertilizers) (11.21 days).

The study in 2015-16 also showed similar trend where T_{12} (50% NPK + 25% Pig manure + Biofertilizers) (12.03 days) registered marked increase in vase life and was statistically at par with T_{11} (50% NPK + 25% FYM + Biofertilizers) (12.01 days) and T_7 (50% NPK + 50% Pig manure) (11.78 days) while T_0 was noted to give minimum vase life of 9.44 days which was at par with T_5 (Biofertilizers) with 9.89 days and T_9 (50% NPK + Biofertilizers) with 10.01 days.

Mean data of the two years showed that T_{12} (50% NPK + 25% Pig manure + Biofertilizers) gave maximum vase life (12.51 days) which was at par with T_{11} (50% NPK + 25% FYM + Biofertilizers) (12.39 days), T_7 (50% NPK + 50% Pig manure) (12.19 days), T_6 (50% NPK + 50% FYM) (11.97 days) and T_{13} (50%

Table 4.17: Effect of various nutrient sources on the florets remaining open at a specific time and vase life of gladiolus

Treatments	Florets remaining open at a specific time			Vase life (days)		
	2014-15	**2015-16**	**Pooled**	**2014-15**	**2015-16**	**Pooled**
T_0	6.31	5.01	5.66	9.78	9.44	9.61
T_1	6.42	5.12	5.77	11.41	10.28	10.84
T_2	6.43	5.13	5.78	11.41	10.40	10.90
T_3	6.37	5.07	5.72	10.83	10.16	10.50
T_4	6.63	5.33	5.98	11.99	11.35	11.67
T_5	6.36	5.06	5.71	10.50	9.89	10.20
T_6	6.94	5.64	6.29	12.19	11.74	11.97
T_7	6.95	**5.70**	6.33	12.60	11.78	12.19
T_8	6.74	5.44	6.09	11.95	11.53	11.74
T_9	6.35	5.05	5.70	11.21	10.01	10.61
T_{10}	6.42	5.12	5.77	11.79	11.03	11.41
T_{11}	6.97	5.69	6.33	12.78	12.01	12.39
T_{12}	**6.98**	5.70	**6.34**	**12.99**	**12.03**	**12.51**
T_{13}	6.85	5.41	6.13	12.15	11.59	11.87
SEm±	0.18	0.17	0.13	0.50	0.53	0.36
CD at 5%	0.53	0.50	0.41	1.44	1.53	1.18

NPK + 25% Vermicompost + Biofertilizers) (11.84 days). Control noted the shortest vase life (9.61) followed by T_5 (Biofertilizers) (10.20), T_3 (Vermicompost @ 10 t ha^{-1}) (10.50) and T_9 (50% NPK + Biofertilizers) (10.61).

The highest longevity of cut spikes was obtained with the application of 50% RDF in combination with 25% pig manure or farmyard manure along with biofertilizers. This might be attributed to consistent and slow release of nutrients throughout the growing period which improved the flowering parameters and ultimately increased the vase life of cut spikes. Increased nutrient uptake by plants resulted in greater water conducting tissues which in turn lead to maintaining turgidity and thus improved the longevity of florets and whole spikes. The above results revealed that the post harvest life of cut flower is greatly affected by the pre harvest treatments which are applied in the field. Similar results were also reported by Tripathi *et al*. (2012) and Ranjan *et al*. (2014) in tuberose.

The obtained results might also be due to the fact that higher water absorption maintained better water balance and flower freshness, saved from early wilting and enhanced vase life. These results were in accordance with Varun and Barad (2010). Similar results were reported by Mukesh *et al.* (2007) in gladiolus.

4.5 Nutrient studies

4.5.1 Concentration of NPK % in the index leaf of gladiolus

Flower quality assumes significance from view point of productivity as it is an integrated effect of the nutritional, physiological and biochemical factors. As a general rule, the amount of N, P and K, accumulating in the leaves is a genetic character but it has been realized that the use of chemical fertilizers must be integrated through more economic and eco-friendly organic nutrient sources to achieve the suitable productivity with high quality along with minimum deterioration of the environment. Data presented in Table 4.18 showed that different treatments significantly influenced the leaf N, P and K concentrations.

Most of the treatments responded towards significant improvements in nutrient content of the index leaves in comparison to control.

4.5.1.1 Leaf N content

Nitrogen content in the index leaves was determined annually and pooled data is presented in Table 4.18. It is discernable from the table that maximum nitrogen content of 3.04% was observed during the first season with the treatment T_{12} (50% NPK + 25% Pig manure + Biofertilizers) followed by 3.02% with treatment T_{11} (50% NPK + 25% FYM + Biofertilizers), though statistically on par with 2.89% with T_6 (50% NPK + 50% FYM), 2.86% withT_7 (50% NPK + 50% Pig manure) (2.86%), 2.85% with T_{13} (50% NPK + 25% Vermicompost + Biofertilizers, 2.84% with T_{10} (75% NPK + Biofertilizers), 2.75% with T_8 (50% NPK + 50% Vermicompost) and 2.72% with T_4 (100% NPK) (2.72%). However, the control treatment registered the minimum nitrogen content of 2.00%, significantly lower than all other treatments.

Almost similar trend in the result was observed in the second year as well. The highest leaf nitrogen content of 2.82% was recorded with T_{11} (50% NPK + 25% FYM + Biofertilizers), statistically at par with 2.80% with T_{12} (50% NPK + 25% Pig manure + Biofertilizers), 2.76% with T_7 (50% NPK + 50% Pig manure), 2.74% with T_{13} (50% NPK + 25% Vermicompost + Biofertilizers), 2.72% each with treatments T_6 (50% NPK + 50% FYM) and T_8 (50% NPK + 50% Vermicompost), as usual, control produced the minimum leaf content of nitrogen of 1.90% followed by 2.11% with T_5 (Biofertilizers) and 2.12% with T_9 (50% NPK + Biofertilizers).

Pooled data analysis supported the observations made annually on changes in leaf nutrient composition. The highest nitrogen content of 2.93% was recorded with T_{11} (50% NPK + 25% FYM + Biofertilizers), statistically on par as 2.92% with T_{12} (50% NPK + 25% Pig manure + Biofertilizers), but significantly superior to other treatments except 2.81% with T_7 (50% NPK + 50% Pig manure), 2.80% each with T_6 (50% NPK + 50% FYM) and T_{13} (50% NPK + 25% Vermicompost + Biofertilizers), besides the control treatment recording the lowest value of 1.95 %, significantly inferior to other treatments.

4.5.1.2 Leaf P content

The data related to P content in leaves of gladiolus presented in Table 4.18 indicated the changes in leaf P concentration, similar to response on N content. During 2014-15, the highest P content 0.43% was observed with treatment T_{12} (50% NPK + 25% Pig manure + Biofertilizers), followed by 0.41% with T_{11} (50% NPK + 25% FYM + Biofertilizers) and 0.40% each with T_{13} (50% NPK + 25% Vermicompost + Biofertilizers) and T_7 (50% NPK + 50% Pig manure), all being statistically at par with each other. While the lowest P content of 0.22% was observed with control, statistically on par with T_5 (Biofertilizers) (0.25%), thereby, showing least effectiveness of even biofertilizers when applied alone.

In 2015-16, the highest P content 0.40% was observed with T_{12} (50% NPK + 25% Pig manure + Biofertilizers), statistically at par with T_7 (50% NPK + 50% Pig manure) registering 0.39%, 0.37% with T_{11} (50% NPK + 25% FYM + Biofertilizers) and 0.36% with T_6 (50% NPK + 50% FYM). On the contrary, the lowest P content 0.20% was observed with T_0 followed by 0.24% with T_5 (Biofertilizers) and 0.25% with T_3 (Vermicompost @ 10 t ha^{-1}).

In pooled data, similar trend of results was obtained where T_{12} (50% NPK + 25% Pig manure + Biofertilizers) registered the maximum P content of 0.41%, statistically non significant with T_{11} (50% NPK + 25% FYM + Biofertilizers) as 0.40%, 0.39% with T_7 (50% NPK + 50% Pig manure) and 0.38% with T_{13} (50% NPK + 25% Vermicompost + Biofertilizers). While, control recorded significantly lowest P content of 0.21% compared to response with rest of the other treatments.

The treatments involving combined application of nutrient sources such as pig manure or FYM produced significantly higher leaf P content, due to the improved availability of readily available forms of soil P. The role of phosphate solubilizing bacteria *via* phosphotica increased the availability of phosphorus in soil through dissolution of precipitated phosphorous at such low soil pH by accelerated secretion of phosphatase enzymes, eventually hastening the process of transformation of organic phosphorus into readily available forms (Abou *et al*., 2007). These processes built up more favorable rhizosphere environment for an enhanced phosphorus absorption and onward accumulation in plant tissues.

4.5.1.3 Leaf K content

The response of different treatments with respect to K content in leaves was similar to the observations made with respect to other nutrients like N and P (Table 4.18). In the year 2014-15, the highest K content of 2.15% was recorded with treatments *viz*., T_{11} (50% NPK + 25% FYM + Biofertilizers) and T_{12} (50% NPK + 25% Pig manure + Biofertilizers), statistically at par with 2.11% with T_6 (50% NPK + 50% FYM), 2.10% with T_7 (50% NPK + 50% Pig manure), 2.07% with T_{13} (50% NPK + 25% Vermicompost + Biofertilizers), T_8 (50% NPK + 50% Vermicompost), 2.01% with T_4 (100% NPK) and 2.00% with T_{10} (75% NPK + Biofertilizers). However, the leaf K content of 1.30% was lowest in control, statistically on par as 1.54% with T_5 (Biofertilizers). All the manures involving treatments T_1 (FYM), T_2 (Pig manure) and T_3 (Vermicompost) displayed no significant difference amongst themselves, since the leaf K content varied between 1.65% and 1.72% but comparing with treatment T_4 (100% NPK), T_3 (Vermicompost) and T_5 (Biofertilizers), leaf K content is significantly improved as 2.01%.

During 2015-16, the treatments containing integration of all three diverse sources *viz*., manures, inorganic fertilizers and biofertilizers, produced the best response on leaf K concentration. Treatments, T_6 (50% NPK + 50% FYM) and T_{11} (50% NPK + 25% FYM + Biofertilizers) recorded the maximum content of K in index leaves with 2.11%, statistically on par with T_{12} (50% NPK + 25% Pig manure + Biofertilizers) as 2.10 % and 2.09% with T_7 (50% NPK + 50% Pig manure). However, control registered the lowest K content of 1.25% followed by T_5 (Biofertilizers) with 1.45%, without any significant difference between the two.

Pooled data analysis of 2014-15 and 2015-16 showed no different results to what we observed on an annual basis. The highest leaf K content of 2.13% was observed with T_{11} (50% NPK + 25% FYM + Biofertilizers) and T_{12} (50% NPK + 25% Pig manure + Biofertilizers), but at par with T_6 (50% NPK + 50% FYM), T_7 (50% NPK + 50% Pig manure), T_{13} (50% NPK + 25% Vermicompost + Biofertilizers), T_4 (100% NPK), T_8 (50% NPK + 50% Vermicompost) and T_{10} (75% NPK + Biofertilizers), showing that leaf K is not so much influenced by such diverse sources of nutrients. While control resulted in minimum K content of leaf (1.28%) followed by 1.50% with T_5 (Biofertilizers). Pooled data also revealed no significant difference amongst the treatments involving different organic manures versus inorganic fertilizers (T_4). Likewise, biofertilizers also failed to establish their superiority over any of the treatments involving the different organic manures.

These results need to be looked in the light of an increased availability of most of the macro- and micro- nutrients in right amounts and at right time, thereby, giving a balanced soil fertility environment for improvised uptake of different nutrients. Use of *Azospirillum* and Phosphotica in combination with organic and inorganic sources of nutrients increased the nitrogen, phosphorus and potassium uptake significantly due to their complementarities and establishes different dynamics of nutrient release in an available form throughout the growing period of the crop. The better crop development conditioned by leaf nutrient concentration is attributed to elevated absorption of required nutrients from the

Table 4.18: Nutrient composition of gladiolus leaves as influenced by various sources of nutrients

T	Nutrient content (%)								
	N			P			K		
	2014-15	2015-16	Pooled	2014-15	2015-16	Pooled	2014-15	2015-16	Pooled
T_0	2.00	1.90	1.95	0.22	0.20	0.21	1.30	1.25	1.28
T_1	2.52	2.30	2.41	0.28	0.26	0.27	1.72	1.72	1.72
T_2	2.61	2.23	2.42	0.30	0.27	0.29	1.72	1.69	1.71
T_3	2.50	2.20	2.35	0.25	0.24	0.25	1.65	1.55	1.60
T_4	2.72	2.30	2.51	0.38	0.35	0.36	2.01	2.00	2.01
T_5	2.46	2.11	2.29	0.26	0.26	0.26	1.54	1.45	1.50
T_6	2.89	2.72	2.80	0.37	0.36	0.37	2.11	**2.11**	2.11
T_7	2.86	2.76	2.81	0.40	0.39	0.39	2.10	2.09	2.10
T_8	2.75	2.72	2.74	0.37	0.35	0.36	2.01	2.00	2.00
T_9	2.50	2.12	2.31	0.31	0.30	0.30	1.91	1.82	1.86
T_{10}	2.84	2.32	2.58	0.37	0.32	0.35	2.00	1.97	1.98
T_{11}	3.03	**2.82**	2.93	0.41	0.37	0.40	**2.15**	**2.11**	**2.13**
T_{12}	**3.04**	2.80	**2.92**	**0.43**	**0.40**	**0.41**	2.15	2.10	2.12
T_{13}	2.85	2.74	2.80	0.40	0.35	0.38	2.07	2.00	2.04
SEm±	0.12	0.14	0.09	0.01	0.01	0.01	0.10	0.10	0.07
CD at 5%	0.34	0.40	0.30	0.04	0.04	0.03	0.29	0.29	0.23

and onward effective efficient translocation coupled with partitioning inside the plant (Jaggi, 2007). Kumar *et al.* (2011) reported that combined application of biofertilizers and recommended doses of fertilizers increased the NPK concentration of gladiolus cv. Sancerre. Similar findings were reported by Chaitra (2006) and Muthamizhselvi *et al.* (2006).

4.5.2 Soil Fertility-related Parameters

Soil chemical and biological properties were studied during both the years of experimentation and the results are presented in Table 4.19-4.21.

4.5.2.1 Soil organic carbon

On the perusal of data highlighted in Table 4.19, it is inferred that changes in soil organic carbon (SOC) differed significantly in response to different treatments over control. SOC was observed as 2.15%, maximum with T_1 (FYM @ 40 t ha^{-1}) which was found to be statistically at par with 2.12% exhibited by T_6 (50% NPK + 50% FYM), 2.105 by T_2 (Pig manure @ 35 t ha^{-1}) and 2.08% by T_7 (50% NPK + 50% Pig manure) during 2014-15. However, control (T_0) noted the minimum organic carbon of 1.71% followed by 1.73% with T_5 (Biofertilizers).

Similar results were obtained during the year 2015-16, where T_1 (FYM @ 40 t ha^{-1}) registered maximum organic carbon content of 2.17%, followed by 2.16% with T_6 (50% NPK + 50% FYM), 2.14% with T_2 (Pig manure @ 35 t ha^{-1}), 2.13% with T_7 (50% NPK + 50% Pig manure) and 1.99% with T_3 (Vermicompost @ 10 t ha^{-1}) which also showed statistically at par values. The lowest organic carbon of 1.78% was observed with T_0 (Control) followed by 1.79% with T_5 (Biofertilizers).

The organic carbon content in soil was significantly influenced by various treatments where application of T_1 (FYM @ 40 t ha^{-1}) produced the highest organic carbon content of 2.16% , at par with 2.14% recorded with T_6 (50% NPK

+ 50% FYM), 2.12% with T_2 (Pig manure @ 35 t ha^{-1}), 2.11% with T_7 (50% NPK + 50% Pig manure) and 1.93% with T_3 (Vermicompost @ 10 t ha^{-1}) compared to lower values of soil organic carbon content observed with some treatments like 1.74% with T_0 (Control), 1.76% with T_5 (Biofertilizers) and 1.78% with T_9 (50% NPK + Biofertilizers) as evident from pooled data analysis.

The increase in organic carbon after harvest in all the treatments is accountable primarily to addition of organic manures that consequently triggered the root growth, thereby, adding to root exudates–induced soil microbial diversity. Earlier, Shaktawat and Shekhawat (2010) reported that use of organic manure, especially FYM in combination with balanced use of nitrogen and phosphorus, enhanced the status of soil biological properties and productivity of crop as well. Increase in the organic soil carbon content after crop harvest is due to additional mineralization of root biomass adding organic matter directly into soil in such treatments and eventually the supply of readily decomposable organic matter transforming the effective rhizosphere environment (Goyal *et al*., 1999).

4.5.2.2 Changes in soil pH

Soil pH is such a strong chemical property of the soil that undergoes changes with great difficulty, regardless of management practices being followed. The response of different treatments on changes in soil pH was studied, the data of which are presented in Table 4.19. There was hardly any significant change in soil pH in response to different treatments; however, it increased in all the treatments from its initial value (4.74) except in control, where it decreased numerically from its initial value. The maximum soil pH was recorded in organic treatment T_1 (FYM @ 40 t ha^{-1}) with pH value of 4.88 and the minimum was recorded T_0 treatment (4.73). Integrated treatment comprising of organic manures gave numerically higher pH values than the treatments involving chemical fertilizers, either alone or along with biofertilizers.

Table 4.19: Response of various sources of nutrients on soil organic carbon content and soil pH after harvest

Treatments	Soil organic carbon %			Soil pH		
	2014-15	**2015-16**	**Pooled**	**2014-15**	**2015-16**	**Pooled**
T_0	1.71	1.78	1.74	4.73	4.74	4.73
T_1	**2.15**	**2.17**	**2.16**	**4.88**	**4.88**	**4.88**
T_2	2.10	2.14	2.12	4.84	4.87	4.86
T_3	1.87	1.99	1.93	4.82	4.81	4.82
T_4	1.82	1.81	1.82	4.74	4.77	4.76
T_5	1.73	1.79	1.76	4.79	4.79	4.79
T_6	2.12	2.16	2.14	4.84	4.82	4.83
T_7	2.08	2.13	2.11	4.82	4.82	4.82
T_8	1.77	1.85	1.81	4.80	4.79	4.79
T_9	1.74	1.81	1.78	4.73	4.78	4.75
T_{10}	1.77	1.82	1.79	4.72	4.75	4.74
T_{11}	1.92	1.93	1.92	4.82	4.81	4.82
T_{12}	1.88	1.90	1.89	4.81	4.79	4.80
T_{13}	1.83	1.80	1.82	4.76	4.80	4.78
SEm ±	0.08	0.08	0.05	0.16	0.14	0.11
CD at 5%	0.22	0.23	0.18	NS	NS	NS

The variations in soil pH (Table 4.19) during both the seasons of field experimentation under different treatments were quite marginal and could not reach the level of significance. However, T_1 (FYM @ 40 t ha^{-1}) recorded an increase in soil pH in both the years of observation (4.88 with T_1 against 4.73 with T_0) and the lowest pH was obtained with control (4.73) followed by 4.74 with T_{10} (75% NPK + Biofertilizers), as revealed through pooled analysis.

Though, the pH of the soil did not vary significantly, but initial trends supported the fact that soils supplemented with manures and compost appeared to have registered higher pH. The soil pH was higher with FYM followed by pig manure and vermicompost in decreasing order. These results are in line with the findings of Stockdale and Brookes (2006) who observed the direct impacts of farmyard manure on the rise in soil pH and addition of organic matter that further stimulated or slowed down the rate of mineralization.

4.4.2.3 Changes in available macronutrients

The data regarding plant assimilable NPK content of soil are presented in the Table 4.20. The available NPK content of the soil increased in all the treatments over the initial value during both the years. It is amply evident from the data that the use of combined nutrient sources significantly improved the nutrient supply level of the soil over their initial value, including untreated control plots and the plots treated with single source of nutrients. Application of organic manures, in fact, act as an amendments to ensure long term sustainability of soil fertility by improving levels of soil organic carbon, maintaining the optimum supply level of different nutrients and soil microbial activities.

4.5.2.3.1 Available nitrogen content

Nitrogen is highly mobile in soil and is subjected to several losses *viz*. denitrification, volatile losses of ammonia gas and nitrate losses with percolating water. After its removal by crop and losses, very little is left in the soil. During the study it was found that there was a positive content of nitrogen in the soil in all the treatments except control and sole biofertilizer treatment after crop harvests compared to its initial status of 240.8 kg ha^{-1}. Changes in soil available nitrogen in response to different treatments were quite discernable from Table 4.20. The available nitrogen content was the maximum of 280.5 kg ha^{-1} with treatment T_6 (50% NPK + 50% FYM) during 2014-15 and was at par with 276.9 kg ha^{-1} with T_7 (50% NPK + 50% Pig manure), accounting for increase of 27.21% and 25.58%, respectively over control (220.5 kg ha^{-1}) or even where biofertilizers alone were applied (232.4 kg ha^{-1}). The minimum increase was, however, observed in organic treatments followed by the treatments receiving chemical fertilizers.

During 2015-16, T_6 (50% NPK + 50% FYM) registered soil available nitrogen content of 288.8 kg ha^{-1} followed by 285.8 kg ha^{-1} with T_7 (50% NPK + 50% Pig manure) and 278.2 kg ha^{-1} with T_8 (50% NPK + 50% Vermicompost), all being the most effectively expressed treatments which were also statistically at par while, the lowest value of 222.7 kg ha^{-1} was observed in control followed by 237.7 kg ha^{-1} with biofertilizers (T_5).

Available N content in soil varied from 221.6 kg ha^{-1} in T_0 to 284.7 kg ha^{-1} in T_6 in the pooled data analysis. The magnitude of increase in soil available nitrogen was significantly higher with T_6 (50% NPK + 50% FYM) over control (T_0) and 100% NPK (T_4) as 28.47% and 6.55%, respectively. However, it was statistically at par with treatment T_7 (50% NPK + 50% Pig manure) with soil available nitrogen content of 281.4 kg ha^{-1}. Incorporation of organic manures along with 50% NPK in (T_6) and (T_7) has only moderately improved the available N status by 7.84% and 8.94% respectively, over their sole application in T_1 (FYM) and T_2 (Pig manure).

Changes in soil fertility status with regard to NPK availability showed that these nutrients were maintained in optimum supply levels in all the treatments, except control and exclusive use of biofertilizer treatment. Such varied nutrient sources have differential rates of mineralization, releasing tagged nutrients at different time intervals, all effectively utilized to ensure constant rate supply of different nutrients on one hand, putting check on the leaching and off-site movement of nutrients on the other hand, coupled with dissolution and release of native soil nutrients also culminate into better soil fertility regime throughout the crop growth. However, the long term sustenance of soil fertility is another crunch issue, we all are looking forward. This is where such a combination of organic manures, inorganic fertilizers and biofertilizers compliment each other so effectively. Besides, improving soil fertility, these manures work a world of good to conserve native soil nutrients, enhancing biological nitrogen fixation and soil biological activity (Javaria & Khan, 2011) that will serve soil a biologically active system.

4.5.2.3.2 Available phosphorus content

Phosphorus moves very slowly from the point of placement as the phosphate ion is almost immobile in soil and hence retained in the soil not only for a season or so but for longer period. During the course of present investigation it was found that there was a higher content of phosphorus in the soil from its initial value of 17.12 kg ha^{-1} after crop harvests in all the treatments except control and lone treatment with biofertilizers. The various nutrient sources gave similar result in both the years of experiment. In the first year of experiment, T_7 (50% NPK + 50% Pig manure) recorded the highest available P content of 22.5 kg ha^{-1} after harvest which was at par with 22.2 kg ha^{-1} with T_6 (50% NPK + 50% FYM), while the lower values of 14.5 kg ha^{-1} and 19.5 kg ha^{-1} were recorded with treatment T_0 (Control) and T_9 (50% NPK + Biofertilizers), respectively.

The available P in soil after harvest during the second year, was highest with 24.3 kg ha^{-1} with T_7 (50% NPK + 50% Pig manure), which was statistically at par with 24.0 kg ha^{-1} with T_{12} (50% NPK + 25% Pig manure + Biofertilizers) and 22.9 kg ha^{-1} with treatment T_6 (50% NPK + 50% FYM), while it was lowest of 14.8 kg ha^{-1} with T_0 followed by 15.9 kg ha^{-1} with T_9 (50% NPK + Biofertilizers).

Pooled analysis of the two years data revealed no different pattern of observation. The available phosphorus content in soil ranged from 14.7 kg ha^{-1} with treatment T_0 to 23.4 kg ha^{-1} with treatment T_7. The highest available phosphorus content of 23.4 kg ha^{-1} in soil was observed with T_7 (50% NPK + 50% Pig manure), amounting to an increase of 59% and 15%, respectively, over control (14.7 kg ha^{-1}) and 100% NPK (20.30 kg ha^{-1}). The treatment T_7 (50% NPK + 50% Pig manure) was observed at par with T_{12} (50% NPK + 25% Pig manure + Biofertilizers) (23.1 kg ha^{-1}) and T_6 (50% NPK + 50% FYM) (22.5 kg ha^{-1}).

The increase in available P in soil after harvest could be explained by the slow release of P from the applied manures, adding organic matter with a lower C:N ratio, triggering the release of tapped nutrients following an effective mineralization, especially where inorganic fertilizers are mixed, and the rate of mineralization being further hastened by addition of biofertilizers. On the contrary, a significant reduction in available P content of soil was observed under unfertilized treatment and sole biofertilizer treatment, where P-use was in excess of availability due to removal of P by crops in the absence of external source of P. Incorporation of organics with inorganic nutrient sources significantly maintained higher available P as reported by Kumar *et al*. (2012).

The increased availability of P with organic manures is ascribed to their strong solubilizing effect on the native insoluble P fractions through release of various organic acids, thus resulting into a significant improvement in available P status of the soil (Urkurkar *et al*., 2010). In addition, the organic matter also reduced the further fixation of phosphate by providing protective cover on sesquioxides and thus increased the available P in soil solution (Bharadwaj *et al*., 1994). Incorporation of FYM along with inorganic P in our studies increased the availability of P to crop and mineralization of organic P due to microbial action and enhanced mobility of P (Tiwari *et al*., 2010). The improvement in the soil available P is attributed to many factors, such as addition of P through FYM and retardation of soil P fixation by organic anions formed during FYM mineralisation (Ali *et al*., 2009).

Application of organic manures along with PSB has vital role to play in improvement of the available P status of soil, because of addition of organic manures enhanced the activity of phosphate solubilizing bacteria (PSB) by providing carbon as a source of energy, that reflected in increased solubilization of P. The increase in available P in organic+inorganic+PSB treatments is primarily due to elevated efficiency of organic matter along with PSB in facilitating the release of P from both applied as well as native inorganic P source (Pazhanivelan *et al*., 2006), resulted in significantly higher available P than the sole usage of the nutrient.

4.5.2.3.3 Available potassium content

Potassium ion tends to attach itself to the colloidal complex as it is positively charged and as a result it is restricted in increment. Hence, the amount and type of clay and the amount of organic matter present in the soil invariably influence its movement and as such are reported to be retained in the soil for longer periods. The present study revealed that there was a higher content of available potassium in the soil after crop harvests during both the years as compared to the initial status (219.43 kg ha^{-1}). Available potassium content was found significantly higher in almost all the INM –based treatments as compared to control and other treatments containing single source of nutrients in both the years of experiment. The maximum soil available K was observed with T_6 and minimum in control. In the first year, available potassium content, 250.3 kg ha^{-1}, in T_6 (50%

NPK + 50% FYM) was observed to be the maximum followed by T_7 (50% NPK + 50% Pig manure) with 248.1 kg ha^{-1} with the lowest available potassium content of 200.8 kg ha^{-1} and 208.4 kg ha^{-1} respectively, observed with control and T_5 (Biofertilizers).

The maximum soil available potassium content of 258.4 kg ha^{-1} was registered with T_6 (50% NPK + 50% FYM), which was at par with 251.5 kg ha^{-1} with T_7 (50% NPK + 50% Pig manure), 250.6 kg ha^{-1} with T_{11} (50% NPK + 25% FYM + Biofertilizers) and 247.9 kg ha^{-1} T_{12} (50% NPK + 25% Pig manure + Biofertilizers) while the lowest value of 219.7 kg ha^{-1} with control.

The pooled data analysis further provided no different set of observations. The maximum available potassium in the soil as 254.4 kg ha^{-1} was recorded with treatment T_6 (50% NPK + 50% FYM), 249.8 kg ha^{-1} with T_7 (50% NPK + 50% Pig manure), 248.7 kg ha^{-1} with T_{11} (50% NPK + 25% FYM + Biofertilizers) and 245.6 kg ha^{-1} with T_{12} (50% NPK + 25% Pig manure + Biofertilizers). While the lowest soil available status of potassium was observed as 210.3 kg ha^{-1} with T_0 followed by 214.7 kg ha^{-1} with T_5 (Biofertilizers).

The exclusion of K in plant nutrient T_0 and T_5 has led to the maximum removal of K from its native K reserve in soil. The increase in available K under all the integrated treatments contributed handsomely through the addition of organic matter that reduced K fixation and released K due to coating of organic matter on clay minerals, besides the direct addition to the K pool of the soil (Urkurkar *et al*., 2010; Subehia & Sepehya, 2012). An increase in availability of K through addition of manures ascribed to the decomposition of organic matter accompanied by the release of appreciable quantities of CO_2, later dissolved in water to form carbonic acid, capable of decomposing certain primary minerals and, thereby, release of nutrients into the plant rhizosphere.

Table 4.20: Available nutrient status of the soil as influenced by various sources of nutrients

T	Available nutrients (kg ha^{-1})								
	N			P			K		
	2014-15	2015-16	Pooled	2014-15	2015-16	Pooled	2014-15	2015-16	Pooled
T_0	220.5	222.7	221.6	14.5	14.8	14.7	200.8	219.7	210.3
T_1	257.8	270.3	264.0	19.1	19.7	19.4	224.2	239.6	231.9
T_2	247.8	268.9	258.3	19.1	20.6	19.9	219.9	235.6	227.7
T_3	239.2	259.8	249.5	18.1	18.3	18.2	211.6	229.3	220.5
T_4	262.0	272.4	267.2	19.5	21.0	20.3	235.6	242.2	238.9
T_5	232.4	237.7	235.1	15.9	15.9	15.9	208.4	221.0	214.7
T_6	**280.5**	**288.8**	**284.7**	22.2	22.9	22.5	**250.3**	**258.4**	**254.4**
T_7	276.9	285.8	281.4	**22.5**	**24.3**	**23.4**	248.1	251.5	249.8
T_8	273.7	278.2	275.0	20.5	21.9	21.2	239.7	246.9	243.3
T_9	240.7	247.2	244.0	18.0	18.0	18.0	213.2	224.6	218.9
T_{10}	257.5	262.8	260.2	19.4	19.8	19.6	223.4	230.6	227.0
T_{11}	269.8	272.8	271.3	21.4	22.5	21.9	246.8	250.6	248.7
T_{12}	262.3	274.9	268.6	22.1	24.0	23.1	243.3	247.9	245.6
T_{13}	256.3	260.6	258.4	20.6	20.7	20.7	234.1	236.7	235.4
SEm±	3.9	5.5	3.3	1.1	0.9	0.7	4.1	4.5	3.1
CD at 5%	11.2	15.9	10.9	3.1	2.7	2.3	12.0	13.1	10.0

The status of availability of major nutrients, organic carbon and pH after harvest as our experimental findings revealed far better effectiveness of integrated application of chemical fertilizers, organic manures with or without biofertilizers due to synergisms developed amongst the divergent sources of nutrients, thereby, affecting the nutrient release and use-efficiency of the different sources having differential magnitudes of nutrient release. There was an improvement in soil fertility *via* enriched pool of available NPK in treated soil after the crop harvest, in addition to better retention of released nutrients into the soil solution (Ramesh *et al.*, 2008).

4.5.2.4 Soil biological properties

Soil health is a major issue, nowadays in the light of declining productivity of open field floriculture, simply because of depleted soil fertility, with the result, soil health in terms of biological properties has also undergone significant deterioration over time and space. Organic manures, inorganic fertilizers and biofertilizers, either individually or in combination, have shown to affect the soil health related parameters to different proportions, where soil fertility is the major key player (Subhani *et al*., 2001), which has strong cascading effects on entire range of soil properties. The response of different treatments was evaluated in terms of changes in soil microbial biomass and enzyme activities as presented in Table 4.21.

4.5.2.4.1 Dehydrogenase activity

The dehydrogenase activity varied significantly through different nutrient supply modules. The pattern of variation of enzyme activity in the soil during the two years of study was similar, including the pooled data analysis. Dehydrogenase activity is considered as an effective expression of soil nitrogen as well organic carbon content. In our experimentation, dehydrogenase activity improved from 5.59 TPF µg g^{-1} hr^{-1} with T_0 to 9.88 TPF µg g^{-1} hr^{-1} with FYM @ 40 t ha^{-1} (T_1) on a mean basis. It was the minimum in the control and maximum in different treatments supplying FYM, Pig manure or Vermicompost. Application of inorganic fertilizers alone as T_4 (100% NPK) and other integrated treatments carrying chemical fertilizers resulted in lesser dehydrogenase activity compared with organic manure treatments. The plots which received integrated nutrient treatments containing organic manures alongside biofertilizers plus inorganic fertilizers produced a response on dehydrogenase activity, statistically at par with organic manure treated plots. These observations should be viewed that organic manures acted as carrier of certain base population of microbes as an effective bio-inoculants in tandem with biofertilizers, collectively improving the dehydrogenase activity of the rhizosphere, which overtook the response through NPK as an inorganic source of nutrients. On the contrary, the inorganically treated plots with or without bio-inoculants recorded lesser dehydrogenase activity than all the other treatments except control. These observations strongly warrant the unfavorable response of chemical fertilizers on microbial activity.

During 2014-15, the treatment T_1 (FYM @ 40 t ha^{-1}) exhibited the highest dehydrogenase activity of 9.85 TPF µg g^{-1} hr^{-1}, statistically at par value of 9.46 TPF µg g^{-1} hr^{-1} with T_2 (Pig manure @ 35 t ha^{-1}), 9.37 TPF µg g^{-1} hr^{-1} with T_3 (Vermicompost @ 10 t ha^{-1}), 9.18 TPF µg g^{-1} hr^{-1} with T_{11} (50% NPK + 25% FYM + Biofertilizers), 8.95 TPF µg g^{-1} hr^{-1} with T_{13} (50% NPK + 25% Vermicompost + Biofertilizers) and 8.84 TPF µg g^{-1} hr^{-1} with T_{12} (50% NPK + 25% Pig manure + Biofertilizers). Whereas control treatment noted the minimum dehydrogenase activity of 5.06 TPF µg g^{-1} hr^{-1}, followed by 5.12 TP µg g^{-1} hr^{-1} with T_4 (100% NPK) and 5.20 TPF µg g^{-1} hr^{-1} with T_{10} (75% NPK + Biofertilizers). Similarly during 2015-16, different treatments produced response, simple replica of 2014-15. The highest dehydrogenase activity of 9.91 TPF µg g^{-1} hr^{-1} was observed with treatment T_1 (FYM @ 40 t ha^{-1}) followed by 9.75 TPF µg g^{-1} hr^{-1} with T_2 (Pig manure @ 35 t ha^{-1}), 9.71 TPF µg g^{-1} hr^{-1} with T_3 (Vermicompost @ 10 t ha^{-1}) and

9.69 TPF µg g^{-1} hr^{-1} with T_6 (50% NPK + 50% FYM) which showed at par values with each other. While the lowest dehydrogenase activity of 6.11 TPF µg g^{-1} hr^{-1} was observed in control followed by 6.39 TPF µg g^{-1} hr^{-1} with T_4 (100% NPK). Similar results were obtained through pooled data analysis as well. T_1 (FYM @ 40 t ha^{-1}) recorded the highest dehydrogenase enzyme activity of 9.88 TPF µg g^{-1} hr^{-1} which was at par with 9.61 TPF µg g^{-1} hr^{-1} with T_2 (Pig manure @ 35 t ha^{-1}). While the lowest magnitude of response was observed in control (5.59 TPF µg g^{-1} hr^{-1}) followed by T_4 (100% NPK) (5.75 TPF µg g^{-1} hr^{-1}).

Dehydrogenase activity in the organic and integrated treatments was appreciably higher than that in the control and chemical fertilizer treatment after harvest, although less difference were observed between the biofertilizer alone and control treatments. Control treatment showed the lowest dehydrogenase activity among the treatments, although this was not statistically different from that observed in the T_4 (100% NPK) and T_{10} (75% NPK + Biofertilizers). No big differences were observed among the treatments consisting of chemical in combination with biofertilizers, biofertilizers alone treatments and control treatments, indicating that the influence of bacterial fertilizer on dehydrogenase activity was not significant. These results suggest that manure compost was better than bacterial fertilizer alone in enhancing soil enzyme activities, whereas chemical fertilizers degrade the activities of soil enzymes (Zhen *et al*., 2014).

The dehydrogenase activity was significantly higher in organic and integrated treatments comprising of organics than those treatments involving chemical fertilizers. The observed increase in enzymatic activity was accountable to organic fertilizers displaying as a soil amendments, improving the soil physic-chemical and biological properties in a coordinated manner. Addition of farmyard manure alone or with chemical fertilizers along with biofertilizers increased the activity of dehydrogenase enzyme, since the biofertilizers carrying *Azospirillum* and base microbial population of FYM acted in tandem to produce the siderophores, thereby, aiding in improvement of soil aggregate size. These conditions are considered an important pre-condition in better soil-water-plant relationship and ensuring the glue role of elevated dehydrogenase activity (Marinari *et al*., 2000). These results also corroborated with the earlier findings of Verma and Mathur (2009) who reported that integrated use of FYM with chemical fertilizer increased the dehydrogenase activity. Further, addition of nitrogen in the farmyard manure and biofertilizers increased the dehydrogenase activity than the treatment of chemical fertilizer alone, for the simple reason, latter providing more availability of substrate for dehydrogenase enzyme to be activated to next higher level. The increased microbial activity (dehydrogenase, fluorescein diacetate, and phosphatase) due to addition of organic amendments in combination with inorganic chemical fertilizers including micronutrients, is ascribed to greater availability of substrates that support such activities as well as the cofactors of several of the other enzymes that are highly influenced by micronutrients supply (Kremer & Jianmei Li, 2003).

4.5.2.4.2 Changes in soil microbial biomass

Soil microbial biomass is another soil fertility-related parameter considered as an important index of soil health. Different fertilizers significantly affected the community structure of soil bacteria and fungi after harvest. Incorporation of organic sources had profound influence on microbial populations of inoculated soil. Organic matter acts as storehouse for not only various essential nutrients and microbial diversity, but it provides a congenial environment to the plant for growth and multiplication of various microbial communities in the soil according to plant metabolism. The organic matter in soil being the chief source of energy and food for most of the soil organisms, it has great influence on the microbial population. An increase in organic matter of soil is likely to influence directly or indirectly, the population and activity of soil micro biome depending upon other soil conditions.

On perusal of data highlighted in Table 4.21, it is evident that microbial biomass population responded significantly to these treatments with varying magnitude on soil microbial population. Soil microbial population was highest under organic treatment (T_1, T_2 and T_3) followed by the integrated nutrient management (T_{11}, T_{12} and T_{13}). The microbial biomass of the treated soil observed a reduction from its initial status (called baseline population) in control as well as chemical fertilizers carrying treatments (T_4), but the reduction was more pronounced in control treatment than chemical fertilizers applied treatment, for the simple reason that as long as nutrients are applied in balanced quantity and addressing different soil fertility constraints, even chemical fertilizers will continue to produce favorable effects on soil microbial population. Another reason for better response of chemical fertilizers over control is the soil organic matter content, which is above optimum limit, with the result, baseline population of microbes continue to derive the required energy through native soil carbon source. However, the soil bacterial population outweighed the fungal population during both the years of study.

During the first year (2014-15), of all the treatments, T_1 (FYM @ 40 t ha^{-1}) with bacterial count of 143×10^4 cfu g^{-1} recorded the maximum count, statistically at par with treatment T_2 (Pig manure @ 35 t ha^{-1}) with 140×10^4 cfu g^{-1}, T_{11} (50% NPK + 25% FYM + Biofertilizers) with 135×10^4 cfu g^{-1}, T_3 (Vermicompost @ 10 t ha^{-1}) with 132×10^4 cfu g^{-1}, T_{12} (50% NPK + 25% Pig manure + Biofertilizers) with 131×10^4 cfu g^{-1} and T_6 (50% NPK + 50% FYM) with 129×10^4 cfu g^{-1}. However, the lowest bacterial count was observed in control with count of 113×10^4 cfu g^{-1} followed by T_4 (100% NPK) with 115×10^4 cfu g^{-1}.

While during the second year (2015-16), the response was no different. The treatment, T_1 (FYM @ 40 t ha^{-1}), observed the highest bacterial count of 146×10^4 cfu g^{-1}, statistically at par with T_2 (Pig manure @ 35 t ha^{-1}) with a count of 143×10^4 cfu g^{-1} while the lowest count of bacterial population was registered in control and T_4 (100% NPK) with a count of 116 × 10^4 cfu g^{-1}. Interestingly, pooled data analysis displayed similar responses of different treatments compared to their annual evaluation. The treatment T_1 (FYM @ 40 t ha^{-1}) with 144 × 10^4 cfu g^{-1} observed the highest bacterial count, on par with T_2 (Pig manure @ 35 t ha^{-1}) with 141 × 10^4 cfu g^{-1}. It was noted that T_0 and T_4 (100% NPK) showed the lowest bacterial count (114 × 10^4 cfu g^{-1}) and (115 × 10^4 cfu g^{-1}) respectively.

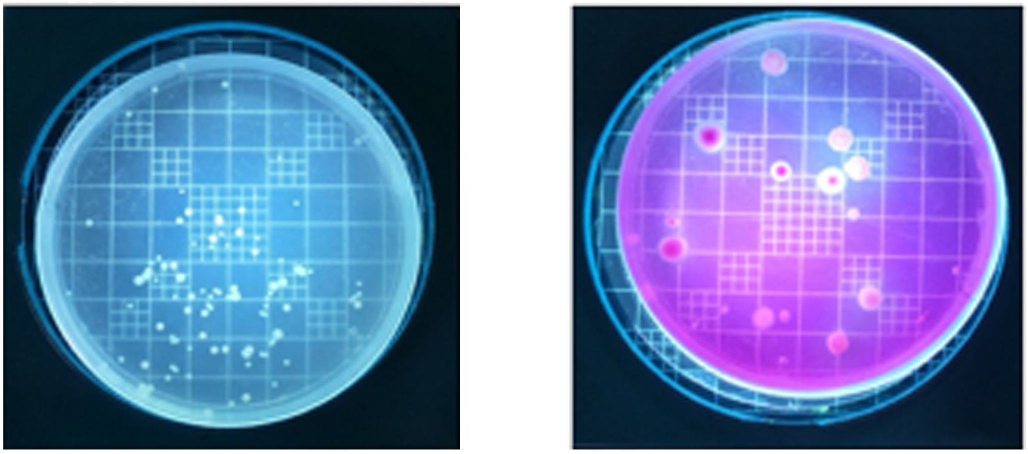
Data on changes in soil fungal population highlighted in Table 4.21, showed a highly significant response of different treatments on soil fungal population. The highest count of soil fungal population was recorded in the organic manure treated plots (T_1, T_2 and T_3). The fungal count during 2014-15, was observed maximum with T_1 (FYM @ 40 t ha^{-1}) with count of 35 × 10^4 cfu g^{-1}, on par with T_2 (Pig manure @ 35 t ha^{-1}) with a count of 34 × 10^4 cfu g^{-1}. While, treatment T_4 (100% NPK) with 22 × 10^4 cfu g^{-1} observed the minimum fungal count, at par with control and T_{10} (75% NPK + Biofertilizers) with fungal count of 23× 10^4 cfu g^{-1}. During 2015-16, T_1 (FYM @ 40 t ha^{-1}) observed the maximum fungal count (37× 10^4 cfu g^{-1}), statistically on par with T_2 (Pig manure @ 35 t ha^{-1}) (36 × 10^4cfu g^{-1}), but significantly superior to T_4 (100% NPK) with a count of 21 × 10^4 cfu g^{-1}. Analysis of pooled data accrued for both the years of experimentation, showed similar response trends. T_1 (FYM @ 40 t ha^{-1}) exhibited maximum fungal count (36 × 10^4 cfu g^{-1}), statistically on par with T_2 (Pig manure @ 35 t ha^{-1}) (35× 10^4cfu g^{-1}), while T_4 (100% NPK) with 22 × 10^4 cfu g^{-1} displaying minimum fungal count of the treated soil.

These results amply demonstrated that microbial biomass and soil enzyme activity far more sensitive in discriminating the response between organic fertilizers and inorganic fertilizer application on soils lower in organic matter content. While on soils rich in organic matter content, such responses are not so distinct. Earlier, Mohammadi (2011), in his two years of research trial on the effect of different fertilization methods on soil biological indices, reported that the dehydrogenase, phosphatase and urease activities in the chemical fertilizer treated soil were significantly lower than FYM and compost treated plots. Application of chemical fertilizer can suppress the microbial activity on low organic carbon soils.

Hota *et al*. (2014) observed that the application of micro- and secondary nutrients in combination with soil amendments, organic manure and optimum doses of NPK, collectively enhanced the population of total fungi, bacteria and actinomycetes count compared to sole application of inorganic chemical fertilizers. Such observations on enzyme activity were due to addition of organic manures as the sole source of carbon and energy for the heterotrophs (Selvi *et al*., 2004; Qureshi *et al*., 2005). Increased soil microbial population accounted for an increase in dehydrogenase activity of soil. A high value of Pearson's correlation coefficient (Appendix- B) showed that the activities of enzymes in soil were significantly and positively correlated with important soil parameters like organic carbon, fungal and bacterial population in the soil, lending strong support that build-up of soil microbes is a pre-requisite for better soil enzymatic activities. The organic sources applied with inorganic fertilizers and biofertilizers were able to put up a joint action into the treated soil over time and complimenting each other, with cycles of fast and slow release rate of nutrients in the early days of crop growth and later as well, at more or less constant rate to ensure better crop yield. The release of nutrients through organic manures through mineralization during later part of crop growth was more guided by these processes, with inoculated microbes to be able to prolong their action through constant supply of carbon and required nutrients, aiding not only in their multiplication but releasing fair amount of crop growth promoting substances. In fact, nature of substrates present in soil influenced the enzymatic activity more than any other soil-based input as reported by Rai and Yadav (2011).

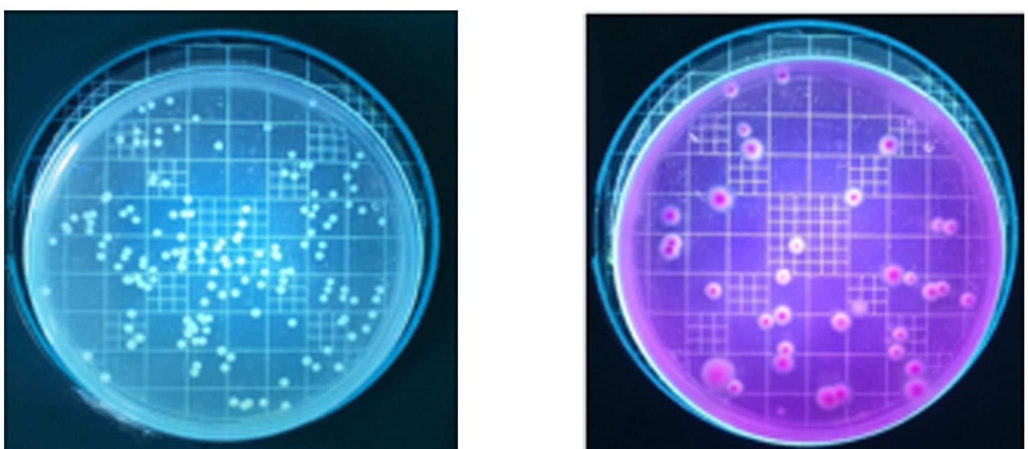
Table 4.21: Changes in soil health parameters in response to various sources of nutrients

Treatments	Dehydrogenase activity (TPF µg g^{-1} hr^{-1})			Bacterial count (1×10^4 cfu g^{-1})			Fungal count (1×10^4 cfu g^{-1})		
	2014-15	**2015-16**	**Pooled**	**2014-15**	**2015-16**	**Pooled**	**2014-15**	**2015-16**	**Pooled**
T_0	5.06	6.11	5.59	113	116	114	23	23	23
T_1	**9.85**	**9.91**	**9.88**	**143**	**146**	**144**	34	**37**	**36**
T_2	9.46	9.75	9.61	140	143	141	**35**	36	**36**
T_3	9.37	9.71	9.54	132	135	133	30	31	31
T_4	5.12	6.39	5.75	115	116	115	22	21	22
T_5	6.21	6.90	6.55	120	124	122	24	24	24
T_6	8.65	9.69	9.17	129	131	130	28	28	28
T_7	8.60	9.14	8.87	127	130	128	27	29	28
T_8	7.96	9.05	8.51	122	129	126	25	25	25
T_9	6.18	6.75	6.47	118	123	120	24	23	23
T_{10}	5.20	6.40	5.80	117	120	119	23	23	23
T_{11}	9.18	9.66	9.42	135	137	136	29	33	31
T_{12}	8.84	9.55	9.20	131	138	135	27	30	28
T_{13}	8.95	9.24	9.10	126	133	129	24	27	25
SEm±	0.38	0.35	0.27	5.03	5.12	3.59	1.41	1.84	1.16
CD at 5%	1.16	1.02	0.87	14.63	14.89	11.72	4.11	5.36	3.79



T_0

T_1



T_{12}

Plate 9. Variations in soil bacterial and fungal biomass in response to different sources of nutrients

4.6 Benefit cost ratio.

The economic feasibility of different practices or treatments is usually a deciding factor for its adoption by the farmers for commercialization of any crop production programme. It is therefore, of common interest to calculate the effect of different treatments tested in the study on the cost and returns of gladiolus crop. 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- B), it was revealed that the major portion of cost of cultivation was consumed by planting material itself. In the present study, the cost of cultivation was marginally increased when the nutrients were applied through the combination of different sources, but due to higher spikes, corm and cormel yields, the net income and cost benefit ratio were also higher under the integrated use of organic and inorganic sources of nutrients (Table 4.22). It is evident from the findings that the most profitable way for cultivating gladiolus cv. Candyman under Nagaland condition can be achieved by application of T_{12} (50% NPK + 25% Pig manure + Biofertilizers) which gave the highest net return of ₹ 15,11,939 and B:C ratio of 2.01 followed by T_{11} (50% NPK + 25% FYM + Biofertilizers) which gave a net return of ₹ 14,95,550 and B:C ratio of 2.00 which was more than that received with 100% NPK (₹ 13,54,571 and B:C ratio of 1.78) . The reason of high net economic return (profit) in the treatment of (T_{12}) 50% NPK + 25% Pig manure + Biofertilizers and (T_{11}) 50% NPK + 25% FYM + Biofertilizers was due to low input cost and high yield. Lowest net return of ₹ 10,28,665 and B:C ratio of 1.42 was obtained in the treatment T_0 (control) which is due to low system productivity.

The use of organic sources of nutrient has not only improved the yield but has also served as a low means of input as compared to chemical fertilizers, thereby increasing the net return of the system. The use of biofertilizers in combination with organic manures and chemical fertilizers in optimum proportion has also enhanced the nutrient status of available nitrogen, phosphorus and potassium in soil besides increasing the yield. Hence, 25% of nitrogen and phosphorus can be saved with the use of biofertilizers (N and P sources) respectively to achieve higher benefit cost ratio without compromising the yield and quality of gladiolus as well as the health and fertility of the soil. This results are in line with the findings of Gangadharan and Gopinath (2000) from their studies on the effect of organic and inorganic fertilizers on gladiolus where the highest benefit: cost ratio (1.56: 1), gross (₹ 13, 16, 400) and net (₹ 8, 01, 779.03) income was obtained with integrated sources of nutrients in optimum doses. Similarly, Pushpalatha *et al*. (2000) reported the economic feasibility of gladiolus cultivation.

Table 4.22: Influence of various sources of nutrient on the economics of cultivation of *Gladiolus primulinus* cv. Candyman

Treatments	Cost of production			Yield of corms (t ha^{-1})	Price of corms (₹ ha^{-1})	Yield of cormels (t ha^{-1})	Price of cormels (₹ha^{-1})	Spikes ha^{-1}	Price of spikes ha^{-1}	Gross return (₹ ha^{-1})	Net return (₹ ha^{-1})	Cost benefit ratio
	Fixed cost (₹ ha^{-1})	Treatment cost (₹ha^{-1})	Total cost (₹ ha^{-1})									
T_0	723200	0	723200	10.35	517383	0.45	11310	152897	1223172	1751865	1028665	1:1.42
T_1	723200	20000	743200	13.03	651520	0.60	14968	175565	1404516	2071004	1322804	1:1.77
T_2	723200	24500	747700	13.21	660383	0.61	15328	182232	1457852	2133562	1380862	1:1.83
T_3	723200	100000	823200	12.53	626643	0.56	14008	173342	1386736	2027386	1199186	1:1.45
T_4	723200	31420	754620	12.15	607605	0.53	13178	186676	1493408	2114191	1354571	1:1.78
T_5	723200	400	723600	10.32	515793	0.49	12315	169787	1358292	1886400	1157800	1:1.59
T_6	723200	25710	748910	13.19	659395	0.64	16058	191121	1528964	2204417	1450507	1:1.92
T_7	723200	27960	751160	13.23	661565	0.66	16510	194455	1555636	2233711	1477551	1:1.95
T_8	723200	65710	788910	13.67	653365	0.57	14163	186898	1495184	2162712	1368802	1:1.72
T_9	723200	16110	739310	11.48	574040	0.52	12920	170898	1367180	1954140	1209830	1:1.63
T_{10}	723200	23965	747165	12.39	619590	0.54	13528	181120	1448960	2082078	1329913	1:1.77
T_{11}	723200	21110	744310	13.24	662225	0.65	16335	195787	1566300	2244860	1495550	1:2.00
T_{12}	723200	22235	745435	13.27	663470	0.66	16600	197788	1582304	2262374	1511939	1:2.01
T_{13}	723200	41110	764310	12.87	643260	0.61	15258	188899	1511188	2169706	1400396	1:1.82

Selling price of corm= ₹ 50000 t^{-1} Selling price of cormel= ₹ 25000 t^{-1} Selling price of spike= ₹ 8 spike^{-1}

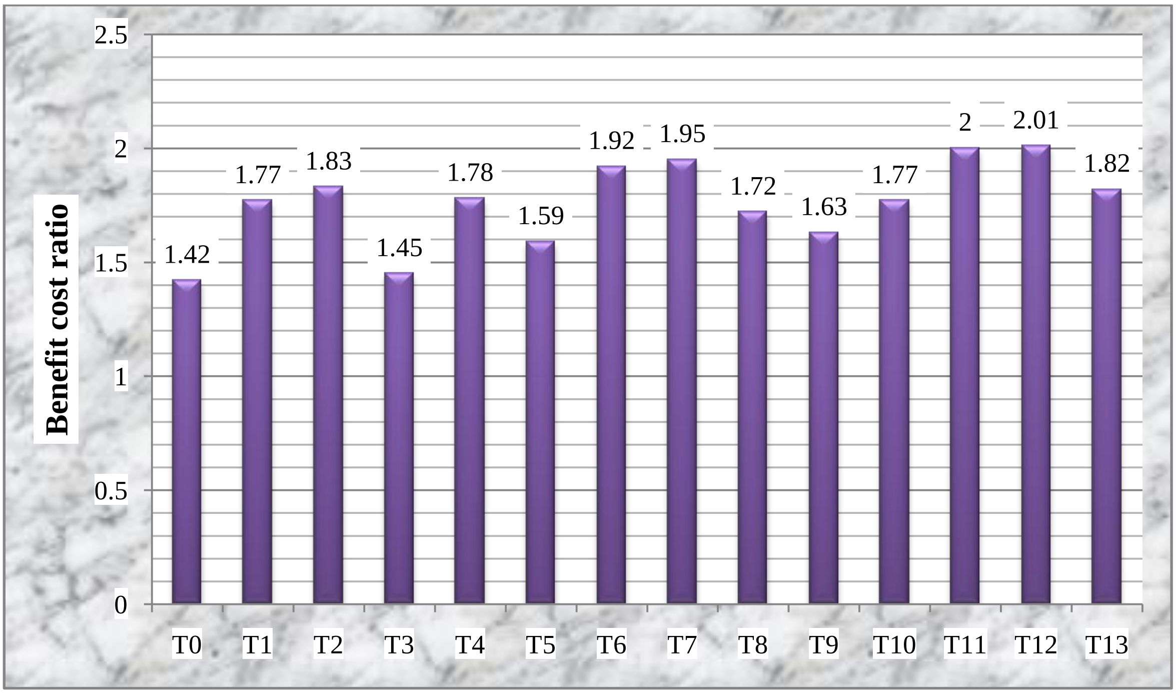


Fig. 4.3: Influence of various sources of nutrient on the economics of cultivation of *Gladiolus primulinus* cv. Candyman

CHAPTER V
SUMMARY & CONCLUSION

SUMMARY AND CONCLUSION

The present investigation entitled "Effect of various nutrient sources on the growth, flowering, yield and vase life of *Gladiolus primulinus* cv. Candyman" was carried out in the experimental farm of the School of Agricultural Sciences and Rural Development, Medziphema, Nagaland University, during the period of 2014-2015 and 2015-2016. The investigation was carried out with the following objectives –

1. To study the effect of various nutrient sources on the growth, flowering, yield and vase life of gladiolus.
2. To study the response of various nutrient sources on the soil fertility changes and plant nutrition behaviour of gladiolus.
3. To study the cost benefit ratio of various treatments for production of gladiolus.

The salient findings thus obtained from the study were summarized below:

6.1 Growth characters

The effect of various treatments on the mean values of growth characters in gladiolus showed different variations. The days to sprouting of corms was found to be non significant while the growth characters with respect to plant height and leaves plant^{-1} (108.55 cm and 9.63 respectively) were highest in T_{11} (50% RDF + 25% FYM + Biofertilizers). Highest leaf area (130.56 cm^2) was noted in T_{12} (50% RDF + 25% Pig manure + Biofertilizers).

6.2 Flowering parameters

Significant variations were found with respect to flowering parameters. Minimum days to spike emergence (68.72 days) was found in T_{11} (50% RDF + 25% FYM + Biofertilizers). Minimum days to full opening of 1^{st} floret (78.36 days), maximum florets spike^{-1} (15.58), minimum days to 5^{th} floret opening from the day of spike emergence (6.11 days), highest spike length (88.76 cm) and rachis length (48.84 cm), highest diameter of floret (10.33 cm) and longest durability of spike (19.42 days) were found in T_{12} (50% RDF + 25% Pig manure + Biofertilizers).

6.3 Yield and yield attributing characters

The results of the findings indicate that T_{12} (50 % NPK + 25% Pig manure + Biofertilizers) recorded maximum result in all yield attributing characters such as spikes plant^{-1} (1.48), spike plot^{-1} (29.67) as well as projected yield of spikes per hectare (197788), corms plant^{-1} (1.53), weight of corms plant^{-1} (99.52 g), weight of corms plot^{-1} (1.99 kg) as well as projected yield of corms (13.27 t ha^{-1}). Corm diameter (6.91 cm) was highest with T_{11} (50% RDF + 25% FYM + Biofertilizers) and cormels plant^{-1} (14.38) was highest with T_{11} (50% RDF + 25% FYM + Biofertilizers) and T_{12} (50% NPK + 25% Pig manure + Biofertilizers) while weight of cormels plant^{-1} (5.01 g), weight of cormels plot^{-1} (0.100 kg) and projected yield of cormels (0.664 t ha^{-1}) was found to be maximum with T_{12} (50% NPK + 25% Pig manure + Biofertilizers).

6.4 Vase life parameters

It is observed that the maximum fresh weight of spike on all the days of observations during vase life was exhibited with T_{12} (50% NPK + 25% Pig manure + Biofertilizers) with the highest fresh weight (65.37 g) recorded on the 3^{rd} day of vase life. Water uptake (21.41 g) was also maximum with T_{12} (50% NPK + 25%

Pig manure + Biofertilizers) on the 3rd day of vase life which was higher than all the rest of the treatments. The lowest water loss (5.71 g) was obtained on the 9th day with control while the highest water balance ratio (1.265) was registered in T_{12} (50% NPK + 25% Pig manure + Biofertilizers) on the 3rd day of vase life.

6.5 Plant nutrition and soil fertility status after harvest

Maximum nitrogen content in plant leaves (2.93%) was recorded with T_{11} (50% RDF + 25% FYM + Biofertilizers) while phosphorus content (0.41%) were reported with T_{12} (50% NPK + 25% Pig manure + Biofertilizers) and potassium content (2.13%) was highest with T_{11} (50% RDF + 25% FYM + Biofertilizers) and T_{12} (50 % NPK + 25 % Pig manure + Biofertilizers). Maximum organic carbon (2.16%) and soil pH (4.88) were recorded with T_1 (FYM 40 t ha^{-1}). The maximum available nitrogen after harvest (284.7 kg ha^{-1}) was found with T_6 (50% NPK+ 50% FYM). The application of T_7 (50% NPK + 50% Pig manure) recorded maximum available P (24.3 kg ha^{-1}) while T_6 (50% NPK + 50% FYM) recorded maximum available K (254.4 kg ha^{-1}) after harvest of crop in experimental plots. The soil health parameters were recorded to be the best in organic treatments alone. The maximum soil dehydrogenase activity (9.88 TPF µg g^{-1} hr^{-1}), soil bacterial count (144×10^4 cfu g^{-1}) and fungal count (35×10^4 cfu g^{-1}) were recorded with T_1 (FYM 40 t ha^{-1}).

6.6 Economics of the treatments

The economics of different treatments were calculated and the highest profit (₹ 9,23,575) and highest cost benefit ratio of 1: 2.01 was obtained with T_{12} (50% NPK + 25% Pig manure + Biofertilizers).

Future line of work

Based on the results obtained in the present study, it is evident that there is lot of scope in future for research on the following aspects for increasing production and improving quality of gladiolus:

1. In order to integrate promising organic resources into INM practice, an organic resource database with respect to nutrient content and quality parameters of manures and crop residues, green manure crops and other locally available organics comparable to that of alternative nutrient sources and the hypothesis for predicting nutrient release rates may be initiated.

2. It is necessary to identify suitable organics and their nutrient as well as non nutrient benefits and biofertilizers for improving physiological and biochemical parameters in gladiolus.

3. Use of other biofertilizers, in place of chemicals and animal or plant based pest control products or growth-promoters, is suggested.

4. Interactions of microbial inoculants with native pool of soil microorganisms are likely to be complex and a better mechanistic understanding is necessary to predict short and long term effect of those interactive or synergistic groups of microorganisms on chemical and biological pool of nutrients in soil.

Conclusion

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

1. Integrated application of 50% NPK (100:100:100 kg ha^{-1}) + 25% Pig manure (8.75 t ha^{-1}) + Biofertilizers (*Azospirillum* + Phosphotica) is considered the best treatment in terms of plant growth, flowering, higher yield and vase life of *Gladiolus primulinus* cv. Candyman under the foothill condition of Nagaland.

2. Organic fertilization or INM is also recommended over lone application of inorganic fertilizers which increased the available nitrogen, phosphorus, potassium, organic carbon, pH and improved soil health parameters after crop harvest, thereby, maintaining fertility and soil health in addition to improving nutrient uptake by crops.

3. Highest cost benefit ratio can be obtained by the integrated application of 50% NPK (100:100:100 kg ha^{-1}) + 25% Pig manure (8.75 t ha^{-1}) + Biofertilizers (*Azospirillum* + Phosphotica) under Nagaland condition which may also be substituted by 50% NPK (100:100:100 kg ha^{-1}) + 25% FYM (10 t ha^{-1}) + Biofertilizers (*Azospirillum* + Phosphotica).

REFERENCES

REFERENCES

Abou El-yazeid, A., Abou- Aly, E. and Moussa, M. 2007. Enhancing growth productivity dissolving microorganism (Bio-phosphor) combined with boron foliar. *Agriculture and Biological Science.* **3** (4): 274-86.

Ahmad, A., Mehmood, T., Hussain, R., Bashir, A., Raza, S., Najam-ud-Din and Ahmad, A. 2013. Investigation of biofertilizers influence on vegetative growth, flower quality, bulb yield and nutrient uptake in gladiolus *(gladiolus grandiflorus l.). International Journal of Plant, Animal and Environmental Sciences.* **4** (1): 94-99.

Ahmed, M., Khan, M. F., Hamid, A. and Hussain, A. 2004. Effect of urea, DAP and FYM on growth and flowering of Dahlia (*Dahlia variabilis*). *International Journal of Agriculture and Biology.* **6** (2): 393-395.

Aiswath, O. P., Dravid, S. and Deshmukh, P. S. 2003. Nitrate reductase activity and chlorophyll content in wheat as influenced by chemical fertilizers, biofertilizers and farmyard manure. *Annals of Agriculture Research.* **24** (3): 466-473.

Ali, M. E., Islan, M. R. and Jahiruddin, M. 2009. Effect of integrated use of organic manures with chemical fertilizers in the rice-rice cropping system and its impact on soil health. *Bangladesh Journal of Agricultural Research*. **34**, 81-90.

Anderson, N. O., Frick, J., Younis, A. and Currey, C. 2012. Heritability of cold tolerance (winter hardiness) in *Gladiolus* × *grandiflorus*. In: I.Y. Abdurakhmonov (ed.), *Plant Breeding*. **13**: 297–312.

APEDA. 2016. Floriculture. www.apeda,gov.in/apedawebsite/SubHead.../ Floriculture. htm.

Asrey, R., Singh, R. and Kumar, S. 2002. Influence of organic manures and flower preservatives on postharvest vase life of gladiolus cut flower. *Annals of Agricultural Research.* **23** (4): 659-663.

Baboo, R. and Singh, R. D. 2006. Response of nitrogen, phosphorus and corm size on flowering and corm production in gladiolus. *Journal of Ornamental Horticulture.* **9**(1): 66-68.

Barman, D., Rajni, K., Rampal. and Upadhyaya, R. C. 2005. Corm multiplication of gladiolus as influenced by application of potassium and spike removal. *Journal of Ornamental Horticulture*. **8** (2): 104-107.

Basil, L. and Singh, V. C. (2010). Effect of Biofertilizers and vermicompost on growth, flowering and yield of tuberose (*Polianthus tuberosa*) cv. Single. *4th Indian Horticulture Congress*. **iii** (129): 256-257.

Basoli, M., Kumar, P. and Kumar, S. 2015. Impact of integrated nutrient management on growth and flowering of gladiolus (*Gladiolus hybrida*) cv. Novalux. *The Indian Journal of Agricultural Sciences.* **85** (5):

Bhalla, R., Kanwar, P., Dhiman, S. R. and Ritu Jain. 2006. Effect of biofertilizers and biostimulants on growth and flowering in gladiolus. *Journal of Ornamental Horticulture*. **9**(4): 248-252.

Bharadwaj, V., Omanwar, P. K., Sharma, R. A. and Vishwanath. 1994. Long-term effects of continuous rotation of cropping and fertilization on crop yield and nutrient uptake. I. Effect on crop yield and nutrient uptake. *Journal of the Indian Society of Soil Science*. **42**: 247-253.

Bhatia, S., Gupta, Y. C. and Dhiman, S. R. 2004. Effect of growing media and fertilization on carnation flower production and protected conditions. *Journal of Ornamental Horticulture.* **7**: 174-178.

Bhattacharjee, S. K. and De, L. C. 2010. Gladiolus. Advanced Commercial Floriculture. Revised Edition. Aavishkar Publication, Joipur. **1**: 309-310.

Bloemberg, G. V., Wijfjes, A. H. M., Lamers, G. E. M., Stuurman, N. and Lugtenberg, B. J. J. 2000. Simultaneous imaging of *Pseudomonas fluorescens* WCS3655 populations expressing three different autofluorescent proteins in the rhizosphere:

new perspective for studying microbial communities. *Molecular Plant-Microbe Interactions*. **13**: 1170-1176.

Bray, R. H. and Kurtz, L. T. 1945. Determination of total organic and available forms of phosphorus in soils. *Soil Science.* **59**: 39-45.

Bunemann, E. K., Schwenka, G. D. and Zwiten, V. L. 2006. Impact of agricultural inputs on soil organisms- a review. *Australian Journal of Soil Research.* **44**: 379-408.

Casida, L. E., Klein, D. A. Jr. and Santoro, T. 1964. Soil dehydrogenase activity. *Soil Science*. **98**: 371-376.

Castro, C. A. M., Ruppenthal, V., Zigiotto, D. C., Bianchini, M. I. F. and Backes, C. 2002. Organic fertilization in the culture of the gladiolus. *Scientia Agraria Paranaensis*. **1** (1): 33-41.

Chaitra, R. 2006. Effect of integrated nutrient management on growth, yield and quality of China aster (*Callistephus chinensis* (L.) Nees). M. Sc. Thesis, University of Agricultural Sciences, Dharwad, Karnataka, India.

Chandra., Shukla, R. and Singh, K. 2010. Effect of vermicompost of different organic wastes on the germination, growth and productivity of certain crops. *Journal of Solid Waste Technology & Management*. **36**.

Chaudhary, N., Swaroop, K., Janakiram, T., Biswas, D. R. and Singh, G. 2012. Response of INM on Gladiolus for corm attributing characters and soil fertility. *Journal of Ornamental Horticulture.* **15** (1&2): 47-52.

Chaudhary, N., Swaroop, K., Janakiram, T., Biswas, D. R. and Singh, G. 2013. Effect of integrated nutrient management on vegetative growth and flowering characters of gladiolus. *Indian Journal of Horticulture.* **70** (1): 156-159.

Chaudhary, S. V. S. 2010. Biofertilizers and their application in floriculture – A Review. *Annals of Horticulture.* **3**: 29-33.

Chettri, M. and Thapa, U. 2004. Integrated nutrient management with farm yard manure on potato (*Solanum tuberosum*) under gangetic plains of West Bengal. *Journal of Environment and Ecology*. **22** (4): 766-769.

Curl, C. L., Fenske, R. A., Kissel, J. C., Shirai, J. H., Moate, T. F., Griffith, W., Coronado, G. and Thompson, B. 2002. Evaluation of take-home organophosphorus pesticide exposure among agricultural workers and their children. *Environmental Health Perspective*. **110**: A787-792.

Dahiya, S. S., Mohansundram, S., Singh, S. and Dahiya, D. S. 2001. Effect of nitrogen and phosphorus on growth and dry matter yield of tuberose (*Polianthes tuberosa* L.). *Haryana Journal of Horticultural Science*. **30**: 198-200.

Dalve, P. D., Mane, S. V. and Nimbalkar, R. R. 2009. Effect of biofertilizers on growth, flowering and yield of gladiolus. *The Asian journal of horticulture*. **4** (1): 227-229.

Dongardive, S. B., Golliwar, V. J., Bhongle, S. A. and Bhongle, S. A. 2009. Influence of organic manure and biofertilizers on corms and cormels yield of gladiolus. *Annals of Plant Physiology*. **23** (1): 114-116.

Dubey, R. K. and Misra, R. L., 2006, Study of chemical and bio-fertilizers on gladiolus. *Progressive Horticulture*. **38** (2): 165-171.

Dubey, R. K., and Mishra, R. L. 2005. Response of chemical and biofertilizers on corm and cormel production in gladiolus. *Progressive Horticulture*. **37** (2): 412-418.

Dubey, R. K., Kumar, P., Singh, N. and Kumar, R. 2008. Effect of *Trichoderma viride* and *Pseudomonas fluorescens* on growth and flowering of gladiolus. *Indian Journal of Ecology*. **35** (1): 554-556.

Dubey, R. K., Misra, R. L., Singh, S. K. and Manisha. 2010. Efficacy of bio- and chemical fertilizers on certain floral qualities of gladiolus. *Indian Journal of Horticulture*. **67** (Special Issue): 382-385.

Gagbhiye, B. R., Vetal, R. A., Puri, A. N. and Adsul, P. B. 2013. Response of FYM, N, P and K levels on growth and flowering of gladiolus (G*ladiolus grandiflorus)* cv. White Prosperity. *The Journal of Rural and Agricultural Research.* **13** (2): 94-97.

Gangadharan, G. D. and Gopinath, G. 2000. Effects of organic and inorganic fertilizers on yield of spikes, corms, cormels and returns of gladiolus cv. White Prosperity. *Karnataka Journal of Agricultural Sciences.* **13** (2): 401-412.

Godse, S. B., Golliwar, V. J., Neha, C., Bramhankar, K. S. and Kore, M. S. 2006. Effect of organic manures and biofertilizers with reduced doses of inorganic fertilizers on growth, yield and quality of gladiolus. *Journal of Soils and Crop.* **16** (2): 445-449.

Goldblatt, P. and Manning, J. C. 1998. Gladiolus in Southern Africa: Systematics, Biology, and Evolution. Fernwood Press, Cape Town, South Africa.

Goyal, S., Chander, K., Mundra, M. C. and Kapoor, K. K. 1999. Influence of inorganic fertilizers and organic amendments on soil organic matter and soil microbial properties under tropical conditions. *Biology and Fertility of Soils*. **29** (2): 196-200.

Gupta, P., Rajwal, N., Dhaka, V. K. and Rajwal, D. 2008. Effect of different levels of vermicompost, NPK and FYM on performance of gladiolus (*Gladiolus grandiflorus* L.) cv. Happy End. *Asian Journal of Horticulture.* **3** (1): 142-143.

Hanway, J. J. and Heidal, H. 1952. Soil analysis methods as well as testing laboratory IOWA. *Agriculture*. **57**: 1-31.

Haque, I. and Jakhro, A. A. 2001. *Soil and fertilizer potassium*. **In**: Soil Science, Published by National Book Foundation, Islamabad, Pakistan, pp 261–263.

Hassandokht, M. R. and Kashi, A. 2000. Effects of farmyard manure and nitrogen application on the quantity and quality of potato crop. *Seed and Plant Journal.* **15** (4): 323-330.

Hatibarua, P., Mishra, R. L. and Bhattacharjee, S. K. 2002. Effect of nitrogen sources and doses on some post harvest characters of gladiolus. *Floriculture Research trend in India*, ISOH, pp. 114-117.

Heather, M. D., Alexandra, G. S. and Richard, P. D. 2006. Compost and manure mediated impacts on soil borne pathogens and soil quality. *Soil Science Society of America Journal*. **70**: 347-358.

Hota, R., Kumar, A. J. and Narayana, K. L. 2014. Effect of inorganic and organic amendments on yield of cocoyam (*Colocasia esculenta*) and on soil properties. *World Journal of Agricultural Research.* **2**(2): 70-81.

Imchalemla. 2016. Studies on integrated nutrient management and storage of lilium var. Brindisi. Ph.D Thesis, Nagaland University, School of Agricultural Sciences and Rural Development, Medziphema Campus, India.

Jackson, M. L. 1973. Soil Chemical Analysis. Prentice-Hall of India Private Limited, New Delhi, India. 82-86.

Jaggi, R. C. 2007. Nutritional research in vegetables of Himachal Pradesh. *Indian Journal of Fertilizers*. **2**: 25-41.

Janakiram, T., Namita, P. P., Ritujai and Narkar, N. D. 2013. Fertilizer based management practices in floriculture. *Indian Journal of fertilizers.* **9**: 160-175.

Javaria, S. and Khan, M. Q. 2011. Impact of integrated nutrient management on tomato yield, quality and soil health. *Journal of Plant Nutrition*. **34**: 140-149.

Jha, S., Sharma, G. L., Dikshit, S. N., Patel, K. L., Tirkey, T. and Sarnaik, D. A. 2012. Effect of vermicompost and FYM in combination with inorganic fertilizer on growth, yield and flower quality of gladiolus (*Gladiolus hybridus*). *Journal of Soils and Crops.* **22** (2): 253-257.

John, A. Q., Mir, M. M., Nelofar and Khan, F. U. 2007. Response of organic manure and inorganic fertilizer on growth and bulb production of tulip. *Journal of ornamental horticulture.* **10** (3): 157-160.

Johnson, C. M. and Ulrich, A. 1959. Analytical methods for use in plant analysis. *California Agricultural Experiment Station Bulletin*. **766**.

Kabir, A. K. M. R., Iman, M. H., Mondal, M. M. A. and Chowdhury, S. 2011. Response of tuberose to integrated nutrient management. *Journal of Environmental Science and Natural Resources*. **4** (2): 55-59.

Kathiresan, C. and Venkatesha, J. 2002. Effect of biofertilizer with levels of N and P on gladiolus. ***In**: Floriculture research trends in India*, pp 118-121.

Keditsu, R. 2012. Response of gerbera to inorganic fertilization versus organic manuring. *Annals of Plant and Soil Research.* **14** (2): 163-166.

Khan, F. N. 2009. Techniques of corm and cormel production in gladiolus. A Ph. D dissertation, BSMRAU, Salna, Gazipur, India.

Khan, F. N., Rahman, M. M., Karim, A. J. M. S. and Hossain, K. M. 2012. Effects of nitrogen and potassium on growth and yield of gladiolus corms. *Bangladesh Journal of Agricultural Research.* **37** (4): 607-616.

Khan, M. A. and Ahmad, I. 2004. Growth and flowering of *Gladiolus hortulanus* L. cv. Wind Song as influenced by various levels of NPK. *International Journal of Agriculture and Biology.* **6** (6): 1037-1039.

Khan, M. S. and Zaidi A. 2002. Plant growth promoting rhizobacterial from rhizospheres of wheat and chickpea. *Annals of Plant Protection Sciences*. **10** (2): 265-271.

Kremer, R. J. and Jianmei, L. 2003. Developing weed-suppressive soils through improved soil quality management. *Soil & Tillage Research*. **72**: 193-202.

Kukde, S., Peillewan, S., Meshram, N., Khobragade, H. and Khobragade, Y. R. 2006. Effect of organic manure and biofertilizer on growth, flowering and yield of Tuberose cv. Single. *Journal of Soils and Crops*. **16** (2): 414-416.

Kumar, M. and Chattopadhyay, T. K. 2001. Effect of NPK on the yield and quality of gladiolus (*Gladiolus grandiflorus* L.) cv. Tropic Sea. *Environment and Ecology*. **19** (4): 868-871.

Kumar, M., Baishya, L. K., Ghosh, D. C., Ghosh, M., Gupta, V. K. and Verma, M. R. 2013. Effects of organic manures, chemical fertilizers and biofertilizers on growth and productivity of rainfed potato in the Eastern Himalayas. *Journal of Plant Nutrition*. **36**: 1065–1082.

Kumar, M., Jatav, M. K., Trehan, S. P., Dua, V.K. and Kumar, S. 2013. Effect on nitrogen and varieties of potato on yield and agronomic N use efficiency in North-Western plains of India. *Potato Journal*. **40** (1): 55-59.

Kumar, P., Raghava, S. P. S. and Mishra, R. L. 2003. Effect of bio-fertilizers on growth and yield of china aster. *Journal of Ornamental Horticulture.* **6**: 85-88.

Kumar, P., Shekhar, C., Basoli, M. and Kumar, V. 2012. Sequential spray of vermiwash at critical stages influences growth and quality in gladiolus cv. White Prosperity. *Progressive Agriculture*. **12**: 103-109.

Kumar, R., Kumar, R. and Kumar, P. 2011. Effect of integrated use of chemical fertilizers, biofertilizers and biostimulants in gladiolus (*Gladiolus grandiflorus* L.) cv. Sancerre. *Progressive Horticulture*. **43** (1): 149-152.

Kumar, S. and Haripriya, K. 2010. Effect of growth retardants on growth, flowering and yield of Nerium *(Nerium odorum L.). Plant Archives.* **10**: 681-684.

Kumari, A., Choudhary, M. and Baloda, S. 2013. Biofertilizers and their application in flower crops - A Review. *Annals of Agri Bio Research.* **18**: 195-205.

Loecke, T. D., Liebman, M., Cambardella, C. A. and Richard, T. L. 2004. Corn response to composting and time of application of solid swine manure. *Agronomy Journal.* **96** (1): 214-223.

Maeder, P., Fliessbach, A., Dubois, D., Gunst, L., Fried, P. and Niggli, U. 2002. Soil fertility and biodiversity in organic farming. *Science*. **296**: 1694-1697.

Mahesh, C., Moond, S. K., Kumara, A. and Beniwal, B. S. 2011. Response of vase solution on keeping quality of cut spikes of gladiolus cv. Priscilla. *Asian Journal of Horticulture*. **6** (2): 319-321.

Marinari, B., Masciandara, G., Ceccanti, B. and Grego, S. 2000. Influence of organic and mineral fertilizers on soil biological and physical properties. *Bioresource Technology*. **72**:9-17.

Meng, L., Ding, W. and Cai, Z. 2005. Long-term application of organic manure and nitrogen fertilizer on N_2O emissions, soil quality, and crop production in a sandy loam soil. *Soil Biology and Biochemistry.* **37** (11): 2037-2045.

Ministry of Statistics & Programme Implementation, 2016. Statistical Year Book, India.

Mittal, R., Patel, H. C., Nayee, D. D. and Sitapara, H. H. 2010. Effect of integrated nutrient management on flowering, yield and vase life of African marigold (*Tagetes erecta* L.) cv. Local under middle Gujarat climatic conditions. *Asian Science*. **5**: 22-24.

Moghadam, M. Z. and Shoor, M. 2013. Effects of vermi-compost and two bacterial bio-fertilizers on some quality parameters of petunia. *Not Science Biology*. **5** (2): 226-231.

Mohammadi, K., 2011. Effect of different fertilization methods on soil biological indexes. *International Journal of Biological, Biomolecular, Agricultural, Food and Biotechnological Engineering*. **5** (6): 329-332.

Momin, M. A. 2006. Floriculture Survey in. A Consultancy report. FAO/UNDP (IHNDP/BGD/97/06).

Mondal, S. S., Acharya, D., Ghosh, A. and Bug, A. 2005. Integrated nutrient management on the growth, productivity and quality of potato in indo-gangetic plain of west Bengal. *Potato Journal.* 32: 75–78.

Mukesh, K., Vipin, K., Sunil, M. and Lokendra, K. 2007. Effect of pulsing solutions and stages of spike harvest for refrigerated storage on postharvest quality of gladiolus cut spikes. *Journal of Ornamental Horticulture.* **10** (1): 25-29.

Muthamizhselvi, M., Arulmozhiyan, R., Jawaharlal, M. and Mani, S. 2006. Integrated nutrient management on nutrient content of leaves and uptake in chrysanthemum (*Dendranthema grandiflora* Tzelev.) Cv. Co.1. S. *Indian Horticulture*. **54** (1-6): 318-322.

Nakhro, N. and Dkhar, M. S. 2010. Impact of Organic and Inorganic Fertilizers on Microbial Populations and Biomass Carbon in Paddy Field Soil. *Journal of Agronomy*. **9**: 102-110.

Narendra, C., Swaroop, K., Janakiram, T., Biswas, D. R. and Singh, G. 2013. Effect of integrated nutrient management on vegetative growth and flowering characters of gladiolus. *Indian Journal of Horticulture.* **70** (1): 156-159.

Nayak, A. K., Kanwar, R. S., Rekha, P. N., Hoang, C. K. and Pederson, C. H. 2009. Phosphorus leaching to subsurface drain water and soil P buildup in long-term swine manure applied corn-soybean rotation system. *International Journal of Agricultural Engineering.* **18** (3-4): 25-33.

Nazki, I. T. and Arora, S. 2000. Effect of GA_3 and nitrogen on gladiolus. *Journal of Ornamental Horticulture*. 124-127.

Ocampo-Juarez, H., Escalante-Estrada, J. A. S., Rodriguez-Gonzalez, M. T., Landeros-Sanchez, F. and Escalante-Estrada, L. E. 2012. Gladiolus production in relation to nitrogen-phosphorus-potassium. [Spanish] *Terra Latinoamericana*. **30** (3): 239-248.

Padmalatha, T., Satyanarayana, G. R., Chandrasekhar, R., Shankar, S. A. and Chaturvedi, A. 2013. Effect of pre-planting soaking of corms with chemicals and plant growth regulators on dormancy breaking and corm and cormel production of gladiolus. *International Journal of Plant, Animal and Environmental Science.***3** (1): 28-33.

Palm, C. A., Gachengo, C. N., Delve, R. J., Cadicsh, G. and Giller, K. E. 2001. Organic inputs for soil fertility management in tropical agroecosystems: application of an organic resource database. *Agriculture Ecosystems & Environment.* **83**: 27-42.

Panse, V. G. and P. V. Sukhatme. 1989. Statistical Methods for Agricultural Workers. ICAR, New Delhi.

Pansuriya, P. B. and Chauhan, R.V. 2015. Effect of integrated nutrient management on growth, yield and quality of gladiolus (*Gladiolus grandiflorus* L.) cv. Psittacinus Hybrid. *Journal of Horticulture.* **2:** 128.

Parolekar, S. S., Chawla, S. L., Ahlawat, R. D., Baghele, and Gurjar, R. A. 2012. Response of bio-fertilizers and their combination with different of chemical fertilizers on Tuberose (*Polianthes tuberose* L.) cv. Prajwal. *Journal of Ornamental Horticulture.* **15** (3 & 4): 227-232.

Pathak, G. and Kumar, P. 2009. Influence of organics on floral attributes and shelf life of gladiolus (*Gladiolus hybrida*) cv. White Prosperity. *Progressive Horticulture.* **41**(1): 116-119.

Patil, H. M., Shete, B. T. and Kolekar, P. T. 2004. Effect of integrated nutrient management on growth and yield of onion (*Allium cepa* L.) seed production. *International Journal of Agricultural Sciences.*

Pazhanivelan, S., Amanullah, M.M., Vaiyapuri, K., Rahale, C. S., Sathyamoorthi, K. and Alagesan, A. 2006. Effect of rock phosphate incubated with FYM on nutrient uptake and yield of lowland rice. *Research Journal of Agriculture and Biological Sciences*. **2**: 365-368.

Peck, G. M., Andrews, P K., Ritcher, C. and Reganold, J.P. 2005. Internationalization of the inorganic fruit market: The case of Washington States‟ organic apple export to be the European Union. *Renewable Agriculture and Food Systems.* **20**: 101-112.

Peterson, H. and Larton, M. 1982. A comparative analysis of soil fauna population and their role in decomposition processes. *Oikos*. **39** (3): 287-288.

Piper, C. S. 1966. Mechanical analysis of soil by International Robinson‟s Pipette method. *Soil and plant analysis*, Hans Publisher. Bombay. pp 368.

Prakash, S., Kushwahsa, I. K., Singh, M. and Shahi, B. P. 2015. Effect of vermicompost and bio-control agents on growth and flowering of gladiolus cv. Pusakiran. *Annals of Horticulture.* **8** (1): 110-112.

Pushpalatha, M. C., Reddy, T. V. and Reddy, B. V. C. 2000. Economics of gladiolus production in Bangalore District, Karnataka. *Mysore Journal of Agricultural Sciences*. **34**(2): 174-178.

Qian, P. and Schoenau, J.J. 2000. Effect of swine manure and urea on soil phosphorus supply to canola. *Journal of Plant Nutrition.* **23** (3): 381-390.

Qureshi, A. A., Narayanasamy, G., Chhonkar, P. K. and Balasundaram, V. R. 2005. Direct and residual effect of phosphate rocks in presence of phosphate solubilizers and FYM on the available P, organic carbon and viable count of phosphate solubilizers in soil after soybean, mustard and wheat crops. *Journal of the Indian Society of Soil Science*. **53**: 97-100.

Rai, T. N. and Yadav, J. 2011. Influence of organic and inorganic nutrient sources on soil enzyme activities. *Journal of the Indian Society of Soil Science.* **59** (1): 54-59.

Rajesh, B., Sandeep, D., Dhiman, S. R. and Ritu, J. 2006. Effect of biofertilizers and biostimulants on growth and flowering in standard carnation *(Dianthus Caryophyllus Linn.). Journal of Ornamental Horticulture.* **9** (4): 282-284.

Rajhansa , K.C. 2010. Studies on integrated nitrogen management in Gladiolus with special reference to growth, yield and flower quality. M.Sc. Thesis, Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G), India.

Ramesh, P., Panwar, N. R., Singh, A. B. and Ramanna, S. 2008. Effect of organic manure on productivity, nutrient uptake and soil fertility of maize-linseed cropping system. *Indian Journal of Agricultural Sciences.* **78** (4): 351- 354.

Ranjan, P., Bhat, K. V., Misra, R. L., Singh, S .K., Ranjan, J. K. 2010. Relationships of gladiolus cultivars inferred from fluorescence based on AFLP markers. *Scientia Horticulturae*. **123** (4): 562-567.

Ranjan, S., Preetham, S. P. and Satish, C. 2014. Effect of organic manures and biofertilizers on vegetative, floral and post harvest attributes in tuberose cv. Shringar. *Asian Journal of biological and life sciences.* **3** (1): 69.

Reshma, M., Sushma, K. and Aruna, J. 2013. Effect of integrated supply of different fertilizers and organic manure on yield of tuberose. *Journal of Biological Agriculture*. **3** (14): 100-101.

Ros, M., Hernandez, M. T. and Garcia, C. 2003. Soil microbial activity after restoration of a semiarid soil by organic amendments. *Soil Biology and Biochemistry.* **35**: 463-469.

Sajjad, Y., Jaskani, M. J., Ashraf, M. Y., Qasim, M. and Ahmad, R. 2014. Response of morphological and physiological growth attributes to foliar application of plant growth regulators in gladiolus “White Prosperity”. *Pakistan Journal of Agricultural Science*. **51**:123-129.

Sarkar, B., Mondal, S. S., Nayak, S. S., Saha, M. and Biswas, S. 2007. Integrated nutrient management for the productivity and quality improvement of potato under irrigated condition. *Potato Journal.* **34**: 99–100.

Sasani, G. V., Patel, C. K., Patel, R. N. and Patel, N. H. 2003. Effect of levels of inorganic fertilizers with and without organic manures on yield of potato in North Gujarat. *Journal of the Indian Potato Association.* **30** (1/2): 77-78.

Scheurell, S. J. and Mahaffe, W. F. 2004. Compost tea as container medium drench for suppressing seedling damping-off caused by *P. ultimatum*. *Phytopathology*. **94**: 1156-1163.

Sehrawat, S. K., Dahiya, D. S., Singh, S. and Rana, G. S. 2003. Growth, flowering and corm production in gladiolus as influenced by NPK application. *Haryana Journal of Horticultural Sciences.* **32** (3/4): 222-224.

Selosse, M. A., Faccio, A., Scappaticci, G. and Bonfante, P. 2004. Chlorophyllous and achlorophyllous specimens of *Epipactis microphylla* (Neottieae, Orchidaceae) are associated with ectomycorrhizal septomycetes, including truffles. *Microbial Ecology*. **47**: 416-426.

Selvaraj, N. 2004. Effect of NPK on the vegetative and flower characters of gladiolus (*Gladiolus hortensis*). *South Indian Horticulture.* **52** (1/6): 381-382.

Selvi, D., Santhy, P., Dhakshinamoorthy, M. and Maheshwari, M. 2004. Microbial population and biomass in rhizosphere as influenced by continuous intensive cultivation and fertilization in an Inceptisol. *Journal of the Indian Society of Soil Science*. **52**: 254-257.

Shaktawat, R. P. S. and Shekhawat, P. S. 2010. Soil fertility status as affected with and without farmyard manure in *kharif* crops and fertilizer levels in barley (*Hordeum vulgare*). *Indian Journal of Agricultural Sciences*, **80** (9): 791-794.

Shankar, D. and Dubey, P. 2005. Effect of NPK, FYM and NPK+FYM on growth, flowering and corm yield of gladiolus when propagated through cormels. *Journal of Soils and Crops.* **15** (1): 34-38.

Shankar, L., Lakhawat, S. S. and Choudhary, M. K. 2010. Effect of organic manures and bio-fertilizers on growth, flowering and bulb production in tuberose. *Indian Journal of Horticulture.* **64:** 554-556.

Sharma, J. R., Gupta, R. B. and Kaushik, R. A. 2003. Growth and flowering of gladiolus as affected by N and P levels. *Journal of Ornamental Horticulture.* **6** (1): 76-77.

Sharpley, A. N., McDowell, R.W. and Kleinman, P. J. A. 2001. Phosphorus loss from land to water: Integrating agricultural and environmental management. *Plant and Soil.* **237** (2): 287-307.

Singh, A. K. 2005. Response of rose plant growth and flowering to organic and inorganic fertlization. *Journal of Ornamental Horticulture.* **8** (4): 296-298.

Singh, A. K. and Bijimol, G. 2000. Response of gladiolus cv. Pink friendship to spacing and nitrogen levels under low hills of Nagaland. *South Indian Horticulture.* **48** (1-6): 72-77.

Singh, A. K., Deepti, S. and Shiva, J. 2006. Response of manures and bio-fertilizers on growth and flowering in rose. *Journal of Ornamental Horticulture.* **9** (4): 278-281.

Singh, A., Kumar, J., Kumar, P. and Singh, V. P. 2005. Influence of 8-Hydroxy Quinoline (8-HQ) and sucrose pulsing on membrane stability and postharvest quality of gladiolus cut spikes. *Journal of Ornamental Horticulture.* **8** (4): 243-248.

Singh, A., Singh, A. K. and Kumar, S. 2015. Flowering duration and vase life enhancement through integrated nutrients management in gladiolus. *Research in Environment and Life Sciences.* **8** (1): 18-20.

Singh, A., Singh, A. K. and Yadava, L. P. 2014. Integrated nutrient management induces flowering duration and flower quality of gladiolus. *Research in Environment and Life Sciences.* **7** (1): 49-52.

Singh, D. P., Prakash, S. and Singh, A. P. 2008. Response of vermicompost and bio-fertilizer on growth and flowering in gladiolus cv. Red Beauty. **In**: Proceedings of National Symposium on Recent Advances in Indian Floriculture, 69.

Singh, F., Kumar, R. and Pal, S. 2008. Integrated nutrient management in rice-wheat cropping system for sustained productivity. *Journal of Indian Society of Soil Science.* **56** (2): 205-208.

Singh, N. K., Kumar, A. and Yadav, V. K. 2008. Integrated effect of organic and inorganic fertilizers on yield and quality of potato (*Solanum tuberosum* L.). *Research on Crops Journal*. **9** (2): 338-341

Singh, W., Sehrawat, S. K., Dahiya, D. S. and Singh, K. 2002. Leaf nutrient status of gladiolus (*Gladiolus grandiflorus* L.) cv. Sylvia as affected by NPK application. *Haryana Journal of Horticultural Sciences*. **31** (1/2): 49-51.

Singh, Y., Sehrawat, S. K., Singh, K and Sindhu, S. S. 2010. Eco-friendly inoculants and their effect on growth and flowering of gladiolus cv. American Beauty. In: Abstract book of the "National seminar on recent trends in horticultural crops-issues and strategies for research and development". CCS HAU, Hisar. pp. 94-95.

Sonmez, F., Cg, A., Gulser, F., Basdogan, G. 2013. The effects of some organic fertilizers on nutrient contents in hybrid Gladiolus. *Eurasian Journal of Soil Science*. **2** (2): 140-144.

Srivastava, R. and Govil M. 2007. Influence of bio fertilizers on growth and flowering in gladiolus cv. American Beauty. *Acta Horticulturae*. **7** (42): 183-188.

Srivastava, R. and Govil, M. 2007. Influence of biofertilizers on growth and flowering in gladiolus cv. American Beauty. *Acta Horticulturae.* **742**: 183-188.

Srivastava, R., Preetham, S. P. and Satish Chand. 2014. Effect of organic manures and biofertilizers on vegetative, floral and post harvest attributes in tuberose (*Polianthes tuberosa*) var. Shringar. *Asian Journal of Biological and Life Sciences*. **3** (1): 6-9.

Stockdale, E. A. and Brookes, P. C. 2006. Detection and quantification of the soil microbial biomass - impacts on the management of agricultural soils. *Journal of Agricultural Science.* **144**: 285-302.

Subbiah, B. V. and Asija, G. L. 1956. A rapid procedure for the estimation of available nitrogen in soils. *Current Science.* **28**: 259-260.

Subehia, S. K. and Sepehya, S. 2012. Influence of long-term nitrogen substitution through organics on yield, uptake and available nutrients in a rice-wheat system in an acidic soil. *Indian Journal of Agricultural Sciences*. **60**: 213-217.

Subhani, A., Changyong, H., Zhengmiao, Y., Min, L. and El-ghamry, A. 2001. Impact of soil environment and agronomic practices on microbial /dehydrogenase enzyme activity in soil. A Review. *Pakistan Journal of Biological Sciences.* **4**: 333-338

Suseela, T., Chandrasekha, R., Bhaskar, V. V., Suneetha, D. R. S. and Umakrishna, K. 2016. Effect of organic manures, inorganic fertilizers and micronutrients on vegetative and floral characters of tuberose (*Polianthes tuberosa L.*) cv. „Suvasini‟. *International Journal of Scientific and Research Publications.* **6** (2): 170-173.

Suwaree, S., Kaewman, O. and Suksawat, M. 2009. Evaluation of media, organic and chemical fertilizer applications on growth of pot gerbera (*Gerbera jamesonii*). *Asian Journal of Food and Agro Industry*. Special Issue: S51-S56.

Swaroop, K. and Janakiram, T. (2010). Response of Bio fertilizers, FYM and their combined application with different levels of inorganic fertilizers in gladiolus (*Gladiolus hybridus* L.). *International Journal of Tropical Agriculture.* **28** (3-4): 435-438.

Sylvia, E. W. 2005. The effect of compost extract on the yield of strawberries and severity of *Botrytis cinerea*. *Journal of Sustainable Agriculture.* **5**: 57-68.

Tabbara, H. 2003. Phosphorus loss to runoff water twenty-four hours after application of liquid swine manure or fertilizer. *Journal of Environmental Quality*. **32** (3): 1044-1052.

Tagaliavini, M. and Marangoni, B. 2002. Major and nutritional issues in deciduous fruit orchards of north Italy. *HortTechnology*. **12**: 26-31.

Tiwari, K. R., Sitaula, B. K., Bajracharya, R. M. and Borresen, T. 2010. Effect of soil and crop management practices on yield, income and nutrient losses from upland farming systems in the middle mountains region of Nepal. *Nutrient Cycling in Agroecosystems*. **86**: 241-253.

Tripathi, S. K., Malik, S., Kumar, A. and Kumar, V. 2013. Effect of integrated nutrient management on bulb yield of tuberose (*Polianthes tuberosa* L.). cv. Suvasini. *Asian Journal of Horticulture.* **3** (1): 150-154.

Tripathi, S. K., Malik, S., Singh, P., Dhyani, B. P., Kumar, V., Dhaka, S. S. and Singh, J. P. 2012. Effect of integrated nutrient management on cut flower production of tuberose (*Polianthes tuberosa* L.) cv. Suvasini. *Annals of Horticulture.* **6** (1): 149-152.

Urkurkar, J. S., Tiwari, A., Chitale, Shrikant and Bajpai, R. K. 2010. Influence of long term use of inorganic and organic manures on soil fertility and sustainable productivity of rice and wheat in Inceptisols. *Indian Journal of Agricultural Sciences*. **80**: 208-212.

Varu, D. K. and Barad, A. V. 2010. Effect of stem length and stage of harvest on vase-life of cut flowers in tuberose (*Polianthes tuberosa* L.) cv. Double. *Journal of Horticultural Sciences.* **5** (1): 42-47.

Verma, G. and Mathur, A. K. 2009. Effect of integrated nutrient management on active pools of soil organic matter under maize-wheat system of a typic haplustept. *Journal of Indian Society of Soil Science.* **57** (3): 317-322.

Waheeduzzama, M., Jawaharlal, M., Arulmozhiyan, R. and Indhumathi, K. 2007. Integrated nutrient management practices to improve flower yield in anthurium (*Anthurium andreanum* Lind.). *Journal of Ornamental Horticulture.* **10** (1): 42-45.

Walkley, A. and Black, I. A. 1934. An examination of Degtjareff method for determining soil organic matter and a proposed modification of the chromic acid titration method. *Soil Science.* **37**: 29-38.

Wange, S. S., Patil, P. L. and Patil, J. J. 1995. Effect of biofertilizers alone and with nitrogen levels on tuberose cv. Singlepetated. *Journal of Soil and Crops.* **5** (2): 97-99.

Warade, A. P., Golliwar, V. J., Chopde, N., Lanje, P. W. and Thakre, S. A. 2007. Effect of organic manures and biofertilizers on growth, flowering and yield of Dahlia. *Journal of Soils and Crops.* **17** (2): 354-357.

Wolum II, A. G. 1982. Cultural methods for soil micro organism. In: Methods of Soil Analysis Part 2. Chemical and Microbiological Properties. Page A L, Miler R H and Keeney D R. (Eds), *American Society of Agronomy, Madison* WI. USA. pp 781-802.

Yadav, S. K., Kumar, C. and Singh, R. 2005. Effect of biofertilizers on floral characters of gladiolus. *Orissa Journal of Horticulture*. **33** (2): 66-72.

Yassen, A. A. and Khalid, K. A. 2009. Influence of organic manures on yield, essential oil and mineral content of onion. *International Agrophysics.* **23**: 183-188.

Younis, A., Riaz, A., Ikram, S., Nawaz, T., Hameed, M., Fatima, S., Batool, R. and Ahmad, F. 2013. Salinity-induced structural and functional changes in three cultivars of *Alternanthra bettzikiana* (Regel) G. Nicholson. *Turkish Journal of Agriculture and Forestry.* **37**: 674-687.

Zaghloul, M. A. R. and Moghazy, E. I. 2001. Response of some gladiolus cultivars to organic manure and NPK fertilizers in a sandy soil under Sinai conditions. *Annals of Agricultural Science.* **39** (1): 585-602.

Zhen, Z., Haitao L., Wang, N., Guo, L., Meng, J., Ding, N., Wu, G. and Jiang, G. 2014. Effects of manure compost application on soil microbial community diversity and soil microenvironments in a temperate cropland in China. *PLOS One*. **9** (10): 1-12.

APPENDICES

Appendix- A

Pearson's correlation coefficient (*r*) of dehydrogenase activity and bacterial count, dehydrogenase activity and fungal count and bacterial count and fungal count during 2014-2015 and 2015-2016

Parameters	***Pearson's correlation coefficient***			
	Dehydrogenase activity (TPF µg g^{-1} hr^{-1})		**Bacterial count (1×10^4 cfu g^{-1})**	
	2014-2015	**2015-2016**	**2014-2015**	**2015-2016**
Bacterial count (1×10^4 cfu g^{-1})	0.9013*	0.8889*	-	-
Fungal count (1×10^4 cfu g^{-1})	0.7533*	0.6793*	0.9131*	0.8663*

Note: * = Significant at 5% level of significance

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

(A) Fixed cost	
1. Planting material @ 5 $corm^{-1}$	₹ 666700
2. Ploughing 2 times @ ₹ 2000	₹ 4000
3. Land preparation by 20 men @ ₹ 250 man^{-1}	₹ 5000
4. Planting by 20 men @ ₹ 250 man^{-1}	₹ 5000
5. Intercultural operations 3 times by 20 men @ ₹ 250 man^{-1}	₹ 15000
6. Irrigation	₹ 5000
7. Plant protection measures	₹ 5000
8. Harvesting, grading and packing by 50 men @ ₹ 250 man^{-1}	₹ 12500
9. Miscellaneous	₹ 5000
Total	₹ **723200**

(B) Treatment cost	
T_0 - Control	₹ 0
T_1 - 100% NPK (200:200:200 kg ha^{-1}) Cost of N through urea @ ₹ 10 kg^{-1} = ₹ 4340 Cost of P_2O_5 through SSP @ ₹ 15 kg^{-1} = ₹ 18750 Cost of K_2O through MOP @ ₹ 25 kg^{-1} = ₹ 8330	₹ 31420
T_2 - FYM (40 t ha^{-1}) @ ₹ 500 t^{-1}	₹ 20000
T_3 - Pig manure (35 t ha^{-1}) @ ₹ 700 t^{-1}	₹ 24500
T_4 - Vermicompost (10 t ha^{-1}) @ ₹ 10000 t^{-1}	₹ 100000
T_5 - Biofertilizers ((*Azospirillum* + Phosphotica)	₹ 400
T_6 - 50% NPK + 50% FYM	₹ 25710
T_7 - 50% NPK + 50% Pig manure	₹ 27960
T_8 - 50 % NPK + 50 % Vermicompost	₹ 65710
T_9- 50 % NPK + Biofertilizers ((*Azospirillum* + Phosphotica)	₹ 16110
T_{10}- 75 % NPK + Biofertilizers ((*Azospirillum* + Phosphotica)	₹ 23965
T_{11}- 50 % NPK + 25 % FYM + Biofertilizers (*Azospirillum* + Phosphotica)	₹ 21110
T_{12}- 50 % NPK + 25 % Pig manure + Biofertilizers *(Azospirillum* + Phosphotica)	₹ 22235
T_{13}- 50 % NPK + 25 % Vermicompost + Biofertilizers *(Azospirillum* + Phosphotica)	₹ 41110