STANDARDIZATION OF PLANTING TIME, ZINC AND BORON NUTRITION AND VASE LIFE OF *Gladiolus primulinus* cv. CANDYMAN

Thesis

submitted to

NAGALAND UNIVERSITY

in partial fulfillment of requirements for the Degree

of

Doctor of Philosophy

in

HORTICULTURE (Floriculture and Landscape Architecture)

by

JONAH DAKHO

Admn. No. Ph – 201/15 Regn. No. 828/2019

Department of Horticulture

School of Agricultural Sciences and Rural Development,

Nagaland University, Medziphema Campus – 797 106

Nagaland

2020

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 (Floriculture and Landscape Architecture)

This is to certify that the thesis entitled **"Standardization of planting time, zinc and boron nutrition and vase life of *Gladiolus primulinus* cv. Candyman"** submitted by Jonah Dakho, Admission No. 201/15 Registration No. 828/2019 to the NAGALAND UNIVERSITY in partial fulfillment of the requirements for the award of degree of Doctor of Philosophy in Horticulture (Floriculture and Landscape Architecture) has been examined by the Advisory Board and External examiner on ……………….............

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

Member	Signature
1. Dr. Rokolhuü Keditsu (Supervisor & Chairman)	………………………….
2. ………………………………. (External examiner)	………………………….
3. Pro Vice Chancellor Nominee (Dean, NU: SASRD)	………………………….
4. Dr. L Hemanta	………………………….
5. Prof. C.S Maiti	………………………….
6. Dr. S.P Kanaujia	………………………….
7. Prof. A.K Singh	………………………….

Head
Department of Horticulture

Dean
School of Agricultural Sciences
and Rural Development

DECLARATION

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

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

Date:
Place: **(JONAH DAKHO)**

………………………………..
Supervisor

ACKNOWLEDGEMENTS

All glory to God; through Him all things are possible.

My profound respect and heartfelt gratitude to my Supervisor, Dr. Rokolhuü Keditsu, Assistant Professor, Department of Horticulture, SASRD: Nagaland University, Medziphema, for her benevolent guidance, constant support and encouragement throughout the course of investigation and preparation of the manuscript.

I am deeply indebted to all the members of my advisory committee; Dr. L. Hemanta, Dr. S. P. Kanaujia, Prof. C. S. Maiti, HoD, Department of Horticulture and Prof. A. K. Singh, Department of ACS, for their valuable advice and suggestions during the research work.

My sincere gratitude to Prof. Akali Sema, Prof. Pauline Alila, Dr. A.K. Sarkar, and all the non-teaching staff of the Department of Horticulture, SASRD, for providing me with all the necessary facilities and rendering their help throughout the entire period of my research work.

I also extend my gratitude to the Dean, SASRD: NU and staff for providing all the necessary facilities and assistance during the course of my study. I am also thankful to the Assistant Librarian and staff members for enabling me to avail the library facilities.

My profound gratitude to my batch mates (cupcakes) for making Ph.D. fun and possible. My hostel mates, my friends; Dr. Nini, Andrew, Dr. Sashilila, Akhon, Thungchobeni, Olivia, Matene, Issactho, for their supports and help throughout this venture. Special thanks to Dr. Dametri Lytan for assisting in the statistical analysis.

Deepest love and gratitude to my beloved family, this work would have been rather incomplete without the constant support, encouragement and inspiration. I'm also indebted to my relatives, friends and well wishers for all the love and supports.

Before I conclude, I record my sincere thanks to all the beloved and respectable people who could not be individually acknowledged.

Special thanks to MOTA-New Delhi, for the NFHE-ST Fellowship during my study and course of investigation. Acknowledge the ICCP-Mao, Manipur for providing the cold storage facilities in subsidized rate to store the research materials.

Great thanks to all.

Date:
Place: (JONAH DAKHO)

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

ABBREVIATIONS

°C	Degree Celsius
%	Percent
±	plus or minus
/	Per
@	at the rate of
B	Boron
CD	Critical Difference
Cl	Chlorine
cm	Centimetre
CRD	Complete Randomized Design
Cu	Copper
cv.	Cultivar
d.f.	Degree of freedom
DNA	Deoxyribonucleic Acid
et al.	et alia (and others)
etc	etcetera
Fe	Iron
Fig	Figure
FYM	Farm Yard Manure
g	gram
ha	hectare
H_3BO_3	Boric acid
i.e.	(*Id est.*) that is
ICAR	Indian Council of Agricultural Research
K	Potassium
Kg	Kilogram
L	Litre
m	Metre
m^2	Square meter
Max	maximum
Min	minimum
mg	miligram
min.	minute
mL	millilitre
Mn	Manganese
Mo	Molybdenum
MoP	Murate of Potash
MT	Metric tonnes
N	Nitrogen
Ni	Nickle
No.	number
NS	Non-significant

NU	Nagaland University
P	Phosphorus
Pb	Lead
pH	negative logarithm of hydrogen ion activity of a soil
ppm	parts per million
RBD	Randomized Block Design
RH	Relative Humidity
RNA	Ribonucleic Acid
S	Sulphur
SEm±	Standard Error Mean
sp.	species
SSP	Single Super Phosphate
t	Tonnes
Viz.	(*Videlicet*) Namely
w.r.t	with respect to
Zn	Zinc
$ZnSO_4$	Zinc sulfate

CONTENTS

ABSTRACT

The present investigation on **"Standardization of planting time, zinc and boron nutrition and vase life of *Gladiolus primulinus* cv. Candyman"** was carried out at Horticulture Farm, School of Agricultural Sciences and Rural Development, Medziphema, Nagaland, during the period from October 2016 to December 2018. Three different experiments were conducted separately.

The first experiment was conducted to studies the effect of planting time on performance of gladiolus, where planting is done on mid of every month, taking January as T_1 and December as T_{12}. The experiment was laid out in Randomized Block Design with 12 treatments and replicated thrice. Early sprouting (7.03 days) was recorded from T_6 (June planting). Maximum number of leaves (9.57), plant height (88.40 cm), length of spike (79.73 cm), length of rachis (42.57 cm), number of florets per spike (14.80), vase life (13.83 days). Maximum number of corms per hill (1.20), weight of corms per hill (85.17 g) and diameter of corm (6.79 cm) were all recorded in T_{10} (October planting).

The second experiment to study the effect of zinc and boron on performance of gladiolus was laid out in RBD with 9 treatments and 3 replications. Zinc ($ZnSO_4$) and boron (H_3BO_3) were given through foliar application during 3 leaf stage and 6 leaf stage. Maximum plant height (99.50 cm), minimum days to spike emergence (63.54 days) and maximum length of spike (89.77 cm) and vase life (14.50 days) were recorded in T_6 ($ZnSO_4$ 0.2% + H_3BO_3 0.2%). Maximum weight of corms per hill (115.43 g) and diameter of corm (7.44 cm) were recorded in T_4 (H_3BO_3 0.2%).

The third experiment to studies the effect of different wrapping materials on vase life of gladiolus was laid out in CRD with 7 treatments and 3 replications. T_5 (Shrink wrap) gives the best result with respect to changes in fresh weight of spikes on 1^{st}, 3^{rd}, 6^{th} and 9^{th} day (54.83, 57.83, 56.17 and 53.17 g respectively), length of spikes on 6^{th} and 9^{th} day (76.42 and 76.08cm), diameter of 1^{st}, 3^{rd} and 5^{th} floret (8.52, 8.33 and 8.15 cm respectively) and vase life (11.83 days). T_4 (Non-perforated plastic) gives the maximum number of florets opened at a time (5.67) and minimum number of unopened florets (1.67).

INTRODUCTION

Floriculture has been promulgated as an emerging industry globally with the commencement of World Trade Organization. It has now become a booming industry because of high demand in both domestic and international market for various individual, social and industrial uses. From a symbol of love and beauty, flowers have transformed into a multi-billion industry, generating both income and employment. Floriculture is a dynamic and expanding industry recording impressive growth rate around the world. Commercial floriculture is one of the most profitable agro-industries in the world and has potential to contribute to the national economies by providing millions of dollars (Bulut, 1994). The country has exported 16,949.37 MT of floriculture products to the world for the worth of Rs. 541.61 Crores in 2019-2020 and USA, Netherland, Germany, UK, and UAE were major importing countries (APEDA, 2020).

Flowers play a cardinal role in human behavior and culture, bringing tranquility and peace of mind. Flowers symbolized love, beauty peace and are intricately associated with social belief. No social function is complete without the use of flowers as flowers are associated with man from birth till death. In India, commercial cultivation of cut flowers such as rose, gladiolus, carnation, gerbera, orchids etc., is becoming very popular and catching the attention of both growers and consumers.

Gladiolus (*Gladiolus sp*.) the 'Queen of bulbous flowers' native to South Africa, belong to the family Iridaceae, subfamily Oxioideae consisting about 270 species (Mifsuda and Hamilton, 2013). The term Gladiolus was originally coined by Pliny Elder (A.D 23-79) which was derived from the Latin word '*gladius'* meaning 'sword' owing to its foliage which has sword like shape and hence known as Sword lily (Goldblatt and Manning, 1998). It is an important cut flower in both domestic and international market (Chanda *et al*., 2000) and considered as most preferable among cut flowers because it is available in different shades and hues and has excellent vase life (Bose *et al*., 2003).

Gladiolus is an annual herbaceous flowering plant. 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 scales or husks. The spike bears a large number of florets with varying sizes and forms with smooth ruffle of deeply crinkled sepals. Florets open in acropetal sequence and long lasting florets providing extended vase life. Flower is two whorled having six perianth segments attach with a funnel shape cup and are trimerous. Stamens are 3 placed opposite to petals, extrose, dithecous with distinct and basified filament. Gynoecium is tricarpellary, syncarpous with inferior ovary. Fruit are loculicidal capsule 3 chambered, number of seeds per capsules ranges from 30-80 having papery wing which aids their dispersal by wing (Singh, 2006). Corm which is modified underground stem and photosynthates sink is the major propagating materials of gladiolus. The gladiolus corm upon plantation produces a new daughter corm on top while it shrivels and dies gradually. The buds developed from the upper surface of the daughter corm from which the new plant grows the following season. While the new daughter corm is forming above the old corm, small vegetative propagules called cormel or cormlets are developed from the base. The corms undergo physiological dormancy by nature which helps to overcome unfavourable environmental conditions. Cold storage of corms at 4-5 ºC for 3 to 4 months is widely practice for breaking dormancy and to cultivate gladiolus throughout the year (Padmalatha *et al.*, 2013).

Gladiolus is a winter crop but can be grown round the year in mild environment. Planting season is the most important feature in regulating growth of gladiolus (Ahmad *et al*., 2011). The performance of gladiolus in open field condition, like other crops, greatly influences by planting time as photoperiods, temperature, humidity and light intensity varied across seasons. Planting schedule play an important role in satisfying the consumers' demand. Staggered planting also ensures availability of flowers for different occasions throughout the year. Year round production can provide employment to the people and increases the economy of the region, also add beauty to the landscape for longer period.

Soil is the medium for plant growth and the major source of nutrients. The mineral nutrients are absorbed by the root system and many factors determine the efficiency of nutrient uptake. The physical and chemical properties of soil also affect the availability of the soil nutrients. Mineral nutrients sustain all plant life on our planet (Aerts and Chapin, 2000 and Epstein and Bloom, 2004). The concentrations of mineral nutrition in soil largely determine the growth and development of plants. Due to the immobile nature of certain nutrients, plants face difficulties in absorbing these nutrients from the soil. There are 17 essential nutrients required for optimal growth and development and to complete the life cycle of the plants. Certain trace elements which are essential for plant growth and required in small concentrations are known as micronutrients *viz.* iron (Fe), manganese (Mn), zinc (Zn), boron (B), copper (Cu), molybdenum (Mo) and chlorine (Cl). The use of micronutrients has been recently increased with advancement in science and technology which acknowledged its importance in plant nutrition (Alloway, 2008). Micronutrients play vital roles in growth and development of plants, due to their stimulatory and catalytic effects on metabolic processes and ultimately on flower yield (Lahijie, 2012) and quality (Khosa *et al*., 2011).

Zinc is an essential micronutrient which is vital for plant growth and metabolism. The essentiality of Zn to plants was established in 1926 (Epstein, 2000). It plays significant role in seed production, membrane integrity, protein synthesis and growth hormones production. It also helps in RNA synthesis, chlorophyll formation, cell wall development, enzyme activity, respiration and photosynthesis. Also, zinc provide defense against pathogens, decreased susceptibility to biotic and abiotic stresses (Cabot *et al*. 2019 and Noman *et al*. 2019). It is a crucial component of almost 60 enzymes and therefore, plays crucial role in many plant functions (Broadley, 2007). Zinc plays a significant role in the production of biomass (Cakmak, 2008). Zinc deficiency occurs in acid sandy soil, neutral or alkaline soil with higher amount of fine clay, high pH and water logged soil. Zinc deficiency is more severe in light soils than in heavy soils. As it is immobile in nature therefore symptoms are first visible in new leaves. The affected leaves become chlorotic with an interveinal mottling and leaf margins are often crinkled or wavy. The visible symptoms of zinc deficiencies are stunted growth, interveinal chlorosis, bronzing of chlorotic leaves, small and deformed leaves and rosetting of leaves.

Boron is a micronutrient of special importance because of its role in the fertilization and flowering process. No crop can reach its full potential without minute but adequate supply of boron (Berger and Truog, 1940). The word ‘boron’ was coined from Borax. It was recognized as an essential plant nutrient in 1928 (Epstein, 2000). The primary role of boron in plants is to improve metabolism, solubility and mobility of calcium and helps the absorption of nitrogen. It involves in metabolism and transport of carbohydrates, regulation of meristematic tissue cell synthesis, lignifications, growth regulatory metabolism, phenol metabolism and integrity of membranes, root elongation, DNA synthesis, pollen formation and pollination (Shukla *et al*. 2009). Facilitating pollination and fruit set is considered to be the most important function of boron besides its role in synthesis of amino acids and protein metabolism. It is also essential to maintain the structural integrity of plant membranes along with calcium and is involved in nucleic acid metabolism (Ganesh and Kannan, 2013). Boron deficiency reduces the normal expansion and growth of cell walls, resulting in short and thick cell walls, symptom develop in young leaves, under severe deficiency, stunted growth and death of growing tissue commonly occur. Root and pollen tube elongation are highly sensitive to boron deficiency and quickly inhibited when it is so. Failure of flowers to set seeds is an established fact of boron deficiency. Research also shows that an adequate B supply is required to ensure effective nitrogen fixation and nodulation in legumes and also for sugar transportation within plants (Aboyeji *et al*. 2019). The practical implication is that when deficiency symptoms are observed, it is already too late and yield has been compromised. Consequently, the best strategy for B is to prevent deficiency by application of boron.

Commercial floriculture is an emerging profitable agro industry and cut flowers like gladiolus, rose, carnation, chrysanthemum etc. have great demand both in domestic and international markets. Cut flowers, in general are highly perishable and gladiolus is no exception to it. The high perishability render them vulnerable to considerable post harvest loses and due to this, there is frequent market gluts and price crush in the country in general and the state in particular. The vase life of cut flowers is influenced by many factors like, climate, variety, harvesting time, post harvest handling etc. Appropriate packaging of gladiolus for optimum duration offers potential advantage of extending their vase life and maintaining flower quality and regulation of flower supply in the markets for higher returns. Area under cultivation of floriculture was about 249 thousand hectares and production estimated to be 1659 thousand tonnes loose flowers and 484 thousand tonnes cut flowers in 2015-16 (APEDA, 2020). Nagaland is estimated to have an area of 0.01 thousand hectare with a production of 0.4 lakh numbers of cut flower (Anon., 2015). Nagaland enjoys sub tropical climate with good amount of annual rainfall. The economy of the state largely depends on agriculture and allied activities. Floriculture has emerged as a promising industry in the state with very good growth prospect for domestic and export market.

Endowed with suitable agro-climate and ample amount of rainfall round the year, it is a wise call to venture scientific studies in year round production for commercial production of gladiolus in the state. The knowledge attributed to applicability and benefits of foliar application of zinc and boron in quality improvement of cut flowers is new. Post harvest loss of flowers is high due to lack of scientific management. Producing round the year to meet the market demand also mitigate unemployment and alleviate economy, enhancing the quality and reduces the postharvest loses are the need of time. Keeping all these in view, the present investigation entitled **"Standardization of planting time, zinc and boron nutrition and vase life of *Gladiolus primulinus* cv. Candyman"** was carried out with the following objective:

1. To identify the suitable season(s) for commercial production of gladiolus cv. Candyman under foothill condition of Nagaland.
2. To study the effect of zinc and boron on growth, flowering, yield, and postharvest quality of gladiolus cv. Candyman.
3. To study the effect of different wrapping materials on vase life of gladiolus cv. Candyman.

REVIEW OF LITERATURE

2.1 Effect of Planting Dates

2.1.1 Growth

Sheikh and Jhon (2005) studied the effect of six dates of planting along with four genotypes on vegetative and floral characters of gladiolus. Planting of corms on 31 March resulted into the maximum plant height (119.12cm), Whereas, the minimum number of days for sprouting (10.88) and days to slipping (74.27) were recorded for corms planted on 15 May. Kour (2009) studied on planting date of gladiolus and reported that minimum number of days (16.75) to sprouting was observed in corms planted on 15th October and maximum number of days (24.86) in corms planted on 15th September. Maximum plant height (102.31) and maximum number of leaves (10.58) were also observed with 15th October planting while minimum plant height (93.36) and number of leaves (8.60) were found with 15th September planting. Leaf length (59.10) and leaf breadth (2.50) were also found maximum with 15th October planting as compared to other planting dates but difference was non-significant.

Ahmad *et al*. (2011) studied the effect of planting dates on the growth of gladiolus corms by planting cormels of gladiolus cv. White Friendship on 5 various dates with a regular interval of 15 days i.e. February-18, March- 05, March-20, April-04 and April-19. Planting dates showed significant effects on various parameters and maximum values were obtained from plantation done on 18th February for sprouting percentage (77.12), number of leaves per plant (7.06), survival percentage (82.96), leaf area (65.76 cm2) and plant height (67.39 cm). Whereas earliest sprouting was observed in cormels planted on 19th April (20.11 days).

Elif and Balut (2011) studied to determine the effect of plantation time (10, 20 and 30 June) on plant growth and floret quality of four commercial varieties of Gladiolus (White Prosperity, Amsterdam, Nova Lux and Victor Borge), planted in open field reported that 20 June was found to be the most suitable plantation time with respect to days to sprouting and White Prosperity is the best varieties. Maximum plant height was recorded in White Prosperity, while the minimum is Nova Lux and plantation time did not affect plant height significantly ($p < 0.01$).

Kumari *et al*. (2011) studied the influence of planting date and gibberellic acid on growth and flowering in gladiolus cultivar Yellow Frilled. The days to corm sprouting, plant height, number of leaves per plant and days to spike emergence were recorded as the maximum in the earliest planting date of 25th October. Rathod *et al*. (2011) studied the effect of planting time and chemicals on growth, flowering and yield parameters of gladiolus cultivar American Beauty. The result revealed that 1st week of October planting significantly increased all growth attributes as compared to 1st week of August and November planting.

Suman *et al*. (2011) investigated the influence of gibberellic acid (GA3) and planting date on growth and flowering in gladiolus cv. Yellow Frilled results revealed that the earliest sprouting in corm, maximum plant height, number of leaves per plant and leaf area per plant were recorded in the earliest planting date, i.e., 25th October. Muhammad *et al*. (2013) studied the effect of different sowing dates and temperature on growth, yield and quality of two gladiolus cultivars Rose Supreme and White Prosperity. The maximum sprouting (94.66 %) was recorded in 10th September planting followed by 25th September plantation (82.19 %) in all the treatments. The maximum plant height, mean value of number of leaves and maximum chlorophyll content were observed in 10th September plantation.

Zubair *et al*. (2013) studied on eight cultivars viz., Deciso, Hong Kong, Jessica, Jester Ruffled, Madonna, Peters Pears, Rose Supreme and White

Friendship were planted on 1st November, 1st December and 1st January. Cultivar White Friendship planted on 1st November resulted in earlier sprouting (8.7 days). However, Jessica when planted on 1st November resulted in more number of plants (2.5) per mother corm. Rose Supreme planted on 1st November produced the tallest plants (154.3 cm). Kaushal *et al*. (2014) studied on different planting date in China aster and reported that among different planting dates 6 April gave best results for plant height (88.10 cm) and plant spread (47.44 cm).

Ahmad *et al*. (2014) evaluated five new cultivars of gladiolus i.e. 'Cantate', 'Corveira', 'Eminence', 'Essential' and 'Fado'. Plant growth, yield and cormel production of the cultivars was evaluated by planting corms at 15 or 16 day intervals from 30th September to 15th November. All cultivars performed well in terms of growth, yield and quality of flowers and cormels, when corms were planted earlier on 30th September followed by 15th October compared with late planting in November. 'Cantate' and 'Fado' planted on 30th September or 15th October had the highest leaf area, while 'Eminence' planted on 30th September had the earliest spike emergence. Ramzan *et al* (2014) investigated to find out the effect of different planting dates on vegetative growth, flowering and corm production in gladiolus (*Gladiolus hybridus* L.) cultivar Novalux reported that maximum plant height and number of leaves per plant, were recorded under 30th October planting.

Sudhakar and Ramesh (2015) studied to investigate the growth and flowering of two gladiolus varieties White Friendship and American Beauty in early and late growing seasons. The seasons compared were, planting by first week of July, September, December and February. Among different season compared, December planting evinced better performance. The correlation between the mean value of growth parameters in different seasons and weather parameters exhibited that the plant height and sprouting percentage were negatively correlated with maximum temperature (within a range of 29.9 to 35.02), minimum temperature (within a range of 22.12 to 25.70) and bright sunshine hours (within a range of 6.25-8.85 hrs). However, days taken for sprouting was positively correlated with these weather parameters.

Thakur *et al*. (2015) studied the effects of five planting date of 10th October, 25th October, 10th November, 25th November and 10th December on growth and floral characters of twelve gladiolus genotypes and reported that the minimum days to sprouting of corms (10.38 days) was recorded under 10th October planting. A study was initiated to elucidate the performance of two cultivars of gladiolus *viz.* Summer Rose and Friendship under 3 planting dates for growth, production and quality of flowers. Among three planting dates tested, planting corms during mid-April indicated better growth performance (Taye *et al*, 2015).

Vasanthakumar *et al*. (2015) studied to elucidate the performance of two cultivars of *Gladiolus grandiflorus*, Summer Rose and Friendship and to find the effect of three planting dates on growth, production and quality of flowers. The studies revealed that among three planting dates tested, planting corms during mid-April indicated better growth performance. Ivanka *et al*. (2016) studied the effect of two planting dates (April 20 and May 10) on cultivars Iva and Ekaterina and reported that May 10 planting date in both gladiolus cultivars had a positive effect on the stem length. Khutiya (2016) studied on twelve planting dates starting from 13th February to 28th July February at 15 days interval reported that among all the planting dates, earliest sprouting, slipping was observed for 28th July planting. However, 13th February planting gave 100% sprouting.

Ikram *et al*. (2016) studied the effect of different planting dates on the growth of *Polianthus tuberosa* reported that less days to emergence were taken by 9th April (2.88 days), maximum plant height was noted in 23rd April (56.18 cm), maximum plant spread was 60.18 cm, maximum number of recorded leaves was 45.42 were recorded in 9th April planting. Kamal *et al*. (2018) reported that among three planting dates (D1- 10th October, D2- 25th October and D3- 9th November). The treatment V2D1 (Hunting Song + 10th October planting) recorded the maximum plant height (116.10 cm), highest number of leaves per plant (8.77) and main stem diameter (1.50 cm), While the maximum leaf length (64.20 cm), leaf width (4.96 cm) in V5D3 (Snow Princess + 9th November).

Meena *at el*. (2018) carried out experiment during 2013 and 2014 to find out an effect of staggered planting date on growth, floral, bulb and economic parameters in tuberose cv. Phule Rajani. The treatment comprised with various staggered planting dates *viz.* 15th April, 30th April, 15th May, 30th May, 15th June and 30th June at 15 days interval. Out of six staggered planting treatment P1- 15th April was found significantly superior for leaves plant-1 (31.09) and plant height (66.81 cm).

2.1.2 Flowering

Al-Humaid (2004) conducted an experiment to study the effect of different environmental conditions on the behavior of gladiolus cultivars Euro vision, Rose Supreme, Prosperity and Novalux. The cultivars were planted on three different dates *viz*. October, November and December. The results showed that November planting substantially improved the length, thickness and dry weight of flowering stem of all cultivars. However, the earliest flowering was recorded in October for all cultivars.

Salvi *et al*. (2004) studied the effect of planting dates on performance of gladiolus cultivars. Cv. American Beauty planted on 15th October was superior in terms of quality of flower spike. Cv. Her Majesty planted on 30th September was recommended for early flowering. The optimum time for planting of gladiolus corms was 15th October for early flowering, better spike length, number of florets, floret size as well as high yield of spike per unit area. (Nijasure and Ranpise, 2005).

Sheikh and Jhon (2005) studied the effect of six dates of planting along with four genotypes on vegetative and floral characters of gladiolus. Planting of corms on 31 March resulted into the maximum spike length (98.06 cm), floret number/spike (13.20) and floret diameter (9.77 cm). Whereas, the minimum days to basal floret opening (86.15) was recorded for corms planted on 15 May. Bala *et al*. (2006) conducted a study on gladiolus cultivars *viz.* Praha, Fiedelio and Jacksonvilla Gold to determine the effect of pre harvest sprays of ZnSO4 and planting date i.e. 1st November, 16th November and 2nd December. The planting done on 1st November resulted in early flowering and Fiedelio recorded maximum fresh weight and the minimum water loss to uptake ratio. The total number of florets opened per day was recorded maximum in November plantings coupled with ZnSO4 sprays.

Zubair *et al*. (2006) found that planting dates affect floral characteristics of gladiolus under the soil and climatic conditions of Peshawar. The corms of cultivars Deciso, Hong Kong, Jessica, Jester Ruffled, Madonna, Peters Pears, Rose Supreme and White Friendship were planted on 1st November, 1st December and 1st January of 2003-04 and 2004-05. A delay in planting date (1st Nov., 1st Dec. and 1st Jan.) resulted in earlier spike emergence (130.3, 129.0 and 121.9 days), earlier first floret opening (146.2, 142.3 and 134.1 days), earlier full spike opening (161.2, 154.7 and 146.1 days) and decreased number of plants (1.4, 1.2 and 1.0) $corm^{-1}$.

Bagde *et al*. (2009) studied the effect of planting dates on flower quality and yield parameters of gladiolus. Ten planting dates were repeated after every seven days interval from 1st September up to 3rd November. Flower quality and yield contributing characters like spike length, rachis length and florets per spike were the maximum in 13th October planting. 13th October and 6th October plantings were at par with each other in respect of flower yield and floret diameter of gladiolus. Kour (2009) studied on planting date of gladiolus and reported that different planting dates significantly affected various flowering attributes. Minimum days to flowering (80.08) was recorded when planted on 15th October as compared to other planting dates. Maximum spike length (96.08), number of florets per spike (14.28), spike yield per plant (1.14) were recorded with 15th October planting as compared to other planting dates. The floret size (9.62) was also found maximum with 15th October planting though the difference was non-significant.

Elif and Balut (2011) studied to determine the effect of plantation time (10, 20 and 30 June) on plant growth and floret quality of four commercial varieties of Gladiolus (White Prosperity, Amsterdam, Nova Lux and Victor Borge), planted in open field reported that 20 June was found to be the most suitable with respect to spike emergence and White Prosperity is the best varieties. White Prosperity is the best variety for floret number and harvesting time (84.24 days) when June 10 is considered to be the best plantation time. Kumari *et al*. (2011) studied the influence of planting date and gibberellic acid on growth and flowering in gladiolus cultivar Yellow Frilled and reported that number of spikes per plant, spike length, number of florets per spike and flowering duration were recorded as the maximum in the earliest planting date of 25th October.

Rathod *et al*. (2011) studied the effect of planting time and chemicals on growth, flowering and yield parameters of gladiolus cultivar American Beauty. The result revealed that 1st week of October planting significantly increased all flowering and quality attributes as compared to 1st week of August and November planting. Suman *et al*. (2011) investigated the influence of gibberellic acid (GA3) and planting date on growth and flowering in gladiolus cv. Yellow Frilled results revealed that early spike emergence, number of spikes per plant per plot, spike length, rachis length, number of florets per spike, and flowering duration were recorded in the earliest planting date, i.e., 25th October.

Muhammad *et al*. (2013) studied the effect of different sowing dates and temperature on growth, yield and quality of two gladiolus cultivars Rose Supreme and White Prosperity. The maximum spike length and number of florets were observed in 10th September plantation. Zubair *et al*. (2013) studied on eight cultivars viz., Deciso, Hong Kong, Jessica, Jester Ruffled, Madonna, Peters Pears, Rose Supreme and White Friendship were planted on 1st November, 1st December and 1st January resulted in earlier spike emergence (130.3, 129.0 and 121.9 days), earlier first floret opening (146.2, 142.3 and 134.1 days), earlier full spike opening (161.2, 154.7 and 146.1 days). Cultivar White Friendship planted on 1st November resulted in early spike emergence (87.5 days) and earlier first floret opening (106.2 days). Cultivar Jessica planted on 1st January was earlier in first floret and full spike opening.

Kaushal *et al*. (2014) studied on different planting date in China aster and reported that among different planting dates 6 April gave best results for number of flowering stems per plant (7.91), and number of flowers per plant (37.58) however, 5 June planting gave best results for flower size (5.51 cm). Ahmad *et al*. (2014) evaluated five new cultivars of gladiolus i.e. 'Cantate', 'Corveira', 'Eminence', 'Essential' and 'Fado'. Plant growth, yield and cormel production of the cultivars was evaluated by planting corms at 15 or 16 day intervals from 30th September to 15th November. All cultivars performed well in terms of growth, yield and quality of flowers and cormels, when corms were planted earlier on 30th September followed by 15th October compared with late planting in November. Late planting on 15th November also produced early spikes, but with less number of florets and poor quality. Early plantings also produced longer stems, greater floret and spike diameter, higher number of florets per spike, higher fresh and stem dry weights, which decreased gradually with delayed planting.

Ramzan *et al*. (2014) conducted experiment to find out the effect of different planting dates on vegetative growth, flowering and corm production in gladiolus (*Gladiolus hybridus* L.) cultivar Novalux. The maximum spike length, floret size and duration of spikes in field were recorded under 30th October planting. The minimum days to spike initiation and days to basal floret opening were recorded under 14th December planting. Thakur *et al* (2015) studied the effects of five planting date of 10th October, 25th October, 10th November, 25th November and 10th December on growth and floral characters of twelve gladiolus genotypes and reported that longest spike length (81.20 cm) was recorded under 10th October. The floret size and number of florets per spike were maximum under 10th November planting (8.62 cm and 13.57).

Vasanthakumar *et al*. (2015) studied to elucidate the performance of two cultivars of *Gladiolus grandiflorus*, Summer Rose and Friendship and to find the effect of three planting dates on growth, production and quality of flowers. The studies revealed that among three planting dates tested, planting corms during mid-April produced good quality flower spikes. A study was initiated to elucidate the performance of two cultivars of gladiolus *viz.* Summer Rose and Friendship under 3 planting dates for growth, production and quality of flowers. Among three planting dates tested, planting corms during mid-April produced good quality flower spikes (Taye *et al*, 2015).

Khutiya (2016) studied on twelve planting dates starting from 13th February to 28th July at 15 days interval reported that earliest day to bud break and flowering were observed for 28th July planting. Whereas, 13th February gave maximum no. of florets (15.06) and 28th February planting also recorded highest no. of spikes (2.50), and duration of flowering (39.33 days). However, maximum size of floret (10.33 cm) and heaviest spikes (89.03 g) was recorded for 30th March planting. This planting was also in accordance with 13th February and 14th April plantings for maximum number of florets (14.13) and spike length (93.54 cm).

Ikram *et al*. (2016) studied the effect of different planting dates on the flowering quality of *Polianthus tuberosa* reported that the spike length of 107.71 cm and most number of florets per spike (35.02) were recorded in 9th April. Maximum spike diameter (2.40 cm) was observed in 26th March, while flower diameter of 3.11 cm was contributed by 16th April. Ivanka *et al*. (2016) studied the effect of two planting dates (April 20 and May 10) on cultivars Iva and Ekaterina and reported that days to flowering for April 20 planting date were 68 and 84 days and for those planted on May 10 were 65 and 78 days respectively. The planting date affected the indexes of the cut flower. The later planting date in both gladiolus cultivars had a positive effect on the flower diameter and the earlier planting date brought the formation of more buds per cut flower in the same cultivars.

Kamal *et al*. (2018) conducted experiment to study the effect of planting dates and varieties on growth and quality on gladiolus under sub-humid zone of Rajasthan having 15 treatment combinations of five Varieties (V1- African Star, V2- Hunting Song, V3- Legend, V4- Pusa Srijana and V5- Snow Princess) and three planting dates (D1- 10th October, D2- 25th October and D3- 9th November). The treatment V2D1 (Hunting Song + 10th October planting) recorded the maximum number of florets per spike (15.8), spike length (91.80 cm), rachis length (57.90 cm), floret diameter (10.04 cm), vase life of spike (13 days).

Meena *at el*. (2018) carried out experiment during 2013 and 2014 to find out an effect of staggered planting date on growth, floral, bulb and economic parameters in tuberose cv. Phule Rajani. The treatment comprised with various staggered planting dates *viz.* 15th April, 30th April, 15th May, 30th May, 15th June and 30th June at 15 days interval. Out of six staggered planting treatment P1-15th April was found significantly superior for spike length (59.94 cm), days to spike emergence (111.03), days to flower bud break (122.03), floret spike-1 (35.72), durability of spike (9.36 days), spike plant-1 (3.78), spike weight (72.12 g) with highest trends in this planting which was found better over other staggered planting dates.

2.1.3 Yield

Al-Humaid (2004) conducted an experiment to study the effect of different environmental conditions on the behavior of gladiolus cultivars Euro vision, Rose Supreme, Prosperity and Novalux. The cultivars were planted on three different dates *viz*. October, November and December. The highest corm and cormel production was also recorded for November planting date. Bagde *et al* (2009) studied the effect of planting dates on flower quality and yield parameters of gladiolus. Ten planting dates were repeated after every seven days interval from 1st September up to 3rd November. Earlier planting dates produced the maximum yield of corms and cormels while September to mid- October plantings recorded the maximum weight of corms and cormels.

Ahmad *et al*. (2011) studied the effect of planting dates on the growth of gladiolus corms by planting cormels of gladiolus cv. White Friendship on 5 various dates with a regular interval of 15 days i.e. February-18, March- 05, March-20, April-04 and April-19. Planting dates showed significant effects on various parameters and maximum values were obtained from plantation done on 18th February for diameter of corms (3.19 cm), percent increase in cormel size (139.58) and corms weight (10.76 g) and maximum numbers of cormels per plant were observed in those planted on 4th April (3.83).

Rathod *et al*. (2011) studied the effect of planting time and chemicals on growth, flowering and yield parameters of gladiolus cultivar American Beauty. The result revealed that 1st week of October planting significantly increased all yield attributes as compared to 1st week of August and November planting. Muhammad *et al* (2013) studied the effect of different sowing dates and temperature on growth, yield and quality of two gladiolus cultivars Rose Supreme and White Prosperity and reported that maximum corm diameter were observed in 10th September plantation.

Kaushal *et al*. (2014) studied on different planting date in China aster and reported among different planting dates 6 April gave best results yield of flower cut stems per plot (158.10). Ahmad *et al*. (2014) evaluated five new cultivars of gladiolus i.e. 'Cantate', 'Corveira', 'Eminence', 'Essential' and 'Fado'. Plant growth, yield and cormel production of the cultivars was evaluated by planting corms at 15 or 16 day intervals from 30th September to 15th November. All cultivars performed well in terms of growth, yield and quality of flowers and cormels, when corms were planted earlier on 30th September followed by 15th October compared with late planting in November. Early plantings also produced higher cormel number, weight and diameter of corms, which decreased gradually with delayed planting.

Ramzan *et al*. (2014) investigated to find out the effect of different planting dates on vegetative growth, flowering and corm production in gladiolus (*Gladiolus hybridus* L.) cultivar Novalux. The maximum number and weight of corms per plant was observed under 30th October planting, whereas, 15th October planting proved beneficial in corm size and weight of cormels per plant. Sudhakar and Kumar (2014) investigated the yield parameters of two gladiolus varieties *viz.* White Friendship and American Beauty in early and late growing seasons. The seasons compared were, planting by first week of July, September, December and

February. The yield parameters were significantly influenced by the interaction effects of different planting seasons and varieties of gladiolus. Among different seasons compared, December planting evinced better performance.

Thakur and Dhatt (2015) studied on Twelve gladiolus genotypes planted on five different dates from 10th October to 10th December at fortnightly interval and reported that number of corms and cormels per plant were maximum under 10th October planting (1.75 and 24.37 respectively) and in cv. Punjab Lemon Delight (2.01) and Punjab Glance (41.52) respectively. The maximum corm weight and corm size was in cv. Rose Supreme (102.70 g and 5.66 cm respectively) and under 10th October planting (76.07g and 4.39cm respectively).

Khutiya (2016) studied on twelve planting dates starting from 13th February to 28th July February at 15 days interval reported that 13th February gave best size of corm (3.99 cm), no. of cormels/plant (97.40), weight of corms/plant (24.64 g) weight of cormels/plant (24.78 g) and 28th February planting was found to be at par with 13th February planting for all these parameters as well.

2.1.4 Post harvest quality

Bala *et al*. (2006) conducted a study on gladiolus cultivars *viz.* Praha, Fiedelio and Jacksonvilla Gold to determine the effect of pre harvest sprays of ZnSO4 and planting date i.e. 1st November, 16th November and 2nd December. The planting done on 1st November recorded maximum fresh weight and the minimum water loss to uptake ratio. The total number of florets opened per day was maximum in November planting.

Pavani *et al*. (2014) studied on planting dates of gladiolus (*Gladiolus grandiflorus*) and reported that the spikes harvested from 15 September planting recorded the maximum vase life and highest number of days taken for wilting. Iftikhar *et al*. (2014) Gladiolus grandiflorus Hort., 'Cantate', 'Corveira', ‘Eminence’, ‘Essential’ and ‘Fado’ were evaluated by planting corms at 15 or 16 days intervals from September 30 to November 15, reported that gladioli planted early in the season, September 30 or October 15, treated with 4% sucrose plus 8-HQS at 200 mg L-1 used to keep cut stems of ‘Eminence’ and ‘Cantate’ gladioli after harvest produced the longest vase life.

Kaushal *et al*. (2014) studied on different planting date in China aster and reported that 5 June planting gave best results for vase life (10.12 days). Khutiya (2016) studied on twelve planting dates starting from 13th February to 28th July February at 15 days interval reported that 28th February planting also recorded longest vase life (7 days). Pavani *et al*. (2014) studied on planting dates of gladiolus (*Gladiolus grandiflorus*) and reported that the planting dates had no significant influence on number of days taken for basal floret opening. The number of florets remained open at a time and the diameter of the second full opened floret were maximum for the spikes of Advance obtained from 15 September planting.

Ikram *et al*. (2016) studied the effect of different planting dates on the flowering quality of *Polianthus tuberosa* reported that the spike length of 107.71 cm and most number of florets per spike (35.02) were recorded in 9th April. Maximum spike diameter (2.40 cm) was observed in 26th March, while flower diameter of 3.11 cm was contributed by 16th April. Kamal *et al*. (2018) conducted experiment to study the effect of planting dates and varieties on growth and quality on gladiolus under sub-humid zone of Rajasthan having 15 treatment combinations of five Varieties (V1- African Star, V2- Hunting Song, V3- Legend, V4- Pusa Srijana and V5- Snow Princess) and three planting dates (D1- 10th October, D2- 25th October and D3- 9th November). The treatment V2D1 (Hunting Song + 10th October planting) recorded the maximum number of florets per spike (15.8), spike length (91.80 cm), rachis length (57.90 cm), floret diameter (10.04 cm), vase life of spike (13 days).

Meena *at el*. (2018) carried out experiment during 2013 and 2014 to find out an effect of staggered planting date on growth, floral, bulb and economic parameters in tuberose cv. Phule Rajani. The treatment comprised with various staggered planting dates *viz.* 15th April, 30th April, 15th May, 30th May, 15th June and 30th June at 15 days interval. Out of six staggered planting treatment P1-15th April was found significantly superior for spike length (59.94 cm), floret spike-1 (35.72), durability of spike (9.36 days) and spike weight (72.12 g) with highest trends in this planting which was found better over other staggered planting dates.

2.2 Effect of zinc application

2.2.1 Growth

Sharma *et al*. (2004) reported that in gladiolus cv. 'Friendship', foliar spray of zinc sulphate at 0.6 per cent increased plant. Jauhari *et al*. (2005) found that foliar spray of zinc sulphate at 0.2 % led to maximum plant height in gladiolus cv. Red Beauty. Katiyar *et al.* (2005) observed that gladiolus cvs. Aldebran, Friendship, Lady First and White Prosperity which were grown on partially reclaimed sodic soil showed increased plant height and content of chlorophyll a due to the foliar application of 0.2% zinc. Farahat *et al*. (2007) observed in gladiolus that zinc enhanced the activity of certain enzymes concerned with metabolism of carbohydrate thus promoting the growth of the plant.

Halder *et al.* (2007a) carried out a study on quality performance of gladiolus and observed that zinc at 3 kg/ha dose significantly increased the plant height (87.70 cm) and maximum effective leaves (10.05/plant). Naik *et al.* (2009) obtained significantly enhanced plant height (106.14 cm) with spraying of Zn 200 mg/l. Maximum fresh weight (57.10 g) and dry weight (15.65 g) was achieved in plants treated with 300 mg/l Zn in gladiolus cv. American Beauty. Reddy and Chaturvedi (2009) recorded increased results on parameters like plant height (73.11 cm) and leaf length (52.81 cm) with foliar application of zinc sulphate at 0.5% on gladiolus cv. Red Majesty.

Khalifa *et al.* (2011) proved in a pot experiment performed on iris plant for evaluating the effect of foliar application of zinc sulphate and boric acid and found out that highest plant height was obtained at zinc sulphate applied at 3 kg/ha whereas highest values of leaves per plant and fresh and dry weight per plant was achieved at 4.5 kg/ha zinc sulphate dose. Katiyar *et al.* (2012) revealed that foliar spray of zinc at 0.5% to *gladiolus* cv. Eurovision influenced the vegetative growth positively. Singh *et al.* (2012) experienced that the vegetative parameters in gladiolus cv. Sapna increased significantly on foliar spray of zinc 0.5%.

Reddy and Rao (2012) experimented on precision foliar application of zinc on gladiolus at (2, 1 and 0%). The treatment 2% zinc has significantly increased plant height, number of leaves, leaf length, leaf width and leaf area. Minimum values were observed in control treatment. Singh *et al.* (2012) experienced that vegetative parameters in gladiolus cv. Sapna increased significantly on foliar spray of zinc at 0.5%. Saeed *et al.* (2013) conducted a field experiment for effect graded levels of zinc on gladiolus. Zinc at 6 mg/kg gave the highest result for increased leaf area, chlorophyll content, fresh and dry biomass weight. Saba *et al*. (2013) reported that application of 40 g ZnSO4 resulted in significantly better performance of gladiolus and control treatment resulted lowest values for almost all the studied traits.

Sharma *et al*. (2013) reported that the height of plant (79.55 cm) significantly increased by foliar application of Zn(0.75%). Also Zn exhibited most significant effect on various parameters studied under the investigation. Maurya and Kumar (2014) investigate on foliar application at 3rd and 6th leaf stage of gladiolus with zinc at 100ppm, 200ppm and 300ppm and reported significant result in all the treatment. Singh and Prasad (2014) investigated on effect of micronutrients spray on plant growth, spike yield and flower quality of gladiolus (*Gladiolus grandiflorus* L.) cv. White Prosperity with zinc (0.0%, 0.2%, 0.3%, 0.4% and 0.5%) and boron (0.0%, 0.2%, 0.3%, 0.4% and 0.5%) and their treatment combinations and reported that the foliar application of zinc at all rates significantly influenced plant growth with maximum value at 0.4% zinc levels.

Hembrom *et al*. (2015) studied the response of gladiolus to foliar application of iron and zinc and reported that ZnSO4 at 0.2% increased dry weight of leaf and ZnSO4 at 0.4% foliar dose increased length of longest leaf, width of longest leaf. Singh *et al*. (2015) conducted field experiment on effect of foliar application of zinc and copper on nutrient accumulation and various growth and flowering parameters in gladiolus (*Gladiolus* spp) reported that maximum duration of flowering was noticed with the treatment Zn 0.2% (17.45 days) Maximum zinc accumulation (58.94 ppm) was recorded with the treatment Zn 0.4%.

2.2.2 Flowering

Rajiv *et al.* (2003) studied on the gladiolus var. Sylvia at 3- leaf stage with borax, $CaSO_4$ and $ZnSO_4$ (0.2, 0.5 and 0.75%) sprayings revealed that $ZnSO_4$ at 0.75% induced earlier flowering (75.81 days). Sharma *et al*. (2004) reported that in gladiolus cv. 'Friendship', foliar spray of zinc sulphate at 0.6 per cent increased spike length. Jauhari *et al.* (2005) investigated gladiolus cv. Red Beauty that was sprayed with 0.2% zinc sulphate which rendered maximum spike length, rachis length and number of florets per spike. Katiyar *et al.* (2005) evaluated the effect of foliar spray of 0.2 % zinc on partially reclaimed sodic soil grown gladiolus cultivars Aldebran, Friendship, Lady First and White Prosperity which exhibited an increase of approximately 22-40% in spike length and 27-40% in the number of florets depending on the cultivars.

Halder *et al.* (2007a) achieved longest length of spike (76.89 cm) and rachis (41.14 cm), number of florets (12.18/spike) and floret size (9.71 × 8.67 cm) in zinc at the rate of 3 kg/ha in a trial taken up on the performance of gladiolus. Naik *et al.* (2009) revealed that plants sprayed with 300 mg/l Zn produced maximum number of florets per spike (10.05) in gladiolus cv. American Beauty. Highest length of spike (101.20 cm) was exhibited in plants sprayed with same dose of zinc. Reddy and Chaturvedi (2009) observed that foliar application of $ZnSO_4$ at 0.5% on gladiolus cv. Red Majesty was found to be significant on days to flowering (66.11 days), length of spike (54.01 cm), length of rachis (46.26 cm), number of florets per spike (14.00) and floret length (9.08 cm).

Eid *et al.* (2010) investigated the effect of foliar application of zinc and benzyladenine on various aspects of tuberose plants and found that the flowering characteristics were significantly enhanced. Khalifa *et al.* (2011) experimented on pot grown iris plants for foliar spray of zinc sulphate and boric acid. The results revealed that fresh and dry weight of flowers was highest at 3 kg/ha zinc sulphate and on the other hand at zinc sulphate 4.5 kg/ha stimulated fresh and dry weight of bulblets per plant, longest spike length and diameter of floret. Singh *et al.* (2012) reported that all the floral parameters except days to heading showed positive result with the foliar spray of zinc at 0.5% on gladiolus cv. Sapna. Katiyar *et al.* (2012) found out that foliar spray of 0.5% zinc enhanced the size of spike in gladiolus cv. Eurovision.

Reddy and Rao (2012) experimented on precision foliar application of zinc on gladiolus at (2, 1 and 0%) and reported that 2% zinc recorded more number of days (97.63) to first floret appearance and 50% flowering (103.32**)** over other treatments whereas, control recorded minimum number of days to first floret appearance and 50% flowering. Similarly, the treatment 2% zinc recorded more number of spikes (1.33), spike length (112.19 cm), number of florets per spike. Saeed *et al*. (2013) in a field experiment for effect graded levels of zinc on gladiolus found that zinc at 6 mg/kg produced highest spike length and flower size. Lower number of days to flowering and more count of florets per spike were noted with 8 mg/kg of zinc. Maurya and Kumar (2014) investigate on foliar application at 3rd and 6th leaf stage of gladiolus with zinc at 100ppm, 200ppm and 300ppm and reported significant result in all the treatment.

Sharma *et al.* (2013) studied on the response of zinc on growth and flowering parameters and reported that application of zinc significantly increases the parameter under studied as compared to controlled. Amin *et al*. (2014) studied the level of zinc on growth, flowering and production of corms and cormels of gladiolus at four different levels of zinc viz. Z0= 0 kg Zn/ha, Z1=1 kg Zn/ha (1.28 Kg ZnO), Z2= 2 kg Zn/ha (2.56 Kg ZnO), Z3= 3 kg Zn/ha (3.84 Kg ZnO) and Z4= 4 kg Zn/ha (5.12 Kg ZnO). Maximum number of spike (22.3/plot), number of floret/spike (16.1), was found from Z3 while lowest number of spike (17.9/plot), number of floret/spike (11.1), was found from Z0.

Singh and Prasad (2014) investigated on effect of micronutrients spray on plant growth, spike yield and flower quality of gladiolus (*Gladiolus grandiflorus* L.) cv. White Prosperity with zinc (0.0%, 0.2%, 0.3%, 0.4% and 0.5%) and boron (0.0%, 0.2%, 0.3%, 0.4% and 0.5%) and their treatment combinations and reported that the foliar application of zinc at all rates significantly influenced flower quality with maximum value at 0.4% zinc levels. Singh *et al*. (2015) conducted field experiment on effect of foliar application of zinc and copper on nutrient accumulation and various growth and flowering parameters in gladiolus (*Gladiolus* spp) reported that maximum duration of flowering was noticed with the treatment Zn 0.2% (17.45 days).

Maurya *et al*. (2018) investigated the Effect of different micronutrients on growth, flowering behavior and corm yield of gladiolus (Gladiolus grandiflorus L.) with three levels of boron (100, 200 and 300 mg/l) and zinc (100, 200 and 300 mg/l) through foliar spraying at 3rd and 6th leaf stage reported that length of spike (cm), number of spike/plant and number of florets/spike was significantly influenced with spraying of Zn @ 300 mg/l.

2.2.3 Yield

Rajiv *et al* (2003) studied on the gladiolus var. Sylvia at 3- leaf stage with borax, $CaSO_4$ and $ZnSO_4$ (0.2, 0.5 and 0.75%) sprayings revealed that increased the number of corms (1.33). Sharma *et al*. (2004) reported that in gladiolus cv. 'Friendship', foliar spray of zinc sulphate at 0.6 per cent increased number of corms and cormels per plant. Jauhari *et al.* (2005) observed increased corms yield per square metre was achieved by foliar application of 0.2% zinc sulphate on gladiolus cv. Red Beauty.

Halder *et al.* (2007b) conducted a field trial on gladiolus for corms and cormels production, application of zinc from 0 to 3.0 kg/ha in treated plants significantly increased corms and cormels yield and their numbers over the control (Zn_0). Number of corms per plant was found to be slightly increased while individual weight of corm and number and weights of cormels also increased simultaneously with increasing dose of zinc up to 3.0 kg/ha. It was also observed that further elevation in dose of zinc reduced the yield of both corms and cormels. However, highest individual weight of corm (22.22 g and 24.21 g) was obtained over control (8.87 g and 11.65 g). Highest number of cormels (9.78and 12.09) and highest weight per plant of same (20.92 g and 36.24 g) were recorded with 3.0 kg Zn/ha. Diameter of corms and cormel narrowly differed to each other for different treatments of zinc.

Naik *et al.* (2009) observed highest number of cormels (38.17) per plant with 300 mg/l $ZnSO_4$ in treated gladiolus cv. American Beauty. Sharova *et al*.

(2009) examined number of corms and cormlets treated with a micronutrient solution of Zn resulted as most effective nutrient on gladiolus. Eid *et al.* (2010) obtained increased number of bulblets/plant and fresh weight of bulbets with foliar application of zinc on tuberose plants.

Reddy and Rao (2012) experimented on precision foliar application of zinc on gladiolus at (2, 1 and 0%) reported 2% zinc recorded maximum values for corm size (4.47 cm), corm weight (37.97 g), number of cormels (32.90) and cormel weight per corm (10.72 g), while minimum values were observed with control. Singh *et al.* (2012) demonstrated that weight (94.38 g) and diameter (5.71cm) of corms was found to increase significantly with the application of Zn along with the increase in the number of corms per plant (1.74) in gladiolus cv. Sapna. Maximum increase in cormels production per plant was influenced due to application of zinc (44.97) as per observation.

Sharma *et al*. (2013) reported that maximum yield of spike (16904.50) was recorded with application of zinc 0.75%. Also Zn exhibited most significant effect on various parameters studied under the investigation. Amin et al (2014) studied the level of zinc on growth, flowering and production of corms and cormels of gladiolus at four different levels of zinc viz. Z0= 0 kg Zn/ha, Z1=1 kg Zn/ha (1.28 Kg ZnO), Z2= 2 kg Zn/ha (2.56 Kg ZnO), Z3= 3 kg Zn/ha (3.84 Kg ZnO) and Z4= 4 kg Zn/ha (5.12 Kg ZnO). Maximum corm yield (1.23 kg/plot) and cormel yield (1.06 kg/plot) was found from Z3 while lowest number of corm yield (0.86 kg/plot) and cormel yield (0.80 kg/plot) was found from Z0.

Maurya and Kumar (2014) investigate on foliar application at 3rd and 6th leaf stage of gladiolus with zinc at 100ppm, 200ppm and 300ppm and reported significant result in all the treatment. Hembrom *et al.* (2015) studied the response of gladiolus to foliar application of iron and zinc and reported that ZnSO4 at 0.2% and ZnSO4 at 0.4% foliar dose improved weight of corms/hill, weight of cormels/hill and diameters of corm. Singh and Prasad (2014) investigated on effect of micronutrients spray on plant growth, spike yield and flower quality of gladiolus (*Gladiolus grandiflorus* L.) cv. White Prosperity with zinc (0.0%, 0.2%, 0.3%, 0.4% and 0.5%) and boron (0.0%, 0.2%, 0.3%, 0.4% and 0.5%) and their treatment combinations and reported that the foliar application of zinc at all rates significantly influenced spike yield with maximum value at 0.4% zinc levels.

Maurya *et al*. (2018) investigated the Effect of different micronutrients on growth, flowering behavior and corm yield of gladiolus (Gladiolus grandiflorus L.) with three levels of boron (100, 200 and 300 mg/l) and zinc (100, 200 and 300 mg/l) through foliar spraying at 3rd and 6th leaf stage reported that number of spike/ha and spike yield/ha (q) was significantly influenced with spraying of Zn @ 300 mg/l.

Mohammed and Khalid (2019) experimented on Gladiolus hybrida cv. Traderhorn when sprayed with Boric acid (17% Boron) at two concentrations of (0, 30 mg.L-1) and with the chelated zinc of (11% zinc) at three concentrates of (0, 30, 60 mg.L-1) at second leaf and emergence of flower stalk stages reported that spraying with zinc had a significant effect on increasing the diameter of corms and number of cormels.

2.2.4 Postharvest quality

Jauhari *et al.* (2005) reported maximum number of florets opened at a time with foliar spray on $ZnSO_4$ on gladiolus cv. Red Beauty whereas percentage of opening of florets was maximum with the effect of foliar treatment of 0.4% $ZnSO_4$ in vase. Katiyar *et al.* (2005) evaluated the effect of foliar spray of 0.2 % zinc on partially reclaimed sodic soil grown gladiolus cultivars Aldebran, Friendship, Lady First and White Prosperity which exhibited an increase of approximately 22-40% in spike length and 27-40% in the number of florets depending on the cultivars.

Halder *et al.* (2007a) achieved longest length of spike (76.89 cm) and rachis (41.14 cm), number of florets (12.18/spike), floret size (9.71 × 8.67 cm) and weight of spike (40.83 g) in zinc at the rate of 3 kg/ha in a trial taken up on the performance of gladiolus. Saeed *et al.* (2013) studied the effect of graded levels of zinc on gladiolus and observed that vase life parameters such as percent of florets opened, vase life and fresh weight change were significant with 8 mg/kg of zinc. Maurya and Kumar (2014) investigate on foliar application at 3rd and 6th leaf stage of gladiolus with zinc at 100ppm, 200ppm and 300ppm and reported significant result in all the treatment.

Fahad *et al*. (2014) investigated the effect of micronutrients (B, Zn and Fe) on growth, flower yield and quality of gladiolus cv. Traderhorn and reported that micronutrients significantly increased flower fresh weight, spike length, florets per spike, florets' fresh weight and diameter and vase-life. Maurya et al (2018) investigated the Effect of different micronutrients on growth, flowering behavior and corm yield of gladiolus (Gladiolus grandiflorus L.) with three levels of boron (100, 200 and 300 mg/l) and zinc (100, 200 and 300 mg/l) through foliar spraying at 3rd and 6th leaf stage reported that average weight of spike (g) was significantly influenced with spraying of Zn @ 300 mg/l.

Mohammed and Khalid (2019) experimented on Gladiolus hybrida cv. Traderhorn when sprayed with Boric acid (17% Boron) at two concentrations of (0, 30 mg.L-1) and with the chelated zinc of (11% zinc) at three concentrates of (0, 30, 60 mg.L-1) at second leaf and emergence of flower stalk stages reported that spraying with zinc had a significant effect on increasing the length of flower stalk, number of florets and vase life.

2.3 Effect of boron application

2.3.1 Growth

Reddy and Chaturvedi (2009) studied the effect of zinc ($ZnSO_4$) at 0.5%, calcium ($CaSO_4$) at 0.5% and boron (borax) at 0.25% on growth and flowering in gladiolus cv. Red Majesty reported that borax have shown non-significant results for vegetative parameters under studied. Sharma et al (2013) reported that the height of plant (79.39 cm) significantly increased by foliar application of B(0.50%).

Umme (2013) reported that all doses of boron significantly improve on the yield contributing characters of tuberose over control, while the most effective dose was B at (2 kg/ha) produced best performance in respect of vegetative growth, flower and bulb production in tuberose.

Fahad *et al*. (2014) conducted field experiment during 2010-2012 to investigate the effect of micronutrients (B, Zn and Fe) on growth, flower yield and quality of gladiolus cv. Traderhorn reported that foliar application of these micronutrients significantly increases the growth parameters under investigation.

Singh and Prasad (2014) investigated on effect of micronutrients spray on plant growth, spike yield and flower quality of gladiolus (*Gladiolus grandiflorus* L.) cv. White Prosperity with zinc (0.0%, 0.2%, 0.3%, 0.4% and 0.5%) and boron (0.0%, 0.2%, 0.3%, 0.4% and 0.5%) and their treatment combinations and reported that the foliar application of boron at all rates significantly influenced plant growth with maximum value at 0.4% boron levels.

Vijay *et al*. (2015) studied the Effect of boron and iron on vegetative growth in three Gladiolus (*Gadiolus grandiflorus* L.) cultivars and reported that the boron @ 0.2 and 0.4% concentrations compared to distilled water as control had significantly influenced the plant height, leaf length, leaf width, number of leaves per plant and leaf area per plant in improving the vegetative growth.

Yashawanth *et al*. (2017) reported that application of micronutrients in gladiolus (*Gladiolus grandiflorus* L) cv. Summer Sunshine, significantly increased the vegetative parameters like plant height (71.60 cm), number of leaves per plant

(9.50), leaf length (67.10 cm), leaf width (4.10 cm), and leaf area (2471.70 cm2). Among the different micronutrient treatments, foliar application of H3BO3 (0.5 %) performed best for all the parameters under investigation.

2.3.2 Flowering

Reddy and Chaturvedi (2009) studied the effect of zinc ($ZnSO_4$) at 0.5%, calcium ($CaSO_4$) at 0.5% and boron (borax) at 0.25% on growth and flowering in gladiolus cv. Red Majesty reported that borax have shown non-significant results for most of the characters except days to flowering (66.13 days) and number of florets (13.93) per spike with boron at 0.25%. Sharma et al (2013) reported that foliar application of B (0.50%) was significantly enhanced the length of floret (8.29 cm).

Fahad *et al*. (2014) conducted field experiment during 2010-2012 to investigate the effect of micronutrients (B, Zn and Fe) on growth, flower yield and quality of gladiolus cv. Traderhorn reported that foliar application of these micronutrients significantly increases the flowering parameters under investigation. Maurya and Kumar (2014) investigate on foliar application at 3rd and 6th leaf stage of gladiolus with boron at 100ppm, 200ppm and 300ppm and reported significant result in all the treatment.

Chopde *et al.* (2016) Reported that foliar application of 0.1% boron has significantly improved quality in respect of florets per spike and also noted the earliest first spike emergence and opening of first floret in gladiolus. Singh and Prasad (2014) investigated on effect of micronutrients spray on plant growth, spike yield and flower quality of gladiolus (*Gladiolus grandiflorus* L.) cv. White Prosperity with zinc (0.0%, 0.2%, 0.3%, 0.4% and 0.5%) and boron (0.0%, 0.2%, 0.3%, 0.4% and 0.5%) and their treatment combinations and reported that the foliar application of boron at all rates significantly influenced flower quality with maximum value at 0.4% boron levels.

Mohammed and Khalid (2019) experimented on Gladiolus hybrida cv. Traderhorn when sprayed with Boric acid (17% Boron) at two concentrations of (0, 30 mg.L-1) and with the chelated zinc of (11% zinc) at three concentrates of (0, 30, 60 mg.L-1) at second leaf and emergence of flower stalk stages reported that spraying with boron had a significant effect on increasing the length of flower stalk, number of florets and vase life.

2.3.3 Yield

Halder *et al*. (2007) reported from field experiment that application of boron increases the yield of gladiolus with a significant difference from that of control or untreated plants. Fahad *et al*. (2014) conducted field experiment during 2010-2012 to investigate the effect of micronutrients (B, Zn and Fe) on growth, flower yield and quality of gladiolus cv. Traderhorn reported that number of corm per plant was not affected significantly by the foliar application of the micronutrients.

Reddy and Chaturvedi (2009) studied the effect of zinc ($ZnSO_4$) at 0.5%, calcium ($CaSO_4$) at 0.5% and boron (borax) at 0.25% on growth and flowering in gladiolus cv. Red Majesty reported that borax have shown non significant results for yield parameters under studied. Amery *et al.* (2011) studied to determine the response of open pollinated sunflower (Helianthus annuus L. cv. Shumos) to boron fertilizer. Spring and autumn grown plots sprayed with boron (0, 50, 100, 150, 200, and 250 mg/L) reported that boron at 200 and 250 mg/L applications gave significant increases in yield compared to the control.

Maurya and Kumar (2014) investigate on foliar application at 3rd and 6th leaf stage of gladiolus with boron at 100ppm, 200ppm and 300ppm and reported significant result in all the treatment. Chopde *et al.* (2016) Reported that foliar application of 0.1% boron has significantly maximum flower yield in respect of spikes per plant. Singh and Prasad (2014) investigated on effect of micronutrients spray on plant growth, spike yield and flower quality of gladiolus (*Gladiolus grandiflorus* L.) cv. White Prosperity with zinc (0.0%, 0.2%, 0.3%, 0.4% and

0.5%) and boron (0.0%, 0.2%, 0.3%, 0.4% and 0.5%) and their treatment combinations and reported that the foliar application of boron at all rates significantly influenced spike yield with maximum value at 0.4% boron levels.

Mohammed and Khalid (2019) experimented on Gladiolus hybrida cv. Traderhorn when sprayed with Boric acid (17% Boron) at two concentrations of (0, 30 mg.L-1) and with the chelated zinc of (11% zinc) at three concentrates of (0, 30, 60 mg.L-1) at second leaf and emergence of flower stalk stages reported that spraying with boron had a significant effect on increasing the diameter of corms and number of cormels.

2.3.4 Postharvest

Halder *et al.* (2007) investigated on B and Zn on Gladiolus reported that B and Zn made promising response to the growth and floral characters of gladiolus. It was also noticed in the tables that B and Zn both either in single or in combination exerted tremendous effect on the yield and quality of gladiolus. The sixteen treatment combinations included in the study noted that B and Zn at the rate of B2.0 Zn4.5 kg/ha exhibited the best performance in flower production and stretched the vase life of flower.

Fahad *et al*. (2014) investigated the effect of micronutrients (B, Zn and Fe) on growth, flower yield and quality of gladiolus cv. Traderhorn and reported that micronutrients significantly increased flower fresh weight, spike length, florets per spike, florets' fresh weight and diameter and vase-life. Chopde *et al.* (2016) Reported that foliar application of 0.1% boron has significantly improved quality in respect of florets per spike and vase life of spike in gladiolus.

Mohammed and Khalid (2019) experimented on Gladiolus hybrida cv. Traderhorn when sprayed with Boric acid (17% Boron) at two concentrations of (0, 30 mg.L-1) and with the chelated zinc of (11% zinc) at three concentrates of (0, 30, 60 mg.L-1) at second leaf and emergence of flower stalk stages reported that spraying with boron had a significant effect on increasing the length of flower stalk, number of florets and vase life.

2.4 Effect of zinc and boron

2.4.1 Growth

Rajiv *et al.* (2003) studied on the gladiolus var. Sylvia at 3- leaf stage with borax, $CaSO_4$ and $ZnSO_4$ (0.2, 0.5 and 0.75%) sprayings reported that Length of leaf (55.75 cm) was significantly increased with 0.2% borax + 0.75% $ZnSO_4$. Halder *et al* (2007) investigated on B and Zn on Gladiolus reported that B and Zn made promising response to the growth and floral characters of gladiolus. It was also noticed in the tables that B and Zn both either in single or in combination exerted tremendous effect on the yield and quality of gladiolus. The studied parameters like plant height (79.83 and 87.61 cm), and leaves number (10.77 and 9.87/plant) significantly responded to the combined application of boron and zinc at the rate of B2.0 Zn4.5 as compared to other treatment combinations.

Reddy and Chaturvedi (2009) studied the effect of zinc ($ZnSO_4$) at 0.5%, calcium ($CaSO_4$) at 0.5% and boron (borax) at 0.25% on growth and flowering in gladiolus cv. Red Majesty reported that interaction between boron (0.25%) and $ZnSO_4$ (0.5%) revealed significant results for plant height 73.27. Khalifa *et al*. (2011) studied the influence of foliar spraying of zinc (as zinc sulphate) and boron (as boric acid) on growth parameters, bulblet, flower characteristics reported that Zinc sulphate (Zn) at concentrations of 0.0, 1.5g/l, 3.0g/l and 4.5g/l and boric acid (B) at concentrations of 0.0, 5ppm, 10 ppm and 20 ppm applied alone and in combinations twice as foliar spray, where the first was after 45 days and the second was after 60 days of planting. Results showed that the foliar spraying of zinc sulphate or boric acid alone at all rates and as combinations significantly increased growth parameters. The most promising results were obtained from plants treated with Zn at 4.5g/l combined with 20 ppm B.

Sharma *et al*. (2013) reported that foliar application of Zn(0.75%) and B(0.50%) significantly increased the height of plant. Fahad et al. (2014) investigated the effect of micronutrients (B, Zn and Fe) on growth, flower yield and quality of gladiolus cv. Traderhorn and reported that micronutrients significantly increased plant height.

Singh and Prasad (2014) investigated on effect of micronutrients spray on plant growth, spike yield and flower quality of gladiolus (*Gladiolus grandiflorus* L.) cv. White Prosperity with zinc (0.0%, 0.2%, 0.3%, 0.4% and 0.5%) and boron (0.0%, 0.2%, 0.3%, 0.4% and 0.5%) and their treatment combinations and reported that interaction between boron and zinc, the best results regarding plant growth was obtained with treatment combination B3 Z3 (B 0.4% + Zn 0.4%).

Yashawanth *et al*. (2017) experimented on influence of micronutrients on growth parameters of gladiolus (*Gladiolus grandiflorus* L) cv. Summer Sunshine and reported that foliar application of ZnSO4 (1.0 %) + H3BO3 (1.0%) significantly increases for all the parameters under investigation.

2.4.2 Flowering

Halder *et al.* (2007a) investigated on B and Zn on Gladiolus reported that B and Zn made promising response to the growth and floral characters of gladiolus. It was also noticed in the tables that B and Zn both either in single or in combination exerted tremendous effect on the yield and quality of gladiolus. The sixteen treatment combinations included in the study noted that B and Zn at the rate of B2.0 Zn4.5 kg/ha exhibited the best performance in flower production. Floral characters like length of spike (71.2 and 67.33 cm) length of rachis (48.86 and 45.08 cm), floret number (12.85 and 12.45/spike), floret size (9.76x8.93 and 10.28x9.77 cm) and weight of stick (36.73 and 45.12 g) also significantly influenced by said treatment (B2.0 Zn4.5 kg/ha which was markedly differed over rest of treatments combination.

Halder *et al*. (2007b) studied on Boron (B) and Zinc (Zn) on Gladiolus reported that integrated use of B and Zn was appeared to be more pronounced as compared to their single application. All the studied flower characters like length and weights of rachis and spike and number and weight of florets per spike and spike weights and size of the florets greater influenced with the increase of B and Zn but subsequent addition of B and Zn beyond that level ($B_{2.0}Zn_{3.0}$ kg/ha) depressed the flower yield. Besides, the highest mean spike weight (55.19 g) were recorded with the combined application of $B_{2.0}Zn_{3.0}$ kg/ha.

Reddy and Chaturvedi (2009) studied the effect of zinc ($ZnSO_4$) at 0.5%, calcium ($CaSO_4$) at 0.5% and boron (borax) at 0.25% on growth and flowering in gladiolus cv. Red Majesty reported that interaction between boron (0.25%) and $ZnSO_4$ (0.5%) revealed significant results for days to flowering (66.13 days). Khalifa *et al*. (2011) studied the influence of foliar spraying of zinc (as zinc sulphate) and boron (as boric acid) on growth parameters, bulblet, flower characteristics reported that Zinc sulphate (Zn) at concentrations of 0.0, 1.5g/l, 3.0g/l and 4.5g/l and boric acid (B) at concentrations of 0.0, 5ppm, 10 ppm and 20 ppm applied alone and in combinations twice as foliar spray, where the first was after 45days and the second was after 60 days of planting. Results showed that the foliar spraying of zinc sulphate or boric acid alone at all rates and as combinations significantly increased flowers characteristics. The most promising results were obtained from plants treated with Zn at 4.5g/l combined with 20 ppm B.

Sharma *et al*. (2013) reported that foliar application of Zn(0.75%) and B(0.50%) significantly increased the length of floret. Fahad et al. (2014) investigated the effect of micronutrients (B, Zn and Fe) on growth, flower yield and quality of gladiolus cv. Traderhorn and reported that micronutrients significantly increased flower stalk length, florets per spike, and flower diameter.

Singh and Prasad (2014) investigated on effect of micronutrients spray on plant growth, spike yield and flower quality of gladiolus (*Gladiolus grandiflorus* L.) cv. White Prosperity with zinc (0.0%, 0.2%, 0.3%, 0.4% and 0.5%) and boron (0.0%, 0.2%, 0.3%, 0.4% and 0.5%) and their treatment combinations and reported that interaction between boron and zinc, the best results regarding flower quality was obtained with treatment combination B3 Z3 (B 0.4% + Zn 0.4%).

Mohammed and Khalid (2019) experimented on Gladiolus hybrida cv. Traderhorn when sprayed with Boric acid (17% Boron) at two concentrations of (0, 30 mg.L-1) and with the chelated zinc of (11% zinc) at three concentrates of (0, 30, 60 mg.L-1) at second leaf and emergence of flower stalk stages reported that spraying with boron or zinc had a significant effect on increasing the length of flower stalk, number of florets and vase life.

2.4.3 Yield

Halder *et al*. (2007) conducted field trial with the objectives to evaluate the response of B and Zn on corm and cormel production and to find out the optimum dose of B and Zn for maximizing yield of bulbs for Gladiolus cultivation. It was reported that B-Zn integration contributed more than their single applications. The interaction effects of B and Zn @ B2.0, and Zn4.5 kg/ha significantly contributed to the yield of individual corm weight (26.07 g and 27.58 g) and number of cormels (9.78 and 14.43) and weight of cormels/plant (31.94 g and 51.67g).

Khalifa *et al*. (2011) studied the influence of foliar spraying of zinc (as zinc sulphate) and boron (as boric acid) on growth parameters, bulblet, flower characteristics reported that Zinc sulphate (Zn) at concentrations of 0.0, 1.5g/l, 3.0g/l and 4.5g/l and boric acid (B) at concentrations of 0.0, 5ppm, 10 ppm and 20 ppm applied alone and in combinations twice as foliar spray, where the first was after 45days and the second was after 60 days of planting. Results showed that the foliar spraying of zinc sulphate or boric acid alone at all rates and as combinations significantly increased bulblet number and yield/plant as compared with the control treatment. The most promising results were obtained from plants treated with Zn at 4.5g/l combined with 20 ppm B.

Fahad *et al*. (2014) investigated the effect of micronutrients (B, Zn and Fe) on growth, flower yield and quality of gladiolus cv. Traderhorn and reported that micronutrients significantly increased diameter as well as fresh weight of corms. The treatment at 2% concentration of micronutrients performed the best for all the parameters except for number of corm per plant, which was not affected significantly by the foliar application of the micronutrients. Singh and Prasad (2014) investigated on effect of micronutrients spray on plant growth, spike yield and flower quality of gladiolus (*Gladiolus grandiflorus* L.) cv. White Prosperity with zinc (0.0%, 0.2%, 0.3%, 0.4% and 0.5%) and boron (0.0%, 0.2%, 0.3%, 0.4% and 0.5%) and their treatment combinations and reported that interaction between boron and zinc, the best results regarding spike yield was obtained with treatment combination B3 Z3 (B 0.4% + Zn 0.4%).

Mohammed and Khalid (2019) experimented on Gladiolus hybrida cv. Traderhorn when sprayed with Boric acid (17% Boron) at two concentrations of (0, 30 mg.L-1) and with the chelated zinc of (11% zinc) at three concentrates of (0, 30, 60 mg.L-1) at second leaf and emergence of flower stalk stages reported that spraying with boron or zinc had a significant effect on increasing the diameter of corms and number of cormels. There were significant differences in most of the studied traits in interaction when sprayed with boron at a concentration of (30 mg.L-1) and (60 mg.L-1).The number of cormels increased with percentage amounted of (143.13%) when mixed with both boron and zinc at a concentration of (60 mg.L-1).

2.5 Effect of wrapping on postharvest qualities

Panicker *et al*. (2003) investigated different packing methods on post harvest behavior of chrysanthemum cv. Yellow Fiji. Among the different treatments, poly-sleeve packing and pulsing with sucrose enhanced the vase life up to 10 days, floret opening was recorded to be 8.10% and flower diameter of 6.62 cm and reduced physiological weight loss by 14.93 per cent in this treatment.

Singh *et al*. (2003) stored the spikes of three cultivars of gladiolus *viz*., Jacksonville Gold, Suchitra and Praha with dry stored in polyethylene sleeves under refrigerated conditions and found decline in vase life and per cent opening of florets and increase in per cent weight loss. The cultivars differed among themselves in their response to storage. Jacksonville Gold exhibited maximum vase life and opening of florets. It could be dry-stored for 11 days without much reduction in vase life, whereas cvs. Suchitra and Praha found only for 7 days.

The cut spikes of gladiolus cv. Her Majesty was kept in various wrapping materials such as polyethylene, cellophane, butter paper, news paper and packed in CFB boxes. Boxes were stored at 40C, 100C and in ambient condition for 2, 4 and 6 days. After storage, the spikes were held in solution of 4 % Sucrose + 100 ppm Al2 (SO4)3 + 200 ppm 8-HQC solution in vase. It was found that spikes stored at 40C and packed in butter paper for 6 days and flowers packaged in cellophane for 2 days proved to be the best for increasing the post harvest life of gladiolus (Beura and Singh, 2003).

Farooq *et al.* (2004) Studied on various packing materials, viz. cellophane paper, butter paper and aluminum lamination foil, on the storage and vase life of cut rose flowers (Rosa hybrid L. cvs. Kardinal, Gold Medal and Anjleeq) reported that flowers of R. hybrid L. cv. Kardinal kept in aluminum lamination foil at tight bud stage gave maximum vase life followed by R. hybrida L. cv. Gold Medal in the same packing material. Cultivar Anjleeq harvested at loose bud stage and placed in cellophane paper exhibited minimum vase life.

Khan *et al*. (2004) revealed that the flowers of *Rosa hybrida* cv. Kardinal harvested at the tight bud stage and packed in aluminum lamination foil recorded the longest storage life. They further observed that cv. Whiskey Mac harvested at the loose bud stage and packed in cellophane registered the shortest storage life (3.81 days) and vase life (1.12 days) in cut rose flowers. Grover *et al*. (2005) studied the effect of pulsing + polypropylene (100 gauge) packaging on floret size and opening of florets in gladiolus spikes stored in MA packages for different storage duration. Pulse treated MA stored gladiolus spikes for 15 days duration recorded maximum floret size (10.14 cm) which was at par with 9 day and maximum floret opened at one time (5.67) at 9 days which was followed by pulsed + MA stored gladiolus (5.54) storage duration at 15 day.

Srivastava *et al*. (2005) studied the effect of packaging material on the post-harvest life of gladiolus cv. Nova Lux. among all packaging and storage treatments, spikes wrapped in brown paper and stored for 72h at 4°C was found suitable for enhancing the longevity of cut spikes. Jain *et al*. (2006) observed that cut flowers of rose cv. First Red wrapped in cellophane paper and stored at 20C for 3 days resulted in increased vase life, volume of solution consumed and appearance as well as showed minimum weight loss. Verma *et al*. (2006) studied three packaging materials *viz*., newspaper, cello paper, cellophane wax paper and polyethylene for packaging and storage of the chrysanthemum flowers for 24, 48 and 72 h at ambient storage, zero energy cool chamber and cold storage. The maximum vase life (19.20 days), volume of solution consumed (259.30 ml), flower size (10.90 cm), total sugars (41.81 mg/g) and minimum weight loss (5.16%) was observed in cut flowers packed in wax paper for 24 h in cold storage.

Alka *et al*. (2007) studied the effect of different types of packaging films on petal senescence and vase life of gladiolus cut spikes, cv. Peter Pears reported that among different packaging films (cellophane, polypropylene, coated paper, brown paper, news-paper and butter paper), polypropylene (60μ) and coated paper packaging proved promising in augmenting the post harvest longevity of stored gladiolus cut spikes. The unpackaged low temperature stored cut spikes exhibited destabilized membrane integrity and decreased vase life. Polypropylene packaged cut spikes exhibited higher membrane stability of the petal tissue of the cut spikes, which delayed the petal senescence and extended the vase life of the gladiolus cut spikes.

Singh *et al*. (2007a) investigated the effects of different type of packaging films for modified atmosphere storage at low temperature (6-10°C) on the factors influencing petal senescence and vase life of gladiolus cut spikes cv. 'Peter Pears'. Polypropylene packaged cut spikes delayed the petal senescence and extended the vase life of gladiolus cut spikes. Polypropylene was found to be an effective packaging film for modified atmosphere (MA) storage at low temperature (6-10°C) for storage of gladiolus cut spikes up to 10 days. Singh *et al*. (2008) studied the effect of different polymeric films on modified atmosphere storage of gladiolus cut spikes and recorded maximum vase life in PP (100 gauge) polymeric film packaged cold stored flowers. Spider lily buds can be stored with acceptable quality for 10 days with news paper wrapping and 15 days with tissue paper wrapping in cold storage at 20 °C (Patel *et al*., 2008)

Varu and Barad (2008) studied the role of packing methods on vase life of tuberose reported that packing methods in which the spikes wrapped in 200 gauge polyethylene sheet (P2) were found for longest vase life of spike, maximum uptake of water, lowest loss uptake ratio, better freshness as well as lowest wilting of florets and highest percentage of opened florets. However, packing method P2 was found at par with wrapping the spike in metal paper (P7). Similarly, the poor response was obtained by the packing in craft paper (P6) and control (P8) where bunch of spikes were packed in CCBB without wrapping. Makwana (2009) studied the effect of different storage techniques on bud opening (%), membrane stability index (MSI) and vase life (days) in two cultivars of rose (cv. Passion and Sunking) and concluded that among different storage techniques rose cut flowers packaged with polypropylene was found superior in maintaining minimum bud opening (0.89 %), higher MSI (88.63 %) and vase life (4.90 days) as compared to other storage techniques like butter paper packaged, wet storage (water and aluminum sulphate) and without any packaged cold stored (2°C) rose cut flowers.

Patel and Singh (2009) studied the effect of MA packaging films and storage temperature on physiological loss in weight (%) just after storage and total water uptake during vase life and concluded that significantly higher water uptake (123.3 ml) and minimum physiological loss in weight ratio (0.0) was found in the treatment P1 (PP). There significantly lower scape bending was also found at 5° C in P1 (PP) on 4th DAS. The jasmine flowers treated with boric acid 4 % and packed in polypropylene 60 μ or CFB boxes with 4 % vent then stored at a temperature and relative humidity of 7-8 °C and 80-85 % has extended the shelf life of flowers to 192.32 h (Thamaraiselvi *et al*. 2010).

Sharma *et al*. (2010) investigated various wrapping materials and storage durations on post harvest life of Asiatic hybrid lily cv. 'Apeldoorn' and reported that Wrapping of cut stems in butter paper, cellophane sheet and polyethylene sheet were found equally effective in improving the quality and extending the vase life of this cultivar. The wrapping material showed outstanding results for all parameters evaluated in the experiment. Storage of wrapped cut stem under a temperature of 4 degrees C up to 6 days did not affect the quality and vase life of cut stems.

Munsi *et al*. (2011) studied on Gladiolus cv. Sylvia packaging and reported that the percent floret display and vase life were higher in flowers wet packed with sucrose 4%, wrapped in polyethylene, up to 48 hours storage, even at ambient condition. However, for low temperature (10°C) storage, sucrose at 3% was more effective when wrapped with polyethylene. Sahare (2011) studied the effect of pre-storage pulsing and cold storage with poly films packaging on post storage quality and life of tuberose. He found significantly improved water uptake (ml), retained fresh weight (%), decreased respiration rate, increased per cent of total dissolve solids (oBrix), total soluble sugar level in florets tissue along with maintained catalase and peroxidase enzymatic activities and reduced electrolyte leakage (%) in florets tissue in pre-storage pulsing with solution containing 100mg/l TDZ +15% sucrose and 50mg/l α-lipoic acid + 15 sucrose for six hours as compare to control and followed by packaging with HDPE 40 μ.. He also found that the same treatment improved per cent floret opening, decreased abscission, decreased chilling injury. Maximum CO2 and O2 gas in packaging films and excellent overall quality with increase in vase life by (7 DAS) as compared to control (0 DAS).

Kumar *et al*. (2012) studied the effect of different chemicals and wrapping materials on post harvest life of cut rose cv. First Red and found that cut rose pulsed with Sucrose 5% + 8HQC 150 ppm for 20 h and packaged with butter paper for 16 h) recorded minimum loss in fresh weight, maximum flower diameter, water uptake and vase life (12.34 days). Gerbera cut flowers when packed with PP packaging and stored at 6°C recorded significantly negligible physiological loss in weight, absence of scape bending after storage, maintained higher water uptake, retained fresh weight with improved flower size during vase life with higher dry weight, membrane stability index (MSI) and total dissolved solutes (TDS) of petals, delayed the petal senescence and enhanced the vase life (Joshi, 2012).

Dastagiri *et al*. (2014) studied the effect of different wrapping material and cold storage durations (3, 6, 9 and 12 days) at 4°C on keeping quality of

Ornithogalum. Among different wrapping materials (polyethylene, newspaper, cellophane, butter paper, low density polyethylene (LDPE) and high density polyethylene (HDPE)), cellophane proved promising in improving the keeping quality of cut spikes. The keeping quality of unpackaged cold stored cut spikes was highly deteriorated and decreased with increase in storage duration. Cut stems wrapped in cellophane and stored recorded maximum water uptake with less number of unopened florets. This material further increased floret size and vase life of cut stems.

Srivastava *et al*. (2015) studied the efficacy of wrapping material on postharvest life of chrysanthemum cultivars Snowball Yellow and Snowball White reported that significant effect of wrapping material and storage condition were also observed on per cent weight loss, total water absorbed maximum flower diameter and vase life in both the cultivars. Wrapping of spikes in PP 200 gauge with refrigerated storage at 3-4 °C for 3 days + 6 hours of simulated transit (T_3S_2) resulted in minimum percent weight loss, maximum total water absorbed, flower diameter and maximum vase life in both the cultivars. Mahawar *et al*. (2015) Studied on polymeric packaging film on modified atmosphere storage of gladiolus cut spikes cv. White Prosperity reported that Polymeric sleeves exerted varying effect on keeping quality of spikes. Vase life was maximum in polypropylene-100 and minimum in low density polyethylene -200 gauge sleeves.

Trupti *et al*. (2016) studied the effect of different packaging films *viz*., PP (24μ), HDPE (28μ), LDPE (112μ) and control(without any packaging) and storage temperature *viz*., 5°C, 10°C and 15°C for a period of 7 days on flower quality and vase life of gerbera cut flowers cv. Savana Red. PP packaged gerbera cut flowers stored at lower temperature at 5ºC showed significantly negligible physiological loss in weight just after storage, maintained maximum water uptake (119.33 ml) and higher retention of fresh weight during vase life after storage as compared to all other treatments. Petal TSS(10.90°Brix) and MSI (87.48%) were also recorded higher in PP packaged cold stored gerbera (5ºC) which delayed the petal senescence and exhibited enhanced vase life (8.33 days) as compared to without packaged cold stored gerbera cut flowers. Flower quality in terms of flower diameter(10.57 cm), percent opening of disc florets(13.33%), absence of scape bending curvature as well as overall quality graded on visual basis were also higher in gerbera cut flowers stored at (5ºC) with PP packaging.

Shalini *et al* (2017) investigated the effect of long term modified atmosphere storage on gladiolus spikes. The spikes of gladiolus cv. Alexander the Great, harvested at tight bud stage, were treated with sucrose (20%) + aluminum sulphate (300 ppm) for 20 h followed by sealing in LDPE and PP sleeves (25 μm) with and without perforations and stored vertically at 3-4°C for 0, 6, 12 and 18 days. After storage, vase-life was evaluated. The basal florets opened in all sleeves after 18 days of storage. Increase in storage duration hastened the opening of basal florets, whereas packaging did not affect significantly. Vase-life, opening of florets (%), floret diameter and physiological weight declined with increase in storage duration. Harsimran *et al*. (2018) experimented on spikes of four cultivars of gladiolus viz. Jacksonville Gold, White Prosperity, Sancerre and Nova Lux to modified atmosphere (MA) storage in polypropylene (PP) and low density polyethylene (LDPE) film sleeves and reported that spikes stored in PP packages exhibited higher vase life and floret opening than those stored in LDPE packages.

Mahawer *et al* (2019) experimented on response of storage duration and packaging materials under passive modified atmosphere storage of tuberose cut spikes cv. Suvasini. The cut spikes were packed in five wrapping materials (LDPE-25μ, 50μ, PP-25μ, 50μ and news paper wrapping served as control) reported that Polypropylene sleeves exerted varying effect on keeping quality of spikes. Vase life was maximum in polypropylene-25µ (11.64 days) and minimum in low density polyethylene 50µ sleeves. The keeping quality of unpackaged stored tuberose cut spikes was highly deteriorated. The spikes stored in polypropylene-25µ with 3 days storage level also showed highest basal florets diameter (3.55 cm), vase life (11.64 days), gain in fresh weight (7.72%) and water uptake (34.39 ml), which continued to decrease with increase in storage duration irrespective to packaging material.

MATERIALS AND METHODS

The present investigation entitled, **“Standardization of planting time, zinc and boron nutrition and vase life of *Gladiolus primulinus* cv. Candyman”** was carried out in three different experiments during October 2016 to December 2018, the plan of work is describe below.

3.1 General

3.1.1 Experimental sites

The field experiments were conducted at the Horticulture Farm, School of Agricultural Sciences and Rural Development, Medziphema, Nagaland. The institution is located at 25°45′ 43″ N latitude and 93° 53′ 04″ E of longitude at an elevation of 305m above mean sea level. Postharvest studies and analysis was carried out in post harvest laboratory of the department.

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 2016 to December 2018 were given in table 3.1

3.1.3 Soil

The soil of the experimental field was found to be well drained and sandy loam in texture. Soil samples were collected from the experimental plots at random location at the depth of 15 cm with the help of screw type auger. The collected samples were mixed thoroughly and reduced to 500g and the sample is dried and sieved which was used for analysis of soil pH, organic carbon, available nitrogen, phosphorus potassium, zinc and boron before the start of field experiments and the results obtained are presented in table 3.2

Table 3.1 Meteorological data recorded during the period of investigation

Month	2016					2017					2018				
	Temperature (°C)		Relative humidity (%)		Rainfall	Temperature (°C)		Relative humidity (%)		Rainfall	Temperature (°C)		Relative humidity (%)		Rainfall
	Max	Min	Max	Min	(mm)	Max	Min	Max	Min	(mm)	Max	Min	Max	Min	(mm)
January	-	-	-	-	-	25.0	8.7	94	49	0.0	23.7	9.6	97	63	0.7
February	-	-	-	-	-	28.2	10.4	93	42	0.0	26.1	10.8	97	54	0.2
March	-	-	-	-	-	28.2	14.0	93	47	4.1	30.2	14.5	95	49	1.0
April	-	-	-	-	-	29.2	19.2	90	58	7.5	31.6	18.1	94	55	2.38
May	-	-	-	-	-	31.4	21.5	91	65	3.6	31.7	21.2	94	65	4.5
June	-	-	-	-	-	31.6	23.8	93	72	9.3	33.4	24.2	94	73	11.8
July	-	-	-	-	-	31.4	24.4	94	75	15.7	33.2	24.9	92	72	8.0
August	-	-	-	-	-	32.0	24.7	93	72	15.9	33.5	24.9	94	71	10.1
September	32.5	23.9	93.8	72.7	9.5	31.6	24.5	95	74	7.9	33.6	23.9	94	67	3.9
October	31.6	21.8	93.8	69.7	1.1	30.3	22.0	95	75	4.2	29.9	20.1	96	67	2.1
November	27.8	15.8	94.7	64.1	4.4	28.1	16.3	96	63	0.5	28.2	14.1	97	54	0.5
December	26.9	11.2	94.3	53.6	0.0	25.5	12.3	96	66	1.0	24.6	11.0	96	56	1.6

(Source: ICAR Research Complex for NEH Region, Jharnapani Nagaland Centre

Table 3.2: Initial soil fertility status of experimental plots

Parameters	Value	Status	Method employed
pH	4.78	Acidic	Digital pH meter (Single electrode meter)
Organic carbon (%)	1.75	High	Walkley and Black Method, (Piper, 1966)
Available N(kg ha-1)	239.4	Medium	The Alkaline – potassium permanganate method (Subbiah and Asija, 1956)
Available P(kg ha-1)	17.2	Medium	Bray and Kurtz method, 1945
Available K (kg ha-1)	218.6	Medium	Flame photometer (Hanway and Heidal,1952)
Available Zn(mg/kg)	0.82	Low	Atomic Absorption Spectrophotometer
Extractable B(mg/kg)	0.43	Low	HWT using Azomithene (Page *et al*. 1982)

3.2 Experimental details

3.2.1 Experiment No. 1: Studies on effect of planting time on performance of gladiolus.

3.2.1.1 Experimental design

The experiment was laid out in Randomized Block Design with 12 treatments and replicated three times. The unit plot size was 0.96 m^2. The corms were planted in line with a spacing of 20 cm between the rows and 30 cm between the corms. There were four plants in each line. The treatments were allocated randomly to a unit plot in each replication. The layout of the experimental field was shown in the Fig. 3.1

3.2.1.2 Details of experiments

Design of experiment	: RBD (Randomized Block Design)
Number of treatment	: 12
Number of replication	: 3
Total number of plots	: 36
Spacing	: 30 cm × 20 cm
Length of each plot	: 1.2 m
Width of each plot	: 0.8 m
Area of each plot	: 0.96 m^2
Number of plants in each plot	: 16
Total area	: 54.18 m^2

3.2.1.3 Details of treatment notations and Treatments (planting time)

T_1: January, **T_2:** February, **T_3**: March, **T_4**: April, **T_5**: May, **T_6**: June, **T_7**: July, **T_8**: August, **T_9**: September, **T_{10}**: October, **T_{11}**: November and **T_{12}**: December.

Planting time was taken as treatment which was done on middle (date 15) of every month.

3.2.1.4 Planting materials

The material used for the experiments was *Gladiolus primulinus* cv. Candyman which were maintained at Department of Horticulture, School of Agricultural Sciences and Rural Development, Medziphema, Nagaland. Planting materials (corms) of fairly uniform size and showing sprouted tips which are healthy and disease-free having diameter of 5-6 cm were selected. Also corms were procured from a reliable commercial nursery in Kalimpong (West Bengal) from time to time. The harvested corms from experiments along with extra corms from procured consignment were also stored in cold storage at Integrated Cold Chain Project (ICCP) – Mao Manipur. The corms for the subsequent trials were also taken from the previous season corms which have broken its dormancy and started to show sprouted tips.

3.2.1.5 Field preparation

The selected field was firstly given deep ploughed with disc plough and weeds were also removed. After that the soil was brought to a comparatively fine tilt with the help of cultivator followed by planking to level the land. The individual plots were raised.

3.2.1.6 Manure and fertilizer application

Basal dose of 2 kg, well rotten farm yard manure per plot was incorporated in the field during plot preparation. A constant dose of P_2O_5 (200 kg/ha) in the form of SSP and K_2O (200 kg/ha) in the form of MoP were applied. Nitrogen was applied in the form of urea at the constant dose of 200 kg/ha. Full dose of phosphorus and potassium were applied at the time of planting. Whereas nitrogen was applied in two equal split doses at 3 and 6 leaf stages respectively.

3.2.1.7 Planting

The selected corms were cleaned and its scales removed prior to planting and dipped in 0.2% Bavistin solution for 15 minutes and dried under shade. Corms were planted in line at a depth of 5-6 cm on the raised beds by maintaining uniform spacing of 20 × 30 cm between row and plants respectively.

3.2.1.8 Intercultural operations

The experimental area was kept weed free throughout the cropping period by manual weeding. Cultural operations were uniformly done for all the treatments.

3.2.1.9 Irrigation

Light irrigation was given immediately after sowing. After sprouting of corms, irrigation was given at three to four days interval during dry seasons in the evening hours and no irrigation were needed during rainy season.

3.2.1.10 Weeding

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

3.2.1.11 Top dressing

Top-dressing of urea was done at 3 leaf stage and 6 leaf stage by applying around the plants but ensuring a safe distance and deep from the plants and mixed with the soil by hand. Earthing up was done with the help of khurpi and irrigation was followed.

3.2.1.12 Plant protection

There was no remarkable incidence of disease and pest and insecticides and fungicides were not used during the investigation. Leaf caterpillar was the most common pest and was managed by handpicking. Staking of the plants was done at the time of spike emergence to provide mechanical support to prevent toppling and produce upright spikes.

3.2.1.13 Harvesting of spikes

Flower spikes were harvested when the lower most floret in the spike starts to unfurl. Harvesting was done during the cool morning hours using a sharp knife and harvested spikes were immediately placed in bucket filled with water. The harvested spikes were taken to laboratory for postharvest studies.

3.2.1.14 Lifting of corms and cormels

The maturity of corms is identified by yellowing of leaves and wilting of plants. The corms and cormels were lifted 60 days after flowering. The corms are lifted with the help of garden spade taking utmost care so as not to induce mechanical injury to the corms. The infected and injured corms and cormels, soil and debris were removed. The corms are then dried in shade for about a week or two depending on the weather condition.

3.2.1.15 Vase life studies

Three spikes having fairly uniform stage of flowering were selected from each plot. They were cut at uniform length of 80 cm and kept in conical flask containing distilled water for post harvest studies.

3.2.2 Experiment no. 2: Studies on effect of zinc and boron on performance of gladiolus.

3.2.2.1 Experimental design

The experiment was laid out in Randomized Complete Block Design with 9 treatments and replicated three times. The unit plot size was 0.96 m^2. The corms were planted in line with a spacing of 20 cm between the rows and 30 cm between the corms. There were four plants in each line. The treatments were allocated randomly to a unit plot in each replication. The layout of the experimental field was shown in the Fig. 3.2

3.2.2.2 Details of experiments

Crop name	: *Gladiolus primulinus* cv. Candyman
Design of experiment	: RCBD (Randomized Complete Block Design)
Number of treatment	: 9
Number of replication	: 3
Total number of plots	: 27
Spacing	: 30 × 20 cm
Length of each plot	: 1.2 m
Width of each plot	: 0.8 m
Area of each plot	: 0.96 m^2
Number of plants in each plot	: 16
Total area	: 43.2 m^2

3.2.2.3 Details of treatments

Three levels of zinc at 0%, 0.2% and 0.4% and three levels of boron at 0%, 0.2% and 0.4% and their treatment combination was taken for studies as indicated below.

T_1- Control (Distilled water)

T_2- Zn1B0 ($ZnSO_4$ 0.2%)

T_3- Zn2B0 ($ZnSO_4$ 0.4%)

T_4- Zn0B1 (H_3BO_3 0.2%)

T_5- Zn0B2 (H_3BO_3 0.4%)

T_6- Zn1B1 ($ZnSO_4$ 0.2% + H_3BO_3 0.2%)

T_7- Zn1B2 ($ZnSO_4$ 0.2% + H_3BO_3 0.4%)

T_8- Zn2B1 ($ZnSO_4$ 0.4% + H_3BO_3 0.2%)

T_9- Zn2B2 ($ZnSO_4$ 0.4% + H_3BO_3 0.4%)

3.2.2.4 Planting time and Cultural practices

Planting was done 5^{th} October 2016 for first year trial and second year trial on same date of 2017. Cultural practices were followed as mentioned in experiment 1.

3.2.2.5 Methods of application

Zinc was given in form of zinc sulphate ($ZnSO_4$) and boron in form of boric acid (H_3BO_3) through foliar application at 3 leaf stage and 6 leaf stages as per their treatments and distilled water was sprayed in case of control treatment

3.2.2.6 Selection of plant for observation

In a field experiment, detail study of the entire population is rather difficult. Therefore, five plants were selected at random from each plot and tagged for recording the observations of field data for growth, flowering, cormel and yield parameters while three random floral spikes from each plot were selected for post harvest studies.

3.2.2.7 Observations

The technique of random sampling was adopted for recording the observations of various characters of gladiolus. The observations for both experiment no.1 and experiment no.2 were recorded on five sample plants categorized into four: Growth parameter, flowering parameter, post harvest parameter and cormel yield parameter. However, in experiment no.2, days to 50% corm sprouting was not taken into account. Important characters were meticulously noted and samples were randomized to reduce error. Data obtained were averaged replication wise and mean data was used for statistical analysis.

3.2.2.8 Growth parameters

1. **Days to 50% corm sprouting**

Sprouting is taken when the shoots emerged above the soil surface and show green colour. Days to 50 per cent corm sprouting was taken when half of the corms were sprouted and mean value was expressed in days.

2. **Days to first leaf emergence**

Days to first leaf emergence was taken when the true leaves emerged and mean value was expressed in days.

3. **Number of leaves per hill**

The total number of leaves was counted at the time of spike emergence and mean value was calculated.

4. **Length of longest leaf**

The longest leaf among the plant was measured using measuring tape from the base to the tip at the time of spike emergence and mean value was expressed in centimeter.

5. **Width of longest leaf**

It was taken from the mid region with the help of measuring tape at the time of spike emergence and mean value was expressed in centimeter.

6. **Leaf area**

Sample leaves were cut to desirable length and plotted against graph paper and areas covered were counted and calculated mean was expressed in square centimeter.

7. **Leaf area index**

Leaf area index was calculated using the formula

$$\text{Leaf area index (L.A.I.)} = \frac{\text{Leaf area}}{\text{Plant spacing}} \times \text{No. of leaves per plant}$$

8. **Plant height**

Plant height was measured from the ground level to the tip of plant at the time of spike emergence with the help of meter scale and mean was expressed in centimeter.

3.2.2.9 Flowering parameters

1. **Days to spike emergence**

Days to spike emergence was counted from the date of planting to the date of flower bud initiation which is spike emergence and mean was recorded.

2. **Days to colour break**

Days to colour break of 1st, 3rd, and 5th florets were counted from the date of planting to the date when the florets starts to show colour after the petals emerged from covered bracts. The date when the 1st, 3rd, and 5th florets show colours were noted carefully and mean value was expressed in day.

3. **Length of spike**

Spike length was measured from the base of last upper fourth leaves to the tip of spike when the 5th floret opened and the mean value was expressed in centimeter.

4. **Length of rachis**

Length of rachis was measured from the first floret node till the last floret with the help scale and mean value was noted in centimeter.

5. **Number of florets per spike**

Total number of florets in each spike were counted and recorded on mean basis.

6. **Days to opening of florets**

Days to opening of 1st, 3rd, and 5th florets were counted from the date of planting to the date when the florets starts to unfurl. The date when the 1st, 3rd, and 5th florets unfurl were noted carefully and mean value was expressed in day.

7. **Diameter of florets**

The diameter of 1st, 3rd, and 5th florets were carefully recorded at full bloom using vernier calliper and mean value expressed in centimeter.

8. **Days to floret withering**

Days to withering was counted from the date of floret opening to the date the same floret withered. The 1st, 3rd and 5th florets were carefully observed from the opening till senescence of the same and the mean value was given in day.

9. **Self life**

Self life was taken as the flowering duration of spikes in field condition. The duration of flowering from the date of first floret opened till 75 per cent of the florets senescence was carefully observed and mean value was work out.

3.2.2.10 Postharvest parameters

1. **Weight of spike**

Weights of individual spike were taken on 1st, 3rd, 6th, and 9th day and mean value recorded in gram.

2. **Length of spike**

Lengths of individual spike were measured on 1st, 3rd, 6th and 9th day and mean value expressed in centimeter.

3. **Days to opening of 50% florets**

This can be taken as full bloom stage. It was noted on the day when 50 per cent of florets in the spike opened.

4. **Diameter of florets**

The diameter of 1st, 3rd, and 5th florets were carefully recorded at full bloom using vernier calliper and mean value expressed in centimeter.

5. **Longevity of florets**

Longevity was taken as the duration of floret opening till senescence. The 1st, 3rd and 5th florets were carefully observed from the opening till senescence of the same and the mean value was given in day.

6. **Number of florets opened at a time**

Maximum number of florets opening at a specific time during the postharvest studies was noted and means value was calculated.

7. **Solution uptake**

Solution uptake was estimated by measuring the vase solution on initial day and at the end of the vase life using volumetric flask and the differences in volume was expressed in milliliter.

8. **Vase life**

Vase life was counted from the first day of postharvest life till 75 per cent of the florets senescence and mean value expressed in day.

3.2.2.11 Yield parameters

1. **Number of corms per hill**

Number of corms per hill was counted from each sample plants and mean was recorded.

2. **Weight of corms per hill**

Individual corm weight was taken from all the sample plants and mean valued expressed in gram.

3. **Diameter of corm**

Diameters of the corms were measured using vernier calliper and mean valued expressed in centimeter.

4. **Number of cormels per hill**

The cormels from each sample plants were counted and mean valued was work out.

5. **Weight of cormels per hill**

Cormels from each plant were weighted and mean value expressed in gram.

3.2.2.12 Statistical analysis

The experimental data recorded during the period of investigation was statistically analyzed adopting the procedure of analysis of variance method (Panse and Sukhatme, 1985) and the treatment variance was be tested against error mean square by applying Fischer Snedecore 'F' test at 5 % level of significance. For comparison among treatment contrasts, Standard Error of Mean was computed as-

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

Critical Difference (CD) at 5% level of significance was computed as-

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

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

3.2.3 Experiment No.3: Studies on effect of different wrapping materials on vase life of gladiolus.

Crop name: *Gladiolus primulinus* cv. Candyman

Design of experiment: CRD

Number of treatment: 7

Number of replication: 3

3.2.3.1 Treatment details

T_1- Control

T_2- Newspaper

T_3- Perforated plastic

T_4- Non-perforated plastic

T_5- Shrink wrap

T_6- Butter paper

T_7- Brown paper

3.2.3.2 Methodology

The flowers were grown separately in the month of April following recommended cultivation practices. Postharvest studies were done in the month of June. The spikes were harvested when the basal floret starts to unfurl and were immediately placed in bucket containing clean water. The harvested spikes were then brought to postharvest laboratory for further investigations. The stem ends of the spikes were trimmed to a uniform length of 70 cm. Three numbers of spikes were taken per replication as per the treatments details. Also wet cotton balls were tied to the end of the spikes which were put into buckets in upright positions to prevent geotropism and kept for 48 hours followed by postharvest quality studies in conical flask.

3.2.3.3 Observations recorded

1. Fresh weight of spike

Weights of individual spike were taken on 1st, 3rd, 6th, and 9th day and mean value recorded in gram.

2. **Length of spike**

Lengths of individual spike were measured on 1st, 3rd, 6th and 9th day and mean value expressed in centimeter.

3. Length of rachis

Length of rachis was noted on 1st, 3rd, 6th, and 9th day by measuring from the first floret node till the last floret with the help scale and mean value was noted in centimeter.

4. Days to opening of 3rd and 5th florets

These florets can be considered as the index florets of the spikes as this indicates the quality and performance of the spikes. The opening of 3rd and 5th florets was observed carefully and noted mean value was given in days.

5. Days to opening of 50% florets

This can be taken as full bloom stage. It was noted on the day when 50 per cent of florets in the spike opened.

6. Diameter of florets

The diameter of 1st, 3rd, and 5th florets were carefully recorded at full bloom using vernier calliper and mean value expressed in centimeter.

7. Longevity of florets

Longevity was taken as the duration of floret opening till senescence. The 1st, 3rd and 5th florets were carefully observed from the opening till senescence of the same and the mean value was given in day.

8. Number of florets opened at a time

Maximum number of florets opening at a specific time during the postharvest studies was noted and means value was calculated.

9. Number of unopened florets

Numbers of unopened florets at the end of vase life was counted and mean value was taken.

10. Water uptake

The amount of water uptake by the spikes was estimated by taking the differences in weight between consecutive measurements of the conical flask + solution (without the spikes). The mean value thus obtained on 3rd, 6th and 9th day was expressed in gram.

11. Water loss

The amount of water loss was estimated by taking the differences in weight between consecutive measurements of the conical flask + solution + spikes. The mean value thus recorded on 3rd, 6th and 9th day was expressed in gram.

12. Vase life

Vase life was counted from the first day of spikes in conical flask till 75 per cent of the florets senescence and mean value expressed in day

3.2.3.4 Statistical analysis

The experimental data recorded during the period of investigation was statistically analyzed adopting the procedure of analysis of variance method (Panse and Sukhatme, 1985) and the treatment variance was be tested against error mean square by applying Fischer Snedecore 'F' test at 5 % level of significance. For comparison among treatment contrasts, Standard Error of Mean was computed as-

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

Critical Difference (CD) at 5% level of significance was computed as-

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

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

RESULTS AND DISCUSSIONS

The results of the present investigation entitled **"Standardization of planting time, zinc and boron nutrition and vase life of *Gladiolus primulinus* cv. Candyman"** which was carried out in three different experiments to studied the effect of planting dates and foliar application zinc and boron on performance of gladiolus and effect of wrapping on vase life attributes of cut gladiolus spikes are embodied and explained in this chapter. The results obtained from the present investigation are discussed using probable causes and effects of analysis in the light of available relevant literature.

4.1 Experiment No. 1

The first experiment entitled "**Studies on effect of planting time on performance of gladiolus"** the results pertaining to various parameters studied were discussed under following major heads

1. Growth parameters

2. Flowering parameters

3. Postharvest parameters

4. Yield parameters

4.1.1 Growth parameters

The progressive data recorded on growth parameters *viz*. days to sprouting, days to first leaf emergence, number of leaves per plant, length of longest leaf, width of longest leaf, leaf area, leaf area index and plant height as affected by various treatments, have been elaborately discussed below.

4.1.1.1 Days to sprouting

The data pertaining to days to sprouting as influenced by different treatments has been presented in table 4.1. It is evident from the results that there was significant difference for time taken to sprouting of corms as influence by different planting time. The variation in the days to sprouting ranged from 7.13 days to 12.27 days in 2016-17 and 6.93 days to 12.13 days in 2017-18. From the pooled data, it is observed that minimum days to sprouting is recorded in T_6 at 7.03 days and maximum from T_{12} with 12.20 days. However, T_1 and T_{11} planting also show late sprouting 11.97 days and 11.53 days respectively. Whereas, T_7, T_5 and T_8 shows early sprouting at 7.27 days, 7.37 days and 7.90 days respectively. Also T_7 (7.27 days) and T_5 (7.37 days) were statistically at par, so is T_{10} (8.97 days) and T_4 (9.13).

The results of the experiment revealed that there is a significant difference between different treatments. This may be attributed to the prevailing environmental conditions during plantings time. This indicates that temperature, humidity and duration of sunshine hours greatly influence days to sprouting of corms. The average temperature for T_6 is around 27°C which is suitable for growth and development of most plants including gladiolus. However, the temperature for T_{12} falls below 10°C as a result of low atmosphere and soil temperature, growth and development is slower when compared to T_6. Also to mention that the planting materials used were already a sprouted corms of uniformity. Therefore the chilling temperature required to break the corm dormancy were already overcome and not taken into account. This finding were in line with the results of Sudhakar and Ramesh (2015) who reported days to sprouting has positive correlation with weather parameters. Sheikh and Jhon (2005) reported minimum days to sprouting from May planting. Similar findings by Ahmad *et al*. (2011) also reported that early sprouting was observed from delayed planting for kharif season crop. Thakur *et al*. (2015) also reported early sprouting from October planting when compared to November and December planting. Khutiya (2016) reported earliest sprouting observed from July planting.

4.1.1.2 Days to first leaf emergence

Data presented in table 4.1 revealed significant difference between treatments with regards to days to first leaf emergence. The result clearly shows that days to leaf emergence directly follow days to sprouting. The variation in the days to leaf emergence ranged from 9.73 days to 15.13 days in 2016-17 and 9.67 days to 15.07 days in 2017-18. From the pooled data, it is observed that T_6 took the minimum days of 9.70 to leaf emergence while T_{12} recorded maximum days (12.20) to leaf emergence. However, T_1 and T_{11} planting also took longer time to leaf emergence, 14.90 days and 14.23 days respectively. Whereas, T_7, T_5 and T_8 shows early leaf emergence at 9.97 days, 10.10 days and 10.70 days respectively. Also T_7 (9.97 days) and T_5 (10.10 days), and T_{10} (11.70 days) and T_4 (11.73 days) were statistically at par.

From the experimental result, it is clearly observed that days to sprouting and days to leaf emergence are closely related. The very fact that sprouting is sheathe leaves emerging from the corms which will eventually develops in to individual leaf. Therefore, the inference for days to leaf emergence can be drawn from the days to sprouting.

4.1.1.3 Number of leaves per hill

The experimental result for number of leaves per hill has been presented in table 4.1. From the given result, it is clear that there was significant difference between different treatments. However, the variations are small and many treatments recorded similar readings. The variation in the number of leaves ranged from 8.87 to 9.60 in 2016-17 and 8.93 to 9.53 in 2017-18. The pooled data from both the years revealed that maximum number of leaves was obtained from T_{10} (9.57) which is closely followed by T_9 (9.43). Also same value were recorded from T_8 (9.37) and T_{11} (9.37) which is statistically at par with T_9 (9.43). Moreover, T_3 (9.17), T_{12} (9.20) and T_4 (9.23) were statistically at par. T_2 and T_5 were also statistically at par with 9.03 and 9.07 respectively. T_1, T_6 and T_7 exhibited minimum number of leaves (8.90).

The results of the study revealed that winter planting performed better when compared to summer planting with regards to number of leaves per plant. This may be attributed to nature of plant, the genetic makeup of the plant and their response to different prevailing environmental condition during the growth and development of the plant. The vast differences in environmental factors like temperature, humidity, sunshine hour and light intensity has big role to play in growth and development of any plants in generals and gladiolus in particular. Therefore, taking this into consideration, gladiolus is considered as winter crop although it can be grown round the years in mild environment condition like Nagaland, but the best performance is produced in winter season. This result were supported by many researchers with similar findings, to mention some, Kour (2009) reported maximum number of leaves (10.58) were observed with 15th October planting. Ahmad *et al*. (2011) also supported spring planting. This finding was in conformity with Kumari *et al*. (2011), Rathod *et al*. (2011), Suman *et al*. (2011) and Ramzan *et al* (2014) in gladiolus reported maximum number of leaves from October planting.

Table 4.1: Effect of planting time on days to sprouting, leaf emergence and no. of leaf

parameters	Days to sprouting			Days to first leaf emergence			No. of leaves per plant		
Treatment	**1st Year**	**2nd Year**	**Pooled**	**1st Year**	**2nd Year**	**Pooled**	**1st Year**	**2nd Year**	**Pooled**
T_1	12.00	11.93	11.97	14.93	14.87	14.90	8.93	8.87	8.90
T_2	10.87	10.73	10.80	13.73	13.67	13.70	9.00	9.07	9.03
T_3	9.93	9.67	9.80	12.67	12.60	12.63	9.13	9.20	9.17
T_4	9.27	9.00	9.13	11.80	11.67	11.73	9.27	9.20	9.23
T_5	7.40	7.33	7.37	10.13	10.07	10.10	9.07	9.07	9.07
T_6	7.13	6.93	7.03	9.73	9.67	9.70	8.87	8.93	8.90
T_7	7.33	7.20	7.27	10.00	9.93	9.97	8.87	8.93	8.90
T_8	7.87	7.93	7.90	10.73	10.67	10.70	9.40	9.33	9.37
T_9	8.60	8.47	8.53	11.27	11.20	11.23	9.47	9.40	9.43
T_{10}	9.00	8.93	8.97	11.73	11.67	11.70	9.60	9.53	9.57
T_{11}	11.73	11.33	11.53	14.33	14.13	14.23	9.33	9.40	9.37
T_{12}	12.27	12.13	12.20	15.13	15.07	15.10	9.20	9.20	9.20
Sem±	**0.10**	**0.07**	**0.06**	**0.07**	**0.05**	**0.04**	**0.06**	**0.06**	**0.04**
CD at 5%	**0.29**	**0.21**	**0.17**	**0.21**	**0.15**	**0.13**	**0.18**	**0.19**	**0.12**

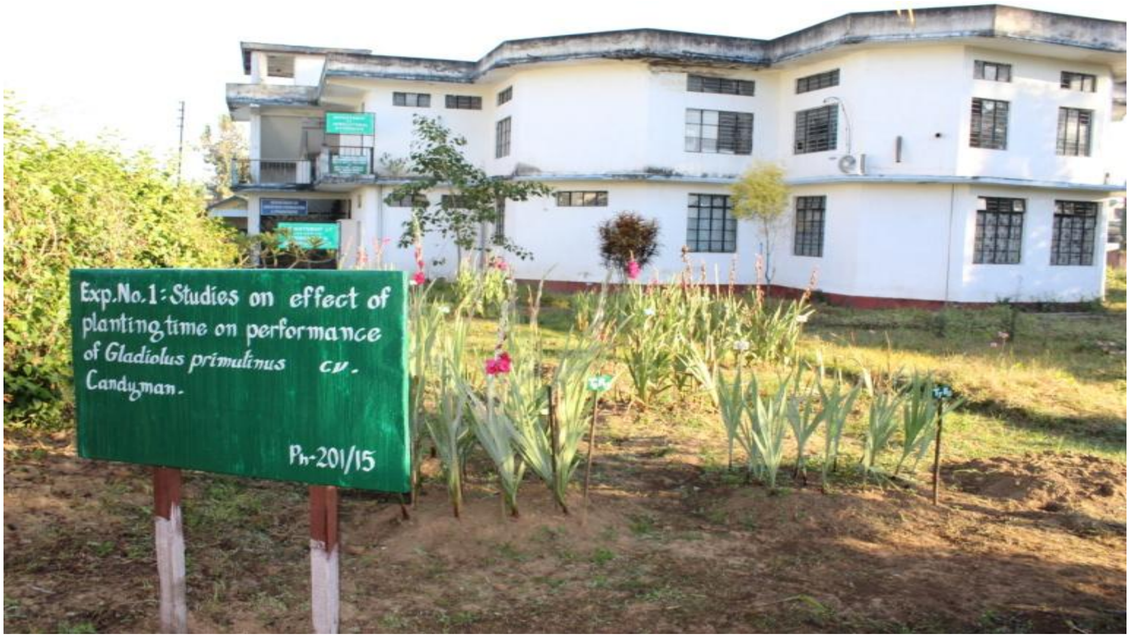

Plate 1. General view of experimental field showing different stages of growth

4.1.1.4 Length of longest leaf

The data pertaining to length of longest leaf as influenced by different treatments has been presented in table 4.2. From the given result it is clear that there was significant difference between different treatments. The variation in length of longest leaf ranged from 55.33 cm to 64.00 cm in 2016-17 and 54.83 cm to 63.00 cm in 2017-18. From the pooled data, it is observed that minimum leaf length (55.08cm) is recorded in T_6 which was closely followed by T_7 (55.50 cm) and maximum leaf length (63.50 cm) from T_{10}, closely followed by T_9 (62.33 cm). T_3 (59.33 cm), T_4 (59.83 cm and T_5 (59.92 cm) were statistically at par. Also T_2 (58.80 cm) and T_{12} (58.17 cm) were statistically at par. Moreover, T_8 and T_{11} recorded close reading with 60.83 and 61.00 respectively which were statistically at par.

It is evident from the present investigation that different planting times have different effect on the growth attributes such as days to sprouting, number of leaves and length of longest leaf in gladiolus. Inference can be drawn from the result that early winter planting performed better compared to summer and late winter planting with reference to leaf length. It may also be noted that prevailing environmental factors greatly influences the vegetative growth such as leaf length. Therefore, due to different environmental factors prevailing during the growing periods of the plant resulted into differences in leaf length. This finding was also advocated by Kour (2009), Sudhakar and Ramesh (2015) and Kamal *et al*. (2018) in gladiolus.

4.1.1.5 Width of longest leaf

Analysis of the experimental data presented in table 4.2 showed significant difference among the treatments in both the years of investigation. The variation in width of longest leaf ranged from 3.17 cm to 3.57 cm in 2016-17 and 3.13 cm to 3.50 cm in 2017-18. From the pooled data of both the year, it is observed that minimum width of leaves was recorded in T_6 (3.17 cm) and closely followed by T_7 (3.23 cm) and T_5 (3.25 cm) which were statistically at par. Maximum width of leaves was recorded from T_{10} (3.53 cm) closely followed by T_2 (3.45 cm), T_{11} (3.45 cm), T_3 (3.43 cm) and T_4 (3.42 cm) which were statistically at par.

It is evident from the present investigation that different planting times have different effect on the growth attributes such as days to sprouting, number of leaves, length and width of longest leaf in gladiolus. Inference can be drawn from the result that early winter planting performed better compared to summer and late winter planting with reference to width of leaves. It may also be noted that prevailing environmental factors greatly influences the vegetative growth such as width of leaves. Therefore, due to different environmental factors prevailing during the growing periods of the plant resulted into differences in width of leaves. This finding was in accordance with the results of Kour (2009), Sudhakar and Ramesh (2015) and Kamal *et al*. (2018) in gladiolus.

4.1.1.6 Leaf area

Table 4.2 clearly depicts the experimental result pertaining to leaf area which showed significant difference between treatments.

It is evident from the presented data that maximum leaf area was recorded from T_{10} with 122.32 cm^2 and minimum from T_6 with 142.22 cm^2. During the first year trial, maximum leaf area was recorded from T_{10} (143.42 cm^2) whereas, T_6 recorded minimum with 122.61 cm^2. T_1 (130.86 cm^2), T_2 (133.38 cm^2),

Table 4.2: Effect of planting time on length, width and leaf area

parameters	Length of longest leaf (cm)			Width of longest leaf (cm)			Leaf area (cm^2)		
Treatment	**1st Year**	**2nd Year**	**Pooled**	**1st Year**	**2nd Year**	**Pooled**	**1st Year**	**2nd Year**	**Pooled**
T_1	57.67	56.83	57.25	3.30	3.40	3.35	130.86	131.42	131.14
T_2	59.00	58.00	58.50	3.47	3.43	3.45	133.38	129.86	131.62
T_3	59.17	59.50	59.33	3.40	3.47	3.43	131.18	132.48	131.83
T_4	59.83	59.83	59.83	3.40	3.43	3.42	132.23	132.75	132.49
T_5	60.50	59.33	59.92	3.37	3.13	3.25	127.81	125.18	126.50
T_6	55.33	54.83	55.08	3.17	3.20	3.18	122.61	122.02	122.32
T_7	55.50	55.33	55.42	3.23	3.23	3.23	129.44	128.23	128.83
T_8	60.83	60.83	60.83	3.37	3.40	3.38	132.99	131.97	132.48
T_9	62.17	62.50	62.33	3.33	3.40	3.37	138.39	139.24	138.81
T_{10}	64.00	63.00	63.50	3.57	3.50	3.53	143.42	141.02	142.22
T_{11}	61.33	60.67	61.00	3.43	3.47	3.45	138.99	137.77	138.38
T_{12}	58.50	57.83	58.17	3.43	3.33	3.38	135.19	134.35	134.77
Sem±	**0.47**	**0.60**	**0.38**	**0.05**	**0.06**	**0.04**	**0.87**	**0.77**	**0.58**
CD at 5%	**1.39**	**1.76**	**1.09**	**0.13**	**0.19**	**0.11**	**2.54**	**2.26**	**1.65**

T_3 (131.18 cm^2), T_4 (132.23 cm^2) and T_8 (132.99 cm^2) were statistically at par. During second year trail, maximum leaf area was recorded from T_{10} (141.02 cm^2)

The pooled data from both the years revealed the maximum leaf area in T_{10} (142.22 cm^2) followed by T_9 (138.81 cm^2) and T_{10} (138.38 cm^2). Whereas minimum was observed from T_6 (122.32 cm^2) followed by T_5 (126.50 cm^2). Also, T_1, T_2, T_3, T_4 and T_8 were statistically at par with 131.14 cm^2, 131.62 cm^2, 131.83 cm^2, 132.49 cm^2, and 132.48 cm^2, respectively.

Amongst the different planting time investigated during the studies, it was observed that winter planting performed better in all vegetative parameters like leaf length, leaf width and leaf area. T_{10} gives the best result with T_9 closely behind which may be attributed to different environmental factors prevailing during the growth period of plant. This finding is in close conformity with Kour (2009), Ahmad *et al*. (2011), Rathod *et al*. (2011), Suman *et al*. (2011) and Ahmad *et al*. (2014).

4.1.1.6 Leaf area index

The data pertaining to leaf area index as influenced by different treatments has been presented in table 4.3. It is evident from the results that there was significant difference for leaf area index as influence by different planting time. Maximum leaf area index was recorded in T_{10} with 1.82 and 1.77 for 2016-17 and 2017-18 respectively. Also minimum leaf area index was recorded in T_6 with 1.40 and 1.41 for 2016-17 and 2017-18 respectively. From the pooled data it is observed that minimum leaf area index is recorded in T_6 at 1.41 and maximum from T_{10} with 1.80.

Amongst the different planting time investigated during the studies, it was observed that winter planting performed better with regards with vegetative parameters like leaf length, leaf width, leaf area and area index. As the spacing between plants are constant across treatments, the result for leaf area index is clearly understood from the total leave area of the plant. T_{10} gives the best result with T_9 closely behind which may be attributed to different environmental factors prevailing during the growth period of plant. This finding is in close conformity with Kour (2009), Ahmad *et al*. (2011), Rathod *et al*. (2011), Suman *et al*. (2011) and Ahmad *et al*. (2014).

4.1.1.7 Plant height

The data recorded for plant height is presented in table 4.3. The perusal of the data of 2016-17 indicated that T_{10} recorded maximum plant height (88.40 cm) which is followed by T_9 (86.07 cm) and T_2 (84.87 cm). Minimum plant height was recorded in T_6 (73.47 cm) which is closely followed by T_7 (74.13 cm) and statistically at par.

In 2017-18 maximum plant height was observed in T_{10} (89.00 cm) and minimum was observed in T_6 (74.27 cm). Similar trend were followed from previous year in all treatments. Pooled analysis of the two years data showed that maximum plant height was observed from T_{10} (88.70 cm) followed by T_9 (86.40 cm) and T_2 (85.33 cm). Minimum plant height was recorded from T_6 (73.87 cm) followed by T_7 (74.67 cm) which were statistically at par. Also T_3, T_4 and T_5 were statistically at par with 77.30 cm, 76.50 cm and 76.00 cm respectively.

In the present experiment, different treatments produced significant response on plant height to varying proportions during both the seasons of 2016-17 and 2017-18 including pooled data analysis (Table 4.3).

Analysis of the experimental results revealed that comparatively shorter plant height were recorded under June and July plantings as compared to winter months planting. Poor performance in respect to plant height in summer plantings may be because of poor growth due to high temperature (>30˚C) during vegetative periods. Also summer planting showed poor performances on other vegetative parameters like number of leaves, leaf length and width, leaf area etc., which results to poor plant heights as well. From the present study, it is evident that better plant height were observed from September till February planting after which from March there was decrease till July planting. The plant height from October plantings was found to be tallest. This maximum plant height may be attributed to ideal mean temperature (20-28˚C) during vegetative growth period. Such congenial temperature resulted in ideal conditions for growth and development, also favoured photosynthesis through which the plants height was well developed. Similar findings by Muhammad *et al* (2013) also observed a strong correlation between plant height and temperature and reported maximum plant height under 10th September plantation in gladiolus under Peshawar conditions.

4.1.2 Flowering parameters

In floriculture industry, the commercial value of a flower crop is decided by specific quality attributes. In gladiolus, floral characters like days to spike emergence, colour break stage and floret opening decide the availability of flowers to the market demand. In addition, flower characters like spike length, rachis length, number of florets, diameter of florets and self life decides the value of flower spike. The present investigation showed flower characters were significantly influenced by different planting times.

Table 4.3: Effect of planting time on leaf area index, plant height and spike emergence

parameters	Leaf area index			Plant height (cm)			Days to spike emergence		
Treatment	**1st Year**	**2nd Year**	**Pooled**	**1st Year**	**2nd Year**	**Pooled**	**1st Year**	**2nd Year**	**Pooled**
T_1	1.51	1.50	1.51	82.13	83.07	82.60	69.67	71.47	70.57
T_2	1.56	1.53	1.54	84.87	85.80	85.33	68.20	68.67	68.43
T_3	1.56	1.59	1.58	77.80	76.80	77.30	66.53	65.40	65.97
T_4	1.60	1.59	1.60	76.93	76.07	76.50	63.67	62.53	63.10
T_5	1.51	1.47	1.49	76.20	75.80	76.00	62.80	60.80	61.80
T_6	1.40	1.41	1.41	73.47	74.27	73.87	63.00	61.80	62.40
T_7	1.48	1.48	1.48	74.13	75.20	74.67	63.20	64.73	63.97
T_8	1.64	1.61	1.63	78.40	79.47	78.93	64.47	65.07	64.77
T_9	1.72	1.72	1.72	86.07	86.73	86.40	65.80	67.13	66.47
T_{10}	1.82	1.77	1.80	88.40	89.00	88.70	66.93	68.13	67.53
T_{11}	1.70	1.70	1.70	83.27	84.93	84.10	68.73	69.73	69.23
T_{12}	1.62	1.61	1.62	79.13	81.73	80.43	70.67	73.07	71.87
Sem±	**0.02**	**0.02**	**0.01**	**0.44**	**0.52**	**0.34**	**0.43**	**0.35**	**0.28**
CD at 5%	**0.05**	**0.05**	**0.04**	**1.28**	**1.53**	**0.97**	**1.25**	**1.03**	**0.79**

4.1.2.1 Days to spike emergence

Days to spike emergence in gladiolus resulting from various planting times are presented in table 4.3.

Different planting times had significant effect on days to spike emergence in gladiolus. In 2016-17, minimum days to spike emergence was recorded from T_5 (62.80 days) followed by T_6 (63.00 days), T_7 (63.20 days) and T_4 (63.67 days) which were statistically at par with each other. Maximum days to spike emergence was recorded from T_{12} (70.67 days) which is statistically at par with T_1 (69.67 days). In 2017-18, minimum days to spike emergence was recorded from T_5 (60.80 days) followed by T_6 (61.80 days) which were statistically at par with each other. Maximum days to spike emergence was recorded from T_{12} (73.07 days) followed by T_1 (71.47 days). Further perusal of the analysed pooled data (Table 4.3) revealed that T_5 took minimum days (61.80 days) to spike emergence which is statistically at par with T_6 which took 62.40 days. Maximum days to spike emergence was recorded from T_{12} with 71.87 days which is followed by T_1 with 70.57 days.

The results of the present study indicate that early spikes emergence were observed from summer months planting when compared to winter months planting. May planting resulted in earliest days to spike emergence whereas, December planting recorded maximum days to spike emergence. This parameter closely correlated to days to sprouting and leaves emergence as early sprouting and leaf emergence resulted to early spike emergence and vice-versa. However, May planting preceded June planting in days to spike emergence although June planting showed early sprouting and leave emergence when compared to May planting, even though they were statistically at par with each other. This may be attributed to the prevailing environmental conditions during the vegetative growth periods. May planting received more congenial temperature (21-30˚C) for growth and development when compared to June planting with temperature (24-33˚C), this may have resulted to longer vegetative phase, as a results transition from vegetative shots to floral primordial, the reproductive parts of the plant was slightly delayed. These findings were also confirmed by Elif and Balut (2011) who reported that 20 June was found to be the most suitable with respect to spike emergence. Suman *et al*. (2011) also reported early spike emergence from early planting. Zubair *et al*. (2013) reported White Friendship planted on 1st November resulted in early spike emergence when compared to 1st December and 1st January planting.

4.1.2.2 Days to colour break

Days to colour break was significantly influenced by time of planting as presented in table 4.4. Pooled data analysis for days to colour break stage of 1st floret recorded minimum from T_5 (70.70 days) and maximum with T_{12} (81.87 days). Minimum days to colour break stage of 3rd floret was observed from T_5 (71.50 days) closely followed by T_6 (71.83 days) and statistically at par. Maximum was recorded from T_{12} (83.03 days). Days to colour break stage of 5th floret also strictly follows the 1st and 3rd floret patterns. Results from pooled data showed that minimum days to colour break was recorded from T_5 (72.30 days) followed by T_6 (72.63 days) whereas, maximum was recorded from T_{12} (83.80 days) followed by T_1 (81.33 days).

The results of the present study indicate that early days to colour break stage of florets were observed from summer months planting when compared to winter months planting. May planting resulted in earliest days to colour break, whereas, December planting recorded maximum days to colour break. This parameter is in parallel with days to spike emergence as early spike emergence

Table 4.4: Effect of planting time on days to colour break stage

parameters	Days to colour break stage of 1st floret			Days to colour break stage of 3rd floret			Days to colour break stage of 5th floret		
Treatment	**1st Year**	**2nd Year**	**Pooled**	**1st Year**	**2nd Year**	**Pooled**	**1st Year**	**2nd Year**	**Pooled**
T_1	78.67	80.47	79.57	79.60	81.27	80.43	80.40	82.27	81.33
T_2	76.60	77.07	76.83	77.40	77.87	77.63	78.20	78.67	78.43
T_3	74.93	73.80	74.37	75.80	74.67	75.23	76.60	75.47	76.03
T_4	72.07	71.00	71.53	72.87	71.87	72.37	73.67	72.67	73.17
T_5	71.33	70.07	70.70	72.13	70.87	71.50	72.93	71.67	72.30
T_6	71.60	70.47	71.03	72.40	71.27	71.83	73.20	72.07	72.63
T_7	71.60	73.13	72.37	72.40	74.00	73.20	73.20	74.80	74.00
T_8	72.80	73.40	73.10	73.73	74.27	74.00	74.40	74.20	74.30
T_9	74.20	75.47	74.83	75.00	76.27	75.63	75.80	76.93	76.37
T_{10}	75.93	77.13	76.53	76.67	77.87	77.27	77.47	78.60	78.03
T_{11}	78.13	79.13	78.63	78.47	79.80	79.13	79.20	80.67	79.93
T_{12}	80.67	83.07	81.87	82.07	84.00	83.03	83.00	84.60	83.80
Sem±	**0.42**	**0.38**	**0.28**	**0.44**	**0.37**	**0.29**	**0.41**	**0.41**	**0.29**
CD at 5%	**1.23**	**1.11**	**0.80**	**1.30**	**1.10**	**0.83**	**1.21**	**1.21**	**0.83**

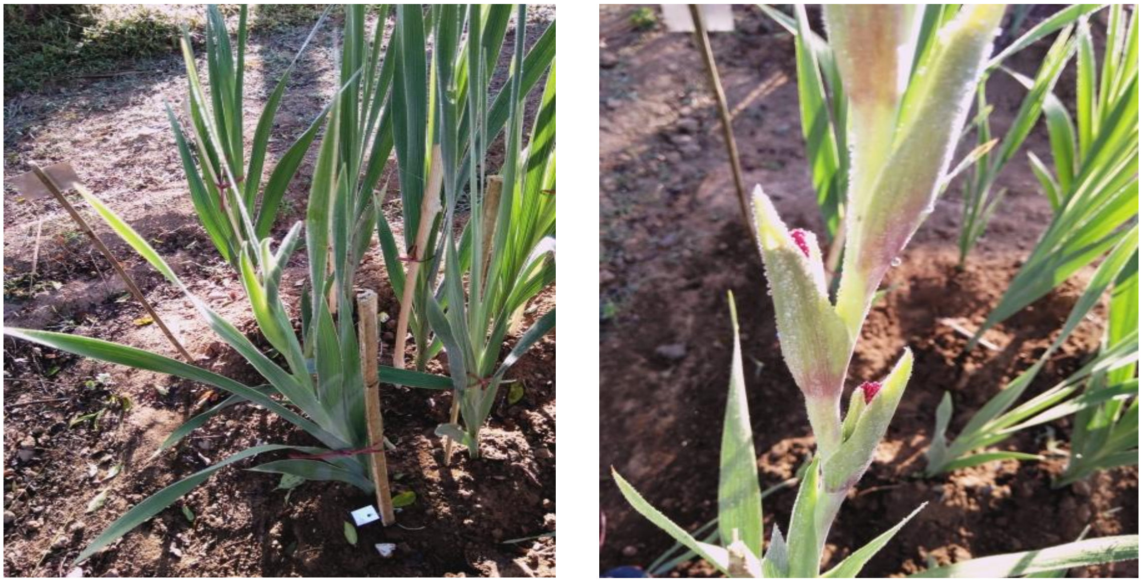

Plate 2. Spike initiation and colour break stages

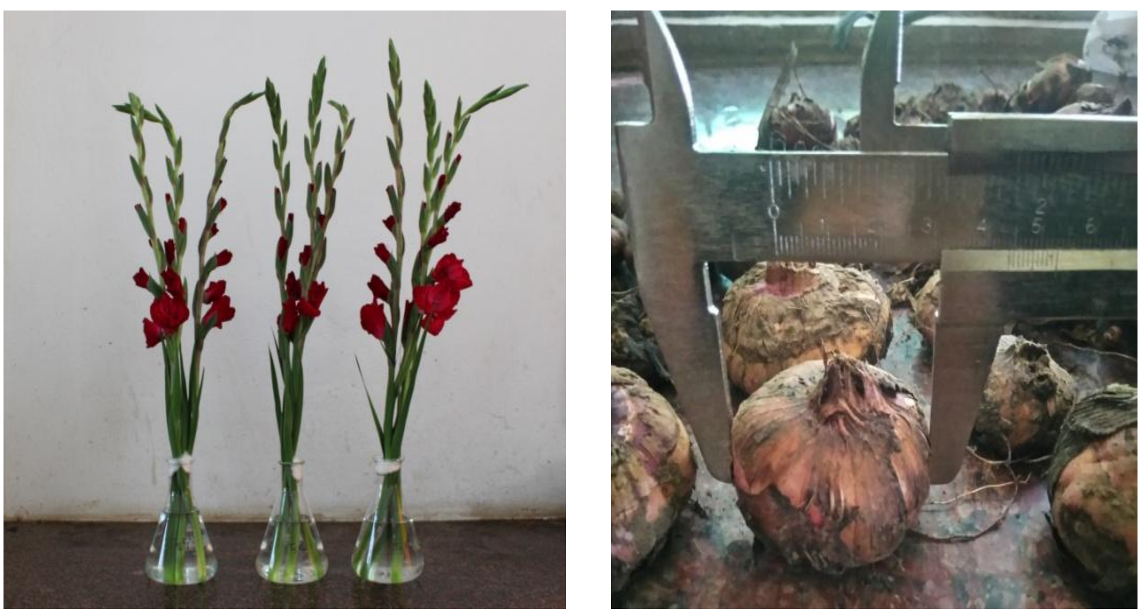

Plate 3. Postharvest and yield studies

resulted to early colour break and vice-versa. These findings were in accordance with Khutiya (2016) who reported that earliest day to bud break and flowering were observed from 28th July planting.

4.1.2.3 Length of spike

The data pertaining to length of spike as influenced by different treatments has been presented in table 4.5. It is evident from the results that there was significant difference in length of spike as influence by different planting time. In the first year of experiment, maximum length of spike was recorded from T_{10} (October planting) with 78.87 cm and closely followed by T_2 (February planting) with 78.13 cm which were statistically at par. Minimum length of spike were recorded in T_7 (July planting) with 68.67 cm. In the second year of experiment, maximum length of spike was also recorded from T_{10} (80.60 cm) and minimum from T_6 (70.33 cm) closely followed by T_7 (70.47 cm) and statistically at par. The result from pooled data analysis showed that T_{10} (79.73 cm) yielded maximum length of spike followed by T_2 (77.50 cm) and T_{11} (77.37 cm). Whereas, minimum length of spike was recorded in T_7 (69.57 cm) followed by T_6 (70.43 cm).

From the experimental results, it is evident that October planting is most ideal time with respect to length of spike, similar performance were obtained from February planting. Summer months planting resulted to shorter spike length. This finding may be attributed to the favourable environmental condition prevailing during the time of plant growth and development in October and February, as a result, plant developed better growth and development which is expressed in reproductive part like spike length. Similar findings were advocated by Kour (2009), Kumari *et al*. (2011), Ramzan *et al*. (2014) and Thakur *et al* (2015) all reported maximum spike length from October planting.

Table 4.5: Effect of planting time on length of spike and rachis and no. of florets

parameters	Length of spike (cm)			Length of rachis (cm)			Number of florets per spike		
Treatment	**1st Year**	**2nd Year**	**Pooled**	**1st Year**	**2nd Year**	**Pooled**	**1st Year**	**2nd Year**	**Pooled**
T_1	74.27	75.20	74.73	39.13	37.80	38.47	13.93	13.80	13.87
T_2	78.13	76.87	77.50	41.00	42.80	41.90	14.60	14.73	14.67
T_3	76.27	76.13	76.20	36.87	36.13	36.50	14.13	13.93	14.03
T_4	72.40	72.80	72.60	35.67	36.20	35.93	12.33	12.80	12.57
T_5	72.67	71.87	72.27	34.93	35.13	35.03	12.27	12.13	12.20
T_6	70.53	70.33	70.43	34.33	33.60	33.97	12.53	12.40	12.47
T_7	68.67	70.47	69.57	35.13	33.53	34.33	12.27	11.93	12.10
T_8	72.40	72.93	72.67	37.00	37.93	37.47	12.40	12.53	12.47
T_9	74.93	75.87	75.40	40.47	41.07	40.77	14.53	14.00	14.27
T_{10}	78.87	80.60	79.73	42.40	42.73	42.57	14.93	14.67	14.80
T_{11}	76.40	78.33	77.37	39.80	40.87	40.33	14.13	14.07	14.10
T_{12}	75.20	76.27	75.73	37.80	39.47	38.63	14.07	12.80	13.43
Sem±	**0.39**	**0.38**	**0.27**	**0.27**	**0.55**	**0.31**	**0.21**	**0.15**	**0.13**
CD at 5%	**1.13**	**1.11**	**0.77**	**0.78**	**1.63**	**0.88**	**0.61**	**0.45**	**0.37**

4.1.2.4 Length of rachis

The experimental result for length of rachis has been presented in table 4.5. From the given result it is clear that there is significant difference between different treatments. In the first year of experiment, maximum length of rachis was recorded in T_{10} (42.40 cm) followed by T_2 (41.00 cm) and minimum in T_6 (34.33 cm) closely followed by T_5 (34.93 cm) which were statistically at par. In the second year of experiment, maximum was recorded in T_2 (42.80 cm) closely followed by T_{10} (42.73 cm) and statistically at par. Minimum was recorded in T_7 (33.53 cm) closely followed by T_6 (33.60 cm) and statistically at par. Results of pooled data showed maximum length of rachis yielded in T_{10} (42.57 cm) and followed by T_2 (41.90 cm). Whereas, minimum was recorded in T_6 (33.97 cm) closely followed by T_7 (34.33 cm) and statistically at par.

From the inference, it is evident that planting time has significant influences on the length of rachis. This result is in close proximity with the length of spike and the attribution to this may be due to similar reasons. The finding is supported by Salvi *et al*. (2004) who reported superior quality of flower spike from 15th October planting. Bagde *et al*. (2009) also reported maximum rachis length from 13th October planting.

4.1.2.5 Number of florets per spike

Table 4.5 clearly expressed the experimental results pertaining to number of florets per spike which showed significant difference between treatments. In the first year of experiment, T_{10} (14.93) recorded maximum florets per spike, followed by T_2 (14.60) and T_9 (14.53) which were statistically at par. Minimum number of florets per spike of 12.27 was recorded from T_5 and T_7 followed by T_4 (12.33), T_8 (12.40) and T_6 (12.53) which were statistically at par. During second year, maximum was recorded from T_2 (14.73) closely followed by T_{10} (14.67) and statistically at par. Minimum was recorded from T_7 (11.93) followed by T_4 (12.33) and statistically at par. Result of the pooled data showed maximum number of florets per spike in T_{10} (14.80) followed by T_2 (14.67) and statistically at par. Minimum was recorded from T_7 (12.10) followed by T_5 (12.20) and both T_6 and T_8 at 12.47 which were all statistically at par.

In the present study, it was observed that number of florets increased significantly from September planting to November planting and February and March planting. Planting from April till August yielded less number of florets per spike. This may be attributed to poor growth and development of plants in summer months planting due to higher temperature which resulted to poor performance in terms of plant height and spike length, this directly influenced the number of florets per spike. This finding was in line with the results by Nijasure and Ranpise (2005) who reported maximum number of florets from 15th October planting. Sheikh and Jhon (2005) reported early planting (March) yielded highest number of florets per spike when compared to late planting (June). Bagde *et al*. (2009) and Kour (2009) reported maximum florets per spike from October planting. Kamal *et al*. (2018) also reported in Gladiolus cv. Hunting Song, maximum number of floret per spike obtained from10th October planting.

4.1.2.6 Days to opening of florets

The data pertaining to days to opening of florets as influenced by different treatments has been presented in table 4.6. It is evident from the results that there was significant difference in days to opening of florets as influenced by different planting time. Pooled data analysis showed minimum from T_5 (72.97 days) followed by T_6 (73.23 days) which were statistically at par and maximum in T_{12} (84.50 days). Days to opening of 3rd floret was in parallel with that of the 1st floret.

Table 4.6: Effect of planting time on days to opening of florets

parameters	Days to opening of 1st floret			Days to opening of 3rd floret			Days to opening of 5th floret		
Treatment	**1st Year**	**2nd Year**	**Pooled**	**1st Year**	**2nd Year**	**Pooled**	**1st Year**	**2nd Year**	**Pooled**
T_1	81.40	83.07	82.23	82.20	83.80	83.00	83.00	84.60	83.80
T_2	78.93	79.87	79.40	79.67	80.60	80.13	80.47	81.40	80.93
T_3	77.33	76.20	76.77	78.20	77.07	77.63	79.07	77.87	78.47
T_4	74.40	73.47	73.93	75.20	74.20	74.70	76.00	75.00	75.50
T_5	73.53	72.40	72.97	74.27	73.27	73.77	75.07	74.07	74.57
T_6	73.67	72.80	73.23	74.40	73.87	74.13	75.20	74.67	74.93
T_7	73.93	75.53	74.73	74.67	76.33	75.50	75.53	77.13	76.33
T_8	75.20	75.00	75.10	76.00	75.77	75.88	76.80	76.57	76.68
T_9	76.53	77.73	77.13	77.33	78.47	77.90	78.13	79.27	78.70
T_{10}	78.07	79.20	78.63	78.93	80.13	79.53	79.67	80.93	80.30
T_{11}	80.00	81.33	80.67	80.93	82.33	81.63	81.87	83.13	82.50
T_{12}	83.73	85.27	84.50	84.40	85.73	85.07	85.40	86.53	85.97
Sem±	**0.42**	**0.41**	**0.30**	**0.44**	**0.39**	**0.29**	**0.42**	**0.39**	**0.29**
CD at 5%	**1.24**	**1.21**	**0.84**	**1.29**	**1.14**	**0.84**	**1.24**	**1.14**	**0.82**

Pooled analysis of two years data revealed that minimum was observed from T_5 (73.77 days) closely followed by T_6 (74.13 days) and statistically at par. Maximum was recorded from T_{12} (85.07 days). Days to opening of 5th floret also strictly follows the 1st and 3rd floret patterns. Results from pooled data showed that minimum days to colour break was recorded from T_5 (74.57 days) whereas, maximum was recorded from T_{12} (85.97 days).

The results of the present study indicate that early days to opening of florets were observed from summer months planting when compared to winter months planting. May planting resulted in earliest days to florets opening, whereas, December planting recorded maximum days to florets opening. This parameter is in parallel with days to spike emergence and days to colour break stages of florets as early spike emergence and days to colour break stages of florets resulted to early florets opening and vice-versa. This finding is in accordance with Al-Humaid (2004) and (Nijasure and Ranpise, 2005) who reported early flowering from early planting during winter months. Khutiya (2016) also reported that staggered planting from 13th February to 28th July at 15 days interval, earliest day to flowering were observed for 28th July planting.

4.1.2.7 Diameter of florets

The data pertaining to diameter of florets as influenced by different treatments has been presented in table 4.7. It is evident from the results that there was significant difference in diameter of florets as influenced by different planting time. Pooled data analysis showed minimum from T_7 (9.13 cm) followed by T_6 (9.20 cm) and T_5 (9.29 cm) which were statistically at par and maximum with T_{10} (10.23 cm) and statistically at par with T_2 (10.18 cm). Pooled analysis of two years data revealed that minimum diameter of 3rd floret was observed from T_7 (8.88 cm) and maximum was recorded from T_{10} (10.03 cm). Diameter of 5th floret also strictly follows the 1st and 3rd floret patterns. Results from pooled data showed that minimum diameter of floret was recorded from T_7 (8.52 cm), whereas, maximum was recorded from T_{10} (9.77 cm).

The results of the present study indicate that winter and early spring crops performed superior with regards to diameter of florets. From the obtained experimental results, it is observed that the diameter of florets steadily decreases with the advancement of florets towards tip with uniformity irrespective of planting time. July planting resulted minimum diameter of florets, whereas, October planting recorded maximum diameter of florets. This variation in diameter of florets may be attributed to the environmental factors prevailing during the growing season. October and February months planting received more congenial environment conditions compared to summer months for gladiolus. This finding are in conformity with the results by Salvi *et al*. (2004), (Nijasure and Ranpise, 2005), Bagde *et al*. (2009) and Kour (2009) who all reported October planting as the best time with regards to flowering parameter particularly, diameter of florets. Also, Vasanthakumar *et al*. (2015), (Taye *et al*, 2015) and Khutiya (2016) who all reported early spring performed better when compared to summer months.

4.1.2.8 Days to withering of florets

The data pertaining to days to withering of florets as influenced by different treatments has been presented in table 4.8. It is evident from the results that there was significant difference in days to withering of florets as influence by different planting time. Pooled data analysis showed minimum from T_4 (3.57 days) followed by T_5 (3.67 days) which were statistically at par and maximum with T_{10} (4.70 days) and statistically at par with T_{11} (4.60 days). Days to withering of 3rd floret was in parallel with that of the 1st floret. Pooled analysis of two years data

Table 4.8: Effect of planting time on days to withering of florets

parameters	Days to withering of 1st floret			Days to withering of 3rd floret			Days to withering of 5th floret		
Treatment	**1st Year**	**2nd Year**	**Pooled**	**1st Year**	**2nd Year**	**Pooled**	**1st Year**	**2nd Year**	**Pooled**
T_1	4.13	4.07	4.10	5.33	5.13	5.23	6.33	6.20	6.27
T_2	3.93	3.93	3.93	5.13	5.00	5.07	6.20	6.13	6.17
T_3	3.67	3.73	3.70	4.87	4.80	4.83	5.93	5.87	5.90
T_4	3.60	3.53	3.57	4.73	4.67	4.70	5.87	5.67	5.77
T_5	3.73	3.60	3.67	4.73	4.67	4.70	5.80	5.67	5.73
T_6	3.93	3.80	3.87	4.87	4.93	4.90	5.87	6.27	6.07
T_7	4.07	3.93	4.00	5.13	4.87	5.00	6.13	5.87	6.00
T_8	4.27	4.27	4.27	5.40	5.33	5.37	6.53	6.47	6.50
T_9	4.67	4.40	4.53	5.87	5.60	5.73	6.87	6.80	6.83
T_{10}	4.73	4.67	4.70	6.00	5.93	5.97	7.00	7.07	7.03
T_{11}	4.60	4.60	4.60	5.87	5.73	5.80	6.87	6.87	6.87
T_{12}	4.13	4.07	4.10	5.67	5.33	5.50	6.60	6.40	6.50
Sem±	**0.06**	**0.05**	**0.04**	**0.07**	**0.08**	**0.05**	**0.06**	**0.11**	**0.06**
CD at 5%	**0.18**	**0.16**	**0.12**	**0.20**	**0.23**	**0.15**	**0.19**	**0.32**	**0.18**

revealed that minimum was observed from T_4 and T_5 at same value of 4.70 days and maximum was recorded from T_{10} (5.67 days). Days to withering of 5th floret also strictly follows the 1st and 3rd floret patterns. Results from pooled data showed that minimum was recorded from T_5 (5.73 days) and maximum was recorded from T_{10} (7.03 days) followed by T_{11} (6.87 days) and were statistically at par.

The results of the present study indicate that October planting performed superior with regards to days to withering of florets. Whereas, April and May planting recorded minimum days to withering of florets. This variation in days to withering of florets may be attributed to the temperature and humidity during flowering in particular and environmental factors prevailing during the growing seasons in general. October planting received more congenial environment conditions during flowering in the month of December (11-24°C and 60-95% RH) compared to April and May plantings which flowers in July (25-33°C and 70-90% RH) and August (24-33°C and 70-90% RH) respectively where the temperature is extreme for the delicate flowers to last. This finding is supported by Salvi *et al*. (2004) who reported superior flower quality from October planting in gladiolus. Kumari *et al*. (2011) also reported October planting gives maximum flowering duration in gladiolus. Rathod *et al*. (2011) also reported that October planting resulted to increase all flowering and quality attributes in gladiolus.

Table 4.7: Effect of planting time on diameter of florets

parameters	Diameter of 1st floret (cm)			Diameter of 3rd floret (cm)			Diameter of 5th floret (cm)		
Treatment	**1st Year**	**2nd Year**	**Pooled**	**1st Year**	**2nd Year**	**Pooled**	**1st Year**	**2nd Year**	**Pooled**
T_1	9.99	10.09	10.04	9.59	9.86	9.73	9.31	9.58	9.45
T_2	10.16	10.21	10.18	9.89	10.01	9.95	9.63	9.75	9.69
T_3	9.92	10.01	9.96	9.69	9.79	9.74	9.37	9.47	9.42
T_4	9.49	9.81	9.65	9.44	9.70	9.57	9.08	9.34	9.21
T_5	9.45	9.12	9.29	9.25	8.90	9.07	8.87	8.52	8.69
T_6	9.22	9.17	9.20	8.97	9.02	9.00	8.57	8.62	8.60
T_7	9.17	9.09	9.13	8.92	8.85	8.88	8.56	8.49	8.52
T_8	9.57	9.57	9.57	9.32	9.24	9.28	9.02	8.94	8.98
T_9	9.70	10.01	9.86	9.46	9.15	9.31	9.18	8.87	9.03
T_{10}	10.19	10.27	10.23	9.98	10.09	10.03	9.72	9.83	9.77
T_{11}	10.09	10.07	10.08	9.85	9.82	9.83	9.57	9.54	9.55
T_{12}	10.01	9.95	9.98	9.73	9.64	9.69	9.43	9.34	9.39
Sem±	**0.12**	**0.04**	**0.06**	**0.12**	**0.21**	**0.12**	**0.12**	**0.21**	**0.12**
CD at 5%	**0.35**	**0.13**	**0.18**	**0.35**	**0.61**	**0.34**	**0.35**	**0.61**	**0.34**

4.1.2.9 Self life

The experimental result for self life has been presented in table 4.9. It is evident from the results that there was significant difference in self life as influence by different planting time. In the first year of experiment, shortest self life was recorded from T_4 (12.13 days) and longest from T_{10} (15.00 days). During the second year of experiment, minimum self life was recorded from T_4 (12.67 days) followed by T_5 (12.80 days) and statistically at par. Maximum self life was recorded from T_{10} (15.13 days) followed by T_{11} (14.80 days) and statistically at par. From the pooled data analysis, minimum self life was obtained from T_4 (12.40 days) and maximum self life was recorded from T_{10} (15.07 days) followed by T_{11} (14.67 days) and T_9 (14.37 days).

Further perusal of the experimental results revealed that comparatively longer self life were observed from winter months planting when compared with summer months planting. The most ideal planting time with special reference to self life of gladiolus spikes under Nagaland condition as per the present investigation would be October followed by September and November planting. However, for summer months planting, the duration of flowering or self life would be compromised significantly. This finding may be attributed to the prevailing environmental conditions during the crop seasons as per their treatments. Congenial environmental factors during growth and development of the plants would result into better performance of the plant including longer flowering duration. Similar findings by Ramzan *et al*. (2014) reported maximum duration of flowering in field from October planting in gladiolus. Khutiya (2016) reported longer duration of flowering from February planting when compared to July planting.

Table 4.9: Effect of planting time on self life

Treatment	1st Year	2nd Year	Pooled
T_1	13.93	14.07	14.00
T_2	13.27	13.60	13.43
T_3	12.67	13.07	12.87
T_4	12.13	12.67	12.40
T_5	12.67	12.80	12.73
T_6	12.93	13.00	12.97
T_7	13.53	13.47	13.50
T_8	13.73	13.87	13.80
T_9	14.13	14.60	14.37
T_{10}	15.00	15.13	15.07
T_{11}	14.53	14.80	14.67
T_{12}	14.13	14.13	14.13
Sem±	**0.07**	**0.12**	**0.07**
CD at 5%	**0.21**	**0.34**	**0.20**

4.1.3 Postharvest parameters

The results of postharvest studies as influences by different treatments exhibited significant variation among planting times with regards to postharvest qualities of cut spikes. The effect of different planting times on the vase life of gladiolus in a standard vase solution was investigated in postharvest laboratory under normal room temperature and the results envisaged that most of the parameters are significantly influenced by different treatments.

4.1.3.1 Weight of spike

Data embodied in table 4.10 presents the effect of planting times on weight of spike. Significant variation as influenced by different planting times on changes in fresh weight of spikes was observed. In general, it was observed that the changes in fresh weight of spikes were maximum on 3rd day which increased from the initial weight. The weights of spikes were almost constant from 3rd day till 6th day and decreases sharply thereafter. Results from pooled data shows minimum in T_6 (42.33g) and maximum in T_{10} (64.67g) followed by T_9 (63.17g) which were statistically at par. The results of the 3rd day is in parallel with the 1st day, Pooled data analysis show maximum from T_{10} (73.83g) and minimum from T_6 (49.67g). On the 6th day, pooled data analysis revealed T_{10} (76.17g) as best treatment and least performance for T_6 (46.17g). On the 9th day, results of the pooled data analysis show similar trends, T_{10} (69.00g) recorded maximum whereas, minimum was recorded from T_5 (41.33g).

Perusal of the experimental results revealed that there are significant differences between different treatments with regards to changes in fresh weight of gladiolus spikes. In general, the spikes from September to December and also February planting recorded maximum value whereas, summer months planting

Table 4.10: Effect of planting time on weight of spikes

parameters	Weight of spike at 1st day (g)			Weight of spike at 3rd day (g)			Weight of spike at 6th day (g)			Weight of spike at 9th day (g)		
Treatment	**1st Year**	**2nd Year**	**Pooled**	**1st Year**	**2nd Year**	**Pooled**	**1st Year**	**2nd Year**	**Pooled**	**1st Year**	**2nd Year**	**Pooled**
T_1	55.67	54.00	54.83	63.67	60.67	62.17	62.33	59.67	61.00	56.33	53.67	55.00
T_2	60.00	56.67	58.33	69.00	65.00	67.00	67.00	62.33	64.67	60.00	55.33	57.67
T_3	56.00	55.67	55.83	64.00	63.67	63.83	61.00	59.67	60.33	53.00	52.67	52.83
T_4	49.67	50.00	49.83	57.67	57.67	57.67	53.67	52.33	53.00	44.67	46.33	45.50
T_5	46.33	43.67	45.00	53.33	50.33	51.83	49.33	45.00	47.17	40.33	42.33	41.33
T_6	43.67	41.00	42.33	50.67	48.67	49.67	47.67	44.67	46.17	41.67	41.33	41.50
T_7	47.00	45.33	46.17	54.00	52.00	53.00	52.00	49.33	50.67	44.00	45.33	44.67
T_8	53.67	52.33	53.00	61.67	61.67	61.67	60.67	60.33	60.50	52.67	54.33	53.50
T_9	64.00	62.33	63.17	72.00	70.67	71.33	74.00	73.33	73.67	67.33	66.33	66.83
T_{10}	65.67	63.67	64.67	74.67	73.00	73.83	76.67	75.67	76.17	69.00	69.00	69.00
T_{11}	62.33	60.33	61.33	71.33	69.00	70.17	72.33	70.33	71.33	66.67	64.67	65.67
T_{12}	61.00	59.00	60.00	69.00	66.67	67.83	69.33	67.00	68.17	63.33	61.00	62.17
Sem±	**1.00**	**0.83**	**0.65**	**1.00**	**0.48**	**0.56**	**1.07**	**0.87**	**0.69**	**0.99**	**0.77**	**0.63**
CD at 5%	**2.93**	**2.44**	**1.86**	**2.93**	**1.41**	**1.58**	**3.14**	**2.56**	**1.97**	**2.91**	**2.27**	**1.80**

performed relatively poor. The changes in fresh weight of spikes can be clearly seen from the 3rd day of the vase life studies and this increase in weight is almost constant till the 6th day of the experiment. Thereafter, on the 9th day there is sharp decrease in the weight of spikes. These parabolic curves of spike weight may be attributed to the water uptake and water loss, number and diameter of florets, increased in length of spikes and withering of florets during the post harvest studies. The differences in weight of spikes between treatments may be attributed to the pre harvest factors such as temperature, sunshine hours, humidity, etc. as the treatment which performed well in field also performed well in post harvest studies. The treatment which received congenial environmental factors during the growing periods resulted to better fresh weight; this might be due to the stored food in the spikes. This finding is in line with the result of Bala *et al*. (2006) who reported among three planting dates (1st November, 15 November and 1st December) the planting done on 1st November recorded maximum fresh weight. Meena *at el*. (2018) also reported that fresh weight of spike is significantly influenced by staggered planting in tuberose.

4.1.3.2 Days to opening of 50% florets

Days to opening of 50% florets was significantly influenced by time of planting as presented in table 4.11. In the first year of the experiment, minimum days to opening of 50% florets was recorded from T_5 (3.33 days), closely followed by T_6 and T_4 (3.67 days) each and T_2, T_3 and T_7 all with 4.00 days each which were all statistically at par. Maximum days to opening of 50% florets was recorded from T_9 and T_{10} (5.33 days) each followed by T_{11} (5.00 days) and T_{12} (4.67 days) which were statistically at par. Similar results were observed on the second year of experiment with minimum recorded from T_4, T_5 and T_6 with 3.33 days each followed by T_3 and T_7 with 3.367 days each and T_1, T_2 and T_8 with 4.00

days which were all statistically at par. Also, maximum days to opening of 50% florets was recorded from T_{10} (5.00 days) followed by T_9 and T_{11} with 4.67 days each and T_{12} with 4.33 days which were statistically at par. Pooled data analysis also showed similar trend with minimum from T_5 (3.33 days) and maximum with T_{10} (5.17 days). This variation may be attributed to the environmental factors influencing growth and development of plant as higher number of florets resulted to longer days to 50% florets opening. Kaushal *et al.* (2014) also reported similar results in variation of post harvest quality of cut gladiolus spikes.

4.1.3.3 Number of florets opened at a time

Table 4.11 clearly expressed the experimental results pertaining to number of florets opened at a time which showed a small significant difference between treatments. In the first year of experiment, T_{10} (7.00) recorded maximum, followed by T_{11} (6.33) which were statistically at par. Minimum was recorded from T_4 (5.00) followed by T_3, T_5 and T_6 all with 5.33 and also T_2, T_7 and T_8 all recorded 5.67 which were all statistically at par. During second year, maximum was recorded from T_{10} (7.33) followed by T_{11} (6.67) and statistically at par. Minimum was recorded from T_3, T_4 and T_6 all recorded 5.00. Result of the pooled data showed maximum number of florets opened at a time in T_{10} (7.17) and minimum was recorded in T_4 (5.00) followed by T_3 and T_6 both with 5.17 and T_2, T_5 and T_7 all at 5.50 which were all statistically at par.

In the present study, it was observed that number of florets opened at a time increased significantly from September planting to October planting. Whereas, April and May planting shows less number of florets opened at a time. This may be attributed to pre harvest factors such as number of florets and stored food materials within the spikes, as higher number of florets and other superior

Table 4.11: Effect of planting time on 50% florets opening and no. of florets opened at a time

parameters	Days to opening of 50% florets			Number of florets opened at a time		
Treatment	**1st Year**	**2nd Year**	**Pooled**	**1st Year**	**2nd Year**	**Pooled**
T_1	4.33	4.00	4.17	6.00	6.00	6.00
T_2	4.00	4.00	4.00	5.67	5.33	5.50
T_3	4.00	3.67	3.83	5.33	5.00	5.17
T_4	3.67	3.33	3.50	5.00	5.00	5.00
T_5	3.33	3.33	3.33	5.33	5.67	5.50
T_6	3.67	3.33	3.50	5.33	5.00	5.17
T_7	4.00	3.67	3.83	5.67	5.33	5.50
T_8	4.33	4.00	4.17	5.67	5.67	5.67
T_9	5.33	4.67	5.00	6.00	6.33	6.17
T_{10}	5.33	5.00	5.17	7.00	7.33	7.17
T_{11}	5.00	4.67	4.83	6.33	6.67	6.50
T_{12}	4.67	4.33	4.50	6.00	5.67	5.83
Sem±	**0.28**	**0.28**	**0.20**	**0.24**	**0.28**	**0.19**
CD at 5%	**0.82**	**0.82**	**0.56**	**0.70**	**0.83**	**0.53**

flowering parameters resulted to higher number of florets opened at a time. Moreover, for September and October planting, post harvest studies will be done during mid winter when the temperature is lowest. As a result of this low temperature, transpirational losses of moisture from the spike is reduced, enzymatic activities is minimized which leads to delayed senescence. This finding is supported by Pavani *et al*. (2014) who reported that maximum number of florets remained open at a time was obtained from 15 September planting. Rathod *et al*. (2011) reported that October planting significantly increased all flowering and quality attributes in gladiolus.

4.1.3.4 Diameter of florets

Diameter of florets as influenced by different treatments has been presented in table 4.12. It is evident from the results that there was significant difference in diameter of florets as influence by different planting time. Pooled data analysis showed minimum from T_7 (9.13 cm) and maximum with T_{10} (10.23 cm). Diameter of 3rd floret is in parallel with that of the 1st floret. Pooled analysis of two years data revealed that minimum diameter of 3rd floret was observed from T_7 (8.88 cm) closely followed by T_6 (9.00 cm) and T_5 (9.07 cm) which were statistically at par. Maximum was recorded from T_{10} (10.03 cm) closely followed by T_2 (9.95 cm), T_{11} (9.83 cm), T_3 (9.74 cm), T_1 (9.73 cm) and T_{12} (9.69 cm) which were statistically at par. Diameter of 5th floret also strictly follows the 1st and 3rd floret patterns. Results from pooled data showed that minimum diameter of floret was recorded from T_7 (8.52 cm) followed by T_6 (8.60 cm) and T_5 (8.69 cm) which were statistically at par. Whereas, maximum was recorded from T_{10} (9.77 cm) followed by T_2 (9.69 cm), T_{11} (9.55 cm), T_1 (9.45 cm), T_3 (9.42 cm) and T_{12} (9.39 cm) which were statistically at par.

Table 4.12: Effect of planting time on diameter of florets

parameters	Diameter of 1st floret (cm)			Diameter of 3rd floret (cm)			Diameter of 5th floret (cm)		
Treatment	**1st Year**	**2nd Year**	**Pooled**	**1st Year**	**2nd Year**	**Pooled**	**1st Year**	**2nd Year**	**Pooled**
T_1	9.99	10.09	10.04	9.59	9.86	9.73	9.31	9.58	9.45
T_2	10.16	10.21	10.18	9.89	10.01	9.95	9.63	9.75	9.69
T_3	9.92	10.01	9.96	9.69	9.79	9.74	9.37	9.47	9.42
T_4	9.49	9.81	9.65	9.44	9.70	9.57	9.08	9.34	9.21
T_5	9.45	9.12	9.29	9.25	8.90	9.07	8.87	8.52	8.69
T_6	9.22	9.17	9.20	8.97	9.02	9.00	8.57	8.62	8.60
T_7	9.17	9.09	9.13	8.92	8.85	8.88	8.56	8.49	8.52
T_8	9.57	9.57	9.57	9.32	9.24	9.28	9.02	8.94	8.98
T_9	9.70	10.01	9.86	9.46	9.15	9.31	9.18	8.87	9.03
T_{10}	10.19	10.27	10.23	9.98	10.09	10.03	9.72	9.83	9.77
T_{11}	10.09	10.07	10.08	9.85	9.82	9.83	9.57	9.54	9.55
T_{12}	10.01	9.95	9.98	9.73	9.64	9.69	9.43	9.34	9.39
Sem±	**0.12**	**0.04**	**0.06**	**0.12**	**0.21**	**0.12**	**0.12**	**0.21**	**0.12**
CD at 5%	**0.35**	**0.13**	**0.18**	**0.35**	**0.61**	**0.34**	**0.35**	**0.61**	**0.34**

The results of the present study indicated that winter and early spring crops performed superior with regards to diameter of florets. From the obtained experimental results, it is observed that the diameter of florets steadily decreases with the advanced of florets towards apical florets with uniformity irrespective of planting time. July planting exhibited minimum diameter of florets, whereas, October planting recorded maximum diameter of florets. This variation in diameter of florets may be attributed to the environmental factors prevailing during the growing season. October and February months planting received more congenial environment conditions compared to summer months for gladiolus. This finding is supported by Salvi *et al*. (2004), (Nijasure and Ranpise, 2005), Bagde *et al*. (2009) and Kour (2009) who all reported October planting as the best time with regards to flowering parameter particularly, diameter of florets. Also, Vasanthakumar *et al*. (2015), (Taye *et al*, 2015) and Khutiya (2016) who all reported early spring performed better when compared to summer months.

4.1.3.5 Longevity of florets

The data pertaining to longevity of florets as influenced by different treatments has been presented in table 4.13. It is evident from the results that there was significant difference in longevity of florets as influenced by different planting time. Pooled data analysis showed minimum from T_4 (3.33 days) and maximum with T_{10} (5.00 days). Longevity of 3rd floret is in parallel with that of the 1st floret. Pooled analysis of two years data revealed that minimum was observed from T_4 (4.67 days) and maximum was recorded from T_{10} (6.33 days). Longevity of 5th floret pooled data showed that minimum was recorded from T_4 (5.83 days) followed by T_5 and T_6 both at 6.00 days which were statistically at par. Whereas, maximum was recorded from T_{10} (7.50 days) followed by T_9 and T_{11} both at 7.17 days and were statistically at par.

Table 4.13: Effect of planting time on longevity of florets

parameters	Longevity of 1st floret (days)			Longevity of 3rd floret (days)			Longevity of 5th floret (days)		
Treatment	**1st Year**	**2nd Year**	**Pooled**	**1st Year**	**2nd Year**	**Pooled**	**1st Year**	**2nd Year**	**Pooled**
T_1	4.33	4.00	4.17	5.67	5.33	5.50	6.67	6.67	6.67
T_2	4.00	4.00	4.00	5.33	5.33	5.33	6.33	6.67	6.50
T_3	4.00	3.67	3.83	5.33	5.00	5.17	6.33	6.33	6.33
T_4	3.33	3.33	3.33	4.67	4.67	4.67	5.67	6.00	5.83
T_5	3.67	3.33	3.50	5.00	4.67	4.83	6.00	6.00	6.00
T_6	3.67	3.67	3.67	5.00	5.00	5.00	6.00	6.00	6.00
T_7	4.00	3.67	3.83	5.33	5.00	5.17	6.33	6.00	6.17
T_8	4.00	4.00	4.00	5.33	5.33	5.33	6.33	6.67	6.50
T_9	5.00	4.67	4.83	6.33	6.00	6.17	7.33	7.00	7.17
T_{10}	5.33	4.67	5.00	6.67	6.00	6.33	7.67	7.33	7.50
T_{11}	5.00	4.33	4.67	6.33	5.67	6.00	7.33	7.00	7.17
T_{12}	4.67	4.00	4.33	6.00	5.33	5.67	7.00	6.67	6.83
Sem±	**0.22**	**0.27**	**0.18**	**0.30**	**0.26**	**0.20**	**0.30**	**0.24**	**0.19**
CD at 5%	**0.66**	**0.80**	**0.50**	**0.87**	**0.78**	**0.57**	**0.87**	**0.70**	**0.54**

The result of the present study indicates that October planting performed superior with regards to longevity of florets, whereas, April and May planting recorded minimum longevity of florets. This variation in longevity of florets may be attributed to the environmental factors prevailing during the growing seasons which would have lead to more food materials stored in the spikes giving to better post harvest qualities including prolong longevity of florets. Also the temperature and humidity during the post harvest studies affects the water balance and physiochemical activities of spikes, as lower temperature resulted to prolonging longevity of florets. October planting received more congenial environment conditions during post harvest studies in the month of December (11-24°C and 60-95% RH) compared to April and May plantings when post harvest studies was conducted in July (25-33°C and 70-90% RH) and August (24-33°C and 70-90% RH) respectively where the temperature is extreme for the delicate flowers to last. This finding is supported by Salvi *et al*. (2004) who reported superior flower quality from October planting in gladiolus. Kumari *et al*. (2011) also reported October planting gives maximum flowering duration in gladiolus.

4.1.3.6 Solution uptake

The data pertaining to solution uptake as influenced by different treatments has been presented in table 4.14. It is evident from the results that there was significant difference in solution uptake as influenced by different planting time. During the first year of experiment, maximum solution uptake was recorded from T_2 (86.67 mL) closely followed by T_3 (85.00 mL) which were statistically at par. Minimum solution uptake was recorded from T_6 (62.67 mL) followed by T_7 (64.67 mL) which were statistically at par. During the second year of experiment, minimum solution uptake was recorded from T_6 (61.33 mL) followed by T_7 (61.67 mL) and T_5 (64.67 mL) which were statistically at par. Maximum was recorded from T_2 (84.67 mL) followed by T_{10} (82.33 mL) which were statistically at par. Pooled data analysis revealed that minimum solution uptake was recorded from T_6 (62.00 mL) followed by T_7 (63.17 mL) which were statistically at par and maximum was recorded from T_2 (85.67 mL) followed by T_3 (83.50 mL) which were statistically at par.

The results of the experiment revealed that there is a significant difference between treatments. This may be attributed to the prevailing environmental conditions during post harvest studies. Solution uptake also closely related to number of florets per spikes, and since T_2 have similar number of florets with T_{10} and the temperature prevailing during post harvest studies of T_2 is 24-33 °C whereas that of T_{10} is 8-22 °C as a result of higher temperature in T_2, the transpirational moisture loses is higher than that of T_{10} which may have lead to more solution uptake by the T_2. This finding was in line with the findings of Bala *et al*. (2006) in gladiolus.

4.1.3.7 Vase life

Vase life as influenced by different treatments has been presented in table 4.14. It is evident from the results that there was significant difference in vase life as influenced by different planting time. In the first year of experiment, maximum vase life was observed in T_{10} (14.00 days) followed by T_9 and T_{11} with same value at 13.33 days which were statistically at par. Minimum vase life was recorded in T_4 and T_5 both at same value of 10.33 days followed by T_6 (10.67 days) which were statistically at par. During the second year of experiment, minimum vase life was recorded from T_4 (10.00 days) and maximum in T_{10} (13.67 days) followed by T_9 and T_{11} at 13.00 days each which were statistically at par. Statistical analysis of the pooled date revealed that maximum vase life was

Table 4.14: Effect of planting time on solution uptake and vase life

parameters	Solution uptake (mL)			Vase life (days)		
Treatment	**1st Year**	**2nd Year**	**Pooled**	**1st Year**	**2nd Year**	**Pooled**
T_1	78.33	78.00	78.17	12.33	12.00	12.17
T_2	86.67	84.67	85.67	12.00	12.00	12.00
T_3	85.00	82.00	83.50	11.33	11.00	11.17
T_4	77.67	79.67	78.67	10.33	10.00	10.17
T_5	68.00	64.67	66.33	10.33	10.33	10.33
T_6	62.67	61.33	62.00	10.67	10.33	10.50
T_7	64.67	61.67	63.17	11.67	11.33	11.50
T_8	72.33	69.33	70.83	12.33	12.00	12.17
T_9	80.33	81.00	80.67	13.33	13.00	13.17
T_{10}	80.67	82.33	81.50	14.00	13.67	13.83
T_{11}	78.33	77.33	77.83	13.33	13.00	13.17
T_{12}	74.00	69.33	71.67	12.33	12.33	12.33
Sem±	**1.13**	**1.39**	**0.89**	**0.30**	**0.28**	**0.21**
CD at 5%	**3.31**	**4.07**	**2.55**	**0.88**	**0.82**	**0.59**

observed from T_{10} (13.83 days) and minimum was recorded from T_4 (10.17 days) followed by T_5 (10.33 days) and T_6 (10.50 days) which were statistically at par.

Further analysis of the experimental results revealed that there are significant differences between the treatments with regards to vase life of gladiolus spikes. This may be attributed to the prevailing environmental conditions during growth and development periods of the crop as parameters like number of florets, spike weight, spike length, all these gives to more stored food materials in the spike leading to longer vase life of the spikes. Also, the temperature and relative humidity during the post harvest studies effected the vase life largely. October planting received more congenial environment conditions during post harvest studies in the month of December (11-24°C and 60-95% RH) compared to April and May plantings when post harvest studies was conducted in July (25-33°C and 70-90% RH) and August (24-33°C and 70-90% RH) respectively where the temperature is extreme for the delicate flowers to last. This finding is supported by Salvi *et al*. (2004) who reported superior flower quality from October planting in gladiolus. Kamal *et al*. (2018) also reported maximum vase life from October planting in gladiolus.

4.1.4 Yield parameters

The availability of any flowers is determined by the availability of planting materials. In gladiolus, corms and cormels are the plant propagules for commercial cultivation of the crop. The successful production of gladiolus relies on the corms and cormels characters such as diameter and weight. The superior corms characters ensure successful production and quality produced. The number of corms and cormels determined the multiplication of the crop. The results of yield parameters as influences by different treatments are carefully investigated and the results envisaged are presented below.

4.1.4.1 Number of corms per hill

Number of corms per hill as influenced by different treatments has been presented in table 4.15. Perusal of the experimental results revealed that number of corms are least affected by the planting time. In the first year of experiment, maximum number of corms per hill was recorded from T_{10} (1.27) followed by T_9 (1.13) and T_7 (1.13) which were statistically at par. Minimum was recorded from T_2, T_4 and T_6 all at same value of 1.00 and statistically at par with all the treatments except the T_{10}. During the second year, there was no significant difference between treatments. However, maximum was recorded from T_{10}, T_8 and T_6 all at same value of 1.00 numbers. Pooled data analysis showed that maximum was recorded from T_{10} (1.20), whereas, minimum of 1.03 numbers were recorded from T_2, T_3, T_4 and T_{12} which were statistically at par with all the other treatments except the T_{10} which is the maximum. This result may be attributed to the fact that single corm is produced at the base of every plant and every mother corms produced normally a single plant and exceptionally more than one if soil and environmental conditions are favourable. This variation in number of corms may be due to different environmental conditions prevailing during the cropping seasons. Similar findings are reported by Thakur and Dhatt (2015) and Ahmad *et al.* (2011) in gladiolus.

4.1.4.2 Weight of corms per hill

Weight of corms per hill as influenced by different treatments has been presented in table 4.15. Perusal of the experimental results revealed that weight of corms was significantly affected by the planting time. In the first year of experiment, maximum weight of corms per hill was recorded from T_{10} (84.87g) and minimum from T_5 (70.07g). During the second year of experiment, maximum was recorded from T_{10} (85.47g) followed by T_{11} (84.27g) which were

Table 4.15: Effect of planting time on corms parameters

parameters	Number of corms per hill			Weight of corms per hill (g)			Diameter of corm (cm)		
Treatment	**1st Year**	**2nd Year**	**Pooled**	**1st Year**	**2nd Year**	**Pooled**	**1st Year**	**2nd Year**	**Pooled**
T_1	1.07	1.07	1.07	80.27	77.73	79.00	6.36	6.17	6.26
T_2	1.00	1.07	1.03	81.00	81.80	81.40	6.34	6.33	6.33
T_3	1.07	1.00	1.03	78.93	75.20	77.07	6.17	6.07	6.12
T_4	1.00	1.07	1.03	73.67	75.80	74.73	5.96	6.13	6.05
T_5	1.07	1.07	1.07	70.07	73.73	71.90	5.77	5.90	5.83
T_6	1.00	1.13	1.07	73.00	71.53	72.27	5.30	5.25	5.28
T_7	1.13	1.00	1.07	76.40	74.53	75.47	5.41	5.54	5.48
T_8	1.07	1.13	1.10	76.53	78.20	77.37	5.86	5.80	5.83
T_9	1.13	1.07	1.10	78.73	80.40	79.57	6.33	6.36	6.35
T_{10}	1.27	1.13	1.20	84.87	85.47	85.17	6.82	6.76	6.79
T_{11}	1.07	1.07	1.07	82.27	84.27	83.27	6.67	6.38	6.53
T_{12}	1.07	1.00	1.03	81.47	82.40	81.93	6.49	6.23	6.36
Sem±	**0.06**	**0.06**	**0.04**	**0.70**	**0.83**	**0.54**	**0.04**	**0.04**	**0.03**
CD at 5%	**0.18**	**0.17**	**0.12**	**2.05**	**2.44**	**1.55**	**0.11**	**0.13**	**0.08**

statistically at par. Minimum was recorded from T_6 (71.53g). Pooled data analysis revealed that maximum weight of corms is recorded from T_{10} (85.17g) whereas, minimum from T_5 (71.90g) followed by T_6 (72.27g) which were statistically at par. Perusal of the result revealed that weight of corms is influenced by the number of leaf, leaf area and other field parameters as the treatments were in synchronizing terms with these parameters. The corms of gladiolus been the sink of photosynthesis, after flowering the photosynthates are directed towards the sink and stored there as food reserved for the next season growth. These findings are in accordance with the findings reported by Ahmad *et al*. (2014) and Ramzan *et al*. (2014) in gladiolus.

4.1.4.3 Diameter of corms

The data pertaining to diameter of corms per hill as influenced by different treatments has been presented in table 4.15. It is evident from the results that there was significant difference in the diameter of corms per hill as influenced by different planting time. During the first year of experiment, maximum was recorded from T_{10} (6.82 cm) and minimum from T_6 (5.30 cm). Similarly, during the second year of experiment minimum was recorded in T_6 (5.25 cm) and maximum in T_{10} (6.76 cm). Pooled data analysis revealed that minimum diameter of corms was recorded from T_6 (5.28 cm) and maximum from T_{10} (6.79 cm). The results of the experiment revealed that there is significant difference in the diameter of corms as influenced by different treatments. In general, the corms of winter months and early spring planting yielded larger diameter when compared to summer months planting. This may be attributed to the variation in agro-climate between different treatments. The leaves which are the sites of photosynthesis directly influenced the yield of corms which act as the sink of photosynthesis. Therefore, the plants which showed better vegetative characters as in October planting, ultimately accumulates higher photosynthates this may have leads to larger and heavier corms. These results were in conformity with the findings of Ahmad *et al*. (2014) and Ramzan *et al*. (2014) in gladiolus.

4.1.4.4 Number of cormels per hill

The data pertaining to number of cormels per hill as influenced by different treatments has been presented in table 4.16. It is evident from the results that there was significant difference in number of cormels per hill as influence by different planting time. During the first year of experiment, maximum number of cormels per hill was recorded from T_9 (11.80) followed by T_8 (10.73), T_{11} (10.07) and T_4 (9.87) which were statistically at par. Minimum was recorded from T_6 (5.80) which is closely followed by T_3 (5.87). In the second year of experiment, maximum number of cormels per hill was yielded from T_3 (11.07) followed by T_4 (10.93) and T_1 (10.33) whereas, minimum was recorded from T_{11} (6.80). From the pooled data analysis it is clear that maximum was yielded from T_9 (10.53) closely followed by T_4 (10.40) and minimum from T_6 (6.57).

4.1.4.5 Weight of cormels per hill

Table 4.16 clearly expressed the experimental results pertaining to weight of cormels per hill as influenced by different treatments. In the first year of experiment, T_9 (2.84) recorded maximum whereas, minimum was recorded from T_2 (1.87) closely followed by T_3 (1.88). There was a significant difference between treatments although it was a small marginal difference. During the second year of experiment, variation between the maximum T_3 (3.27) and minimum T_8 (2.08) was recorded which were significantly different. Pooled data analysis revealed that there was no significant difference between treatments for the weight

Table 4.16: Effect of planting time on cormels parameters

parameters	Number of cormels per hill			Weight of cormels per hill (g)		
Treatment	**1st Year**	**2nd Year**	**Pooled**	**1st Year**	**2nd Year**	**Pooled**
T_1	6.27	10.33	8.30	2.03	3.07	2.55
T_2	7.93	9.33	8.63	1.87	2.49	2.18
T_3	5.87	11.07	8.47	1.88	3.27	2.57
T_4	9.87	10.93	10.40	2.28	2.78	2.53
T_5	6.40	8.13	7.27	2.24	2.61	2.43
T_6	5.80	7.33	6.57	1.97	2.35	2.16
T_7	8.07	9.60	8.83	2.47	2.71	2.59
T_8	10.73	7.27	9.00	2.74	2.08	2.41
T_9	11.80	9.27	10.53	2.84	2.18	2.51
T_{10}	6.47	9.07	7.77	2.11	3.25	2.68
T_{11}	10.07	6.80	8.43	2.54	2.42	2.48
T_{12}	7.93	9.13	8.53	2.07	2.54	2.31
Sem±	**1.18**	**1.18**	**0.83**	**0.24**	**0.31**	**0.19**
CD at 5%	**3.45**	**3.47**	**2.38**	**0.69**	**0.90**	**0.55**

of cormels per hill. However, maximum weight of cormels were recorded from T_6 (2.16) and maximum from T_{10} (2.68).

In the present study, September and October planting recorded uniform yield and were superior as compared to other months planting. This might be due to the favourable environmental condition prevailing during the cropping season which ultimately accumulates more photosynthates in sink, which leads to better performance with regards to number of cormels per hill and weight of cormels per hill. These findings were in corroboration with Ahmad *et al*. (2014) who reported September and October planting as optimum time for corms and cormels yield.

4.2 Experiment No. 2

The second experiment entitled "**Studies on effect of zinc and boron on performance of gladiolus"** the results pertaining to various parameters studied were discussed under following major heads

1. Growth parameters
2. Flowering parameters
3. Postharvest parameters
4. Yield parameters

4.2.1 Growth parameters

The progressive data recorded on growth parameters *viz*. days to first leaf emergence, number of leaves per plant, length of longest leaf, width of longest leaf, leaf area, leaf area index and plant height as affected by various treatments, have been elaborately discussed below.

4.2.1.1 Days to first leaf emergence

The data pertaining to days to first leaf emergence as influenced by different treatments has been presented in table 4.17. The variation in the days to leaf emergence ranged from 8.67 days to 8.93 days in 2016-17 and 8.47 days to 8.73 days in 2017-18. From the pooled data analysis it is observed that minimum days to leaf emergence is observed from T_6 at 8.57 days and maximum from T_1 at 8.83 days however, it could not reached the level of significance.

In the first year, corms of uniformly sprouted bubs are selected for planting and so uniformed sprouting were observed and statistically no significant difference between treatments. Days to leaf emergence were not affected by the treatments as the treatments were giving only at 3 leaves and 6 leaves stages of growth. During the second year, the corms stored in cold storage were used and uniformity was observed, however, T_6 ($ZnSO_4$ 0.2% + H_3BO_3 0.2%) recorded minimum days to leaf emergence at 8.47 days which is statistically significant although quite marginal from the maximum days recorded in T_1 (control) with 8.73 days. The marginal variation between treatments may be due to the slight differences in stored food materials within the corms, as the initial growth and development of gladiolus plant is dependent on the stored food of the corms. This may be attributed to the effect of zinc and boron during the first year trail which facilitates more photo-assimilates and stimulatory and catalytic effects on metabolic processes of corms leading to early leaf emergence. (Lahijie, 2012 and Khosa *et al*., 2011). These findings were in conformity with the findings of Khalifa *et al*. (2011) who reported that foliar spraying of zinc sulphate and boric acid significantly increased growth parameters.

Table 4.17: Effect of zinc and boron on sprouting, no. of leaf and length of leaf

parameters	Days to 1st leaf emergence			No. of leaves per plant			Length of longest leaf (cm)		
Treatment	**1st Year**	**2nd Year**	**Pooled**	**1st Year**	**2nd Year**	**Pooled**	**1st Year**	**2nd Year**	**Pooled**
T_1	8.93	8.73	**8.83**	8.80	8.87	**8.83**	64.07	63.43	**63.75**
T_2	8.80	8.53	**8.67**	8.53	8.67	**8.60**	65.47	64.47	**64.97**
T_3	8.93	8.67	**8.80**	9.27	9.13	**9.20**	68.07	67.97	**68.02**
T_4	8.80	8.53	**8.67**	9.07	9.13	**9.10**	67.73	68.23	**67.98**
T_5	8.73	8.60	**8.67**	9.20	9.27	**9.23**	67.53	68.63	**68.08**
T_6	8.67	8.47	**8.57**	8.60	8.93	**8.77**	66.07	68.60	**67.33**
T_7	8.93	8.60	**8.77**	8.93	8.80	**8.87**	64.60	67.70	**66.15**
T_8	8.73	8.67	**8.70**	8.80	8.73	**8.77**	63.67	66.03	**64.85**
T_9	8.73	8.60	**8.67**	9.07	8.87	**8.97**	63.00	65.73	**64.37**
Sem±	**0.19**	**0.08**	**0.10**	**0.09**	**0.22**	**0.12**	**0.94**	**0.69**	**0.58**
CD at 5%	**NS**	**0.23**	**NS**	**0.26**	**0.65**	**0.34**	**2.83**	**2.06**	**1.68**

4.2.1.2 Number of leaves per hill

The experimental result for number of leaves per hill has been presented in table 4.17. In the first year of experiment, maximum number of leaves was recorded in T_3 ($ZnSO_4$ 0.4%) at 9.27 numbers followed by T_5 (H_3BO_3 0.4%) at 9.20, T_4 (H_3BO_3 0.2%) and T_9 ($ZnSO_4$ 0.4% + H_3BO_3 0.4%) both at 9.07 numbers which were all statistically at par. Minimum number of leaves were recorded in T_2 ($ZnSO_4$ 0.2%) with 8.53 numbers. During the second year of experiment, maximum number of leaves was recorded from T_5 (H_3BO_3 0.4%) at 9.27 numbers and minimum from T_2 ($ZnSO_4$ 0.2%) with 8.67, the variation was quite marginal and could not reached the level of significance. Pooled data analysis however revealed that T_5 (H_3BO_3 0.4%) recorded maximum number of leaves with 9.23 followed by T_3 ($ZnSO_4$ 0.4%) at 9.20 numbers which were statistically at par.

From the result of the experiment, it is clear that variation in number of leaves is marginal, this may be due to the genetic factors determining the number of leaves to a very large extend. However, when zinc or boron are treated @4% concentration, there is marginal increased in number of leaves. This may be attributed to zinc and boron which plays vital roles in growth and development of plants as advocated by Lahijie (2012) and Khosa *et al*. (2011). Similar findings were also reported by Khalifa *et al*. (2011) on foliar application of zinc sulphate and boric acid significantly increased growth parameters in gladiolus.

4.2.1.3 Length of longest leaf

The data pertaining to length of longest leaf as influenced by different treatments has been presented in table 4.17. From the given result it is clear that there is significant difference between different treatments. The variation in length of longest leaf ranged from 63.00 cm to 67.73 cm in 2016-17 and 63.43 cm to 68.63 cm in 2017-18. From the analysis of pooled data, it is observed that maximum leaf length was obtained from T_5 (H_3BO_3 0.4%) (68.08 cm) which is closely followed by T_3 ($ZnSO_4$ 0.4%) (68.02 cm) and T_4 (H_3BO_3 0.2%) (67.98 cm) and T_6 ($ZnSO_4$ 0.2% + H_3BO_3 0.2%) (67.33 cm) which were all statistically at par while minimum leaf length (63.75 cm) was recorded in control.

It is evident from the present investigation that foliar application of zinc and boron positively influences the length of leaves. This may be attributed to the role of zinc and boron which plays crucial role in many plant functions (Broadley, 2007) leading to better performance and expressed longer leave length when compared to control. Similar findings were also reported by Khalifa *et al*. (2011) on foliar application of zinc sulphate and boric acid in gladiolus.

4.2.1.4 Width of longest leaf

Analysis of the experimental data presented in table 4.18 showed significant difference between different treatments in both the years of investigation. In the first year of experiment, maximum width of longest leaf was recorded in T_6 ($ZnSO_4$ 0.2% + H_3BO_3 0.2%) (3.71 cm) and minimum was recorded from T_1 (control) (3.37 cm) which were significantly different. During the second year of experiment, maximum was recorded from T_3 ($ZnSO_4$ 0.4%) (3.77 cm) and minimum in T_1 (control) (3.42 cm) which show significant difference. From the pooled data of both the year, it is observed that minimum width of leaves was recorded in T_1 (control) (3.40 cm) and maximum width of leaves was recorded from T_3 ($ZnSO_4$ 0.4%) and T_6 ($ZnSO_4$ 0.2% + H_3BO_3 0.2%) both at same value of 3.70 cm and significantly different from control.

It is evident from the present investigation that foliar applications of zinc and boron have significant difference in width of longest leaf in gladiolus. Inference can be drawn from the result that foliar application of zinc 0.2% and boron 0.2% combination give better yield followed by single application either zinc or boron. This may be due to the importance of micronutrients in plant nutrition (Alloway, 2008). These findings were also supported by Halder *et al* (2007) who reported that B and Zn made promising response to the growth and floral characters of gladiolus.

4.2.1.5 Leaf area

Table 4.18 clearly expressed the experimental results pertaining to leaf area which showed significant difference between treatments.

During the first year trial, maximum leaf area was recorded from T_4 (H_3BO_3 0.2%) (146.56 cm^2) followed by T_3 ($ZnSO_4$ 0.4%) (144.06 cm^2), T_6 ($ZnSO_4$ 0.2% + H_3BO_3 0.2%) (143.29 cm^2), T_5 (H_3BO_3 0.4%) (141.04 cm^2) and T_7 ($ZnSO_4$ 0.2% + H_3BO_3 0.4%) (140.86 cm^2) which were statistically at par. Minimum was recorded from T_1 (control) (129.47 cm^2). During second year trail, maximum leaf area was recorded from T_7 ($ZnSO_4$ 0.2% + H_3BO_3 0.4%) (144.78 cm^2) closely followed by T_3 ($ZnSO_4$ 0.4%) (144.59 cm^2) and minimum was recorded from T_1 (control) (130.28 cm^2). From the pooled data analysis maximum was observed from T_4 (H_3BO_3 0.2%) (144.79 cm^2) closely followed by T_3 ($ZnSO_4$ 0.4%) (144.32 cm^2), T_7 ($ZnSO_4$ 0.2% + H_3BO_3 0.4%) (142.82 cm^2), T_6 ($ZnSO_4$ 0.2% + H_3BO_3 0.2%) (142.62 cm^2), and T_5 (H_3BO_3 0.4%) (142.18 cm^2) which were statistically at par. Minimum was again observed from control treatment with 129.87 cm^2.

It is evident from the presented data that foliar application of zinc and boron either in single or in combination increase the leaf area significantly. This may be due to the importance of micronutrients in plant nutrition (Alloway, 2008) which leads to increased in leaf area. These findings were also supported by Halder *et al* (2007) who reported that B and Zn made promising response to the growth and floral characters of gladiolus. Similar findings were also reported by Khalifa *et al*. (2011) on foliar spraying of zinc sulphate or boric acid alone at all rates and as combinations significantly increased growth parameters in gladiolus.

4.2.1.5 Leaf area index

The data pertaining to leaves area index as influenced by different treatments has been presented in table 4.18. It is evident from the results that there was significant difference for leaf area index as influence by foliar application of zinc and boron. In the first year of experiment, maximum leaf area index was recorded in T_3 ($ZnSO_4$ 0.4%) (1.71) followed by T_4 (H_3BO_3 0.2%) (1.69) and minimum was recorded from T_1 (control) (1.50). During the second year of experiment, maximum was recorded from T_4 (H_3BO_3 0.2%) (1.70) followed by T_3 ($ZnSO_4$ 0.4%) (1.68) and T_5 (H_3BO_3 0.4%) (1.68) which were statistically at par. Minimum was recorded from control with 1.50. From the analysis of pooled data it is observed that maximum leaf area index of 1.70 was recorded from T_4 (H_3BO_3 0.2%) and T_3 ($ZnSO_4$ 0.4%) followed by T_5 (H_3BO_3 0.4%) (1.68) and T_7 ($ZnSO_4$ 0.2% + H_3BO_3 0.4%) (1.64) which were statistically at par. Minimum leaf area index was recorded at 1.51 from T_1 (control).

Amongst the different treatment investigated during the studies, it was observed that foliar application of zinc and boron either in single or in combination increases the leaf area index significantly. This may be attributed to the function of zinc and boron in facilitating the morphological and metabolic

Table 4.18: Effect of zinc and boron on width of leaf, leaf area, leave area index and plant height

parameters	Width of longest leaf (cm)			Leaf area (cm^2)			Leave area index			Plant height (cm)		
Treatment	**1st Year**	**2nd Year**	**Pooled**	**1st Year**	**2nd Year**	**Pooled**	**1st Year**	**2nd Year**	**Pooled**	**1st Year**	**2nd Year**	**Pooled**
T_1	3.37	3.42	**3.40**	129.47	130.28	**129.87**	1.50	1.52	**1.51**	88.27	91.33	**89.80**
T_2	3.51	3.72	**3.62**	138.45	141.03	**139.74**	1.54	1.62	**1.58**	91.40	99.60	**95.50**
T_3	3.62	3.77	**3.70**	144.06	144.59	**144.32**	1.71	1.68	**1.70**	97.67	99.53	**98.60**
T_4	3.69	3.64	**3.67**	146.56	143.02	**144.79**	1.69	1.70	**1.70**	97.07	100.73	**98.90**
T_5	3.49	3.55	**3.52**	141.04	143.31	**142.18**	1.68	1.68	**1.68**	97.13	100.47	**98.80**
T_6	3.71	3.69	**3.70**	143.29	141.95	**142.62**	1.58	1.65	**1.62**	97.33	101.67	**99.50**
T_7	3.57	3.61	**3.59**	140.86	144.78	**142.82**	1.63	1.64	**1.64**	94.47	99.40	**96.93**
T_8	3.53	3.53	**3.53**	134.60	140.00	**137.30**	1.54	1.63	**1.59**	94.87	97.87	**96.37**
T_9	3.65	3.74	**3.69**	131.08	139.22	**135.15**	1.54	1.61	**1.58**	96.07	96.87	**96.47**
Sem±	**0.09**	**0.05**	**0.05**	**2.71**	**1.84**	**1.64**	**0.03**	**0.01**	**0.02**	**2.26**	**1.12**	**1.26**
CD at 5%	**0.27**	**0.16**	**0.15**	**8.13**	**5.52**	**4.72**	**0.10**	**0.04**	**0.05**	**6.79**	**3.36**	**3.64**

activities in plant growth and development (Lahijie, 2012 and Khosa *et al.*, 2011) which ultimately increases the leaf expansion and thus leading to better performance. On the other hand, the control treatment, been short of important micronutrients like zinc and boron, which adversely affected the performance of plants. This finding is in close conformity with the findings of Halder *et al* (2007) who reported that B and Zn made promising response to the growth characters of gladiolus.

4.2.1.6 Plant height

The data recorded for plant height is presented in table 4.18. The perusal of the first year experimental data indicated that T_3 ($ZnSO_4$ 0.4%) recorded maximum plant height (97.67 cm) which is statistically at par with all the treatments except the control which is minimum (88.27 cm). In the second year, maximum plant height was observed in T_6 ($ZnSO_4$ 0.2% + H_3BO_3 0.2%) (101.67 cm) followed by T_4 (H_3BO_3 0.2%) (100.73 cm) and T_5 (H_3BO_3 0.4%) (100.47 cm). Minimum was observed in control (91.33 cm). Pooled analysis of the two years data showed that maximum plant height was observed from T_6 ($ZnSO_4$ 0.2% + H_3BO_3 0.2%) (99.50 cm) which is statistically at par with most of the treatments, whereas, minimum plant height was recorded from T_1 (control) (89.80 cm).

Perusal of the experimental results revealed that foliar application of zinc and boron either in single or in combination increases the plant height significantly. It is evident from the results that zinc and boron combination ($ZnSO_4$ 0.2% + H_3BO_3 0.2%) gives the best performance. Moreover, single application of either zinc or boron and zinc and boron combination of different concentration increased plant height to level of significance. On the other hand, minimum performance was recorded in control treatment. This may be due to the zinc and boron which plays vital roles in growth and development of plants, due to their stimulatory and catalytic effects on metabolic processes also zinc plays a significant role in the production of biomass (Cakmak, 2008) which ultimately leads to increased plant height. These findings were in accordance with the report of Singh and Prasad (2014) in gladiolus. Similar findings were also supported by Halder *et al* (2007) and Khalifa *et al*. (2011) in gladiolus.

4.2.2 Flowering parameters

In floriculture industry, the commercial value of a flower crop is decided by specific quality attributes. In gladiolus, floral characters like days to spike emergence, colour break stage and floret opening decide the availability of flowers to the market demand. In addition, flower characters like spike length, rachis length, number of florets, diameter of florets and self life decides the value of flower spike. The present investigation showed flowering characters were significantly influenced by foliar application of zinc and boron.

4.2.2.1 Days to spike emergence

Days to spike emergence in gladiolus resulting from foliar application of zinc and boron at different concentrations and various combinations have shown in Table 4.19.

Foliar application of zinc and boron at different concentrations and various combinations showed significant effect on days to spike emergence in gladiolus. In 2016-17, minimum days to spikes emergence was recorded from T_6 ($ZnSO_4$ 0.2% + H_3BO_3 0.2%) (63.53 days) followed by T_5 (H_3BO_3 0.4%) (64.67 days), T_4 (H_3BO_3 0.2%) (64.80 days) and T_3 ($ZnSO_4$ 0.4%) (64.93 days) which were statistically at par. Maximum days to spike emergence was recorded from T_1

(control) (67.23 days). In 2017-18, minimum days to spike emergence was recorded from T_5 (H_3BO_3 0.4%) (63.13 days) closely followed by T_6 ($ZnSO_4$ 0.2% + H_3BO_3 0.2%) (63.55 days) and T_3 ($ZnSO_4$ 0.4%) (64.68 days) which were statistically at par. Analysis of pooled data revealed that T_6 ($ZnSO_4$ 0.2% + H_3BO_3 0.2%) took minimum days (63.54 days) to spike emergence which is statistically at par with T_5 (H_3BO_3 0.4%) which took 63.90 days and T_3 ($ZnSO_4$ 0.4%) (64.81 days). Maximum days to spike emergence (67.27 days) was recorded control.

The results of the present study indicate that early spikes emergence were observed from zinc and boron combination T_6 ($ZnSO_4$ 0.2% + H_3BO_3 0.2%) followed by T_5 (H_3BO_3 0.4%) and T_3 ($ZnSO_4$ 0.4%), moreover, foliar application of zinc and boron either in single or in combination at different concentration increases the plant height significantly. On the other hand, the control treatment, showed late response to spike emergence. This early spike emergence in T_6 ($ZnSO_4$ 0.2% + H_3BO_3 0.2%) may be ascribe to the role of zinc been crucial component of almost 60 enzymes (Broadley, 2007) boron been involves in metabolism and transport of carbohydrates, regulation of meristematic tissue cell synthesis and growth regulatory metabolism (Skukla *et al*. 2009) and boron ensure effective sugar transportation within the plants (Aboyeji *et al*. 2019). Ultimately this lead to better growth and development and prepared the plant for early transformation of vegetative parts to floral primordia. Similar findings were reported by Reddy and Chaturvedi (2009) on interaction effect of boron and zinc for days to flowering in gladiolus. Khalifa *et al*. (2011) also reported that the foliar spraying of zinc sulphate or boric acid alone at all rates and as combinations significantly increased flowers characteristics.

Table 4.19: Effect of zinc and boron on spike emergence and length of spike and rachis

parameters	Days to spike emergence			Length of spike (cm)			Length of rachis (cm)		
Treatment	**1st Year**	**2nd Year**	**Pooled**	**1st Year**	**2nd Year**	**Pooled**	**1st Year**	**2nd Year**	**Pooled**
T_1	67.23	67.30	**67.27**	72.83	74.83	**73.83**	35.52	38.87	**37.19**
T_2	66.30	65.87	**66.08**	81.87	92.53	**87.20**	39.27	50.10	**44.68**
T_3	64.93	64.68	**64.81**	81.27	92.33	**86.80**	40.40	52.17	**46.28**
T_4	64.80	65.32	**65.06**	84.40	92.73	**88.57**	41.13	52.43	**46.78**
T_5	64.67	63.13	**63.90**	80.80	90.47	**85.63**	39.60	50.90	**45.25**
T_6	63.53	63.55	**63.54**	85.20	94.33	**89.77**	42.60	54.43	**48.52**
T_7	66.50	66.20	**66.35**	78.23	92.63	**85.43**	40.87	53.67	**47.27**
T_8	66.17	65.03	**65.60**	81.10	92.07	**86.58**	41.60	53.17	**47.38**
T_9	66.10	67.07	**66.58**	77.87	90.20	**84.03**	37.67	48.67	**43.17**
Sem±	**0.84**	**0.58**	**0.51**	**1.17**	**0.75**	**0.70**	**1.87**	**1.06**	**1.08**
CD at 5%	**2.52**	**1.75**	**1.47**	**3.52**	**2.25**	**2.01**	**5.61**	**3.18**	**3.10**

Plate 4. General view of experimental field at flowering stage

Plate 5. Staking of individual plants and plots

4.2.2.2 Days to colour break

Days to colour break was significantly influenced by foliar application of zinc and boron as presented in table 4.20. Days to colour break stage of 1^{st} floret, results of pooled data analysis showed minimum from T_6 ($ZnSO_4$ 0.2% + H_3BO_3 0.2%) (72.42 days) and maximum in control (76.48 days). Days to colour break stage of 3^{rd} floret is in parallel with that of the 1^{st} floret. Pooled data analysis revealed that minimum days to colour break stage of 3^{rd} floret was observed from T_6 ($ZnSO_4$ 0.2% + H_3BO_3 0.2%) (73.28 days) and maximum from control (77.33 days). Days to colour break stage of 5^{th} floret also strictly follows the 1^{st} and 3^{rd} floret patterns. Pooled data analysis revealed that minimum days to colour break stage of 5^{th} floret was observed from T_6 ($ZnSO_4$ 0.2% + H_3BO_3 0.2%) (74.22 days).

The results of the present study indicate that early days to colour break stage of florets were observed in T_6 ($ZnSO_4$ 0.2% + H_3BO_3 0.2%) followed by T_5 (H_3BO_3 0.4%) and T_3 ($ZnSO_4$ 0.4%), moreover, foliar application of zinc and boron either in single or in combination at different concentration resulted to early days to colour break of florets significantly. It is evident from the results that the sequence of colour break moves acropetally and uniformity in the sequence of colour break is observed across treatments. This earliness in colour break stage of florets may be attributed to the role of zinc been crucial component of almost 60 enzymes (Broadley, 2007) which act as stimulatory and catalytic effects on metabolic processes and ultimately on promotes flowering characteristics (Lahijie, 2012) and (Khosa *et al*., 2011). Similar findings were reported by Khalifa *et al*. (2011) that the foliar spraying of zinc sulphate or boric acid alone at all rates and as combinations significantly increased flowers characteristics.

Table 4.20: Effect of zinc and boron on days to colour break stage of florets

parameters	Days to colour break stage of 1^{st} floret			Days to colour break stage of 3^{rd} floret			Days to colour break stage of 5^{th} floret		
Treatment	**1st Year**	**2nd Year**	**Pooled**	**1st Year**	**2nd Year**	**Pooled**	**1st Year**	**2nd Year**	**Pooled**
T_1	76.67	76.30	**76.48**	77.50	77.17	**77.33**	78.43	77.93	**78.18**
T_2	75.93	75.58	**75.76**	76.50	76.43	**76.47**	77.37	77.30	**77.33**
T_3	74.07	73.73	**73.90**	74.80	74.67	**74.73**	75.73	75.53	**75.63**
T_4	73.87	74.43	**74.15**	74.63	75.33	**74.98**	75.57	76.23	**75.90**
T_5	74.07	72.13	**73.10**	74.97	73.20	**74.08**	75.97	74.10	**75.03**
T_6	72.13	72.70	**72.42**	72.93	73.63	**73.28**	73.90	74.53	**74.22**
T_7	76.20	75.77	**75.98**	76.97	76.67	**76.82**	77.90	77.53	**77.72**
T_8	75.60	74.17	**74.88**	76.37	75.07	**75.72**	77.30	75.93	**76.62**
T_9	75.60	75.97	**75.78**	76.37	76.90	**76.63**	77.33	77.80	**77.57**
Sem±	**0.97**	**0.59**	**0.57**	**0.95**	**0.58**	**0.56**	**0.94**	**0.56**	**0.55**
CD at 5%	**2.90**	**1.78**	**1.63**	**2.86**	**1.73**	**1.61**	**2.83**	**1.69**	**1.59**

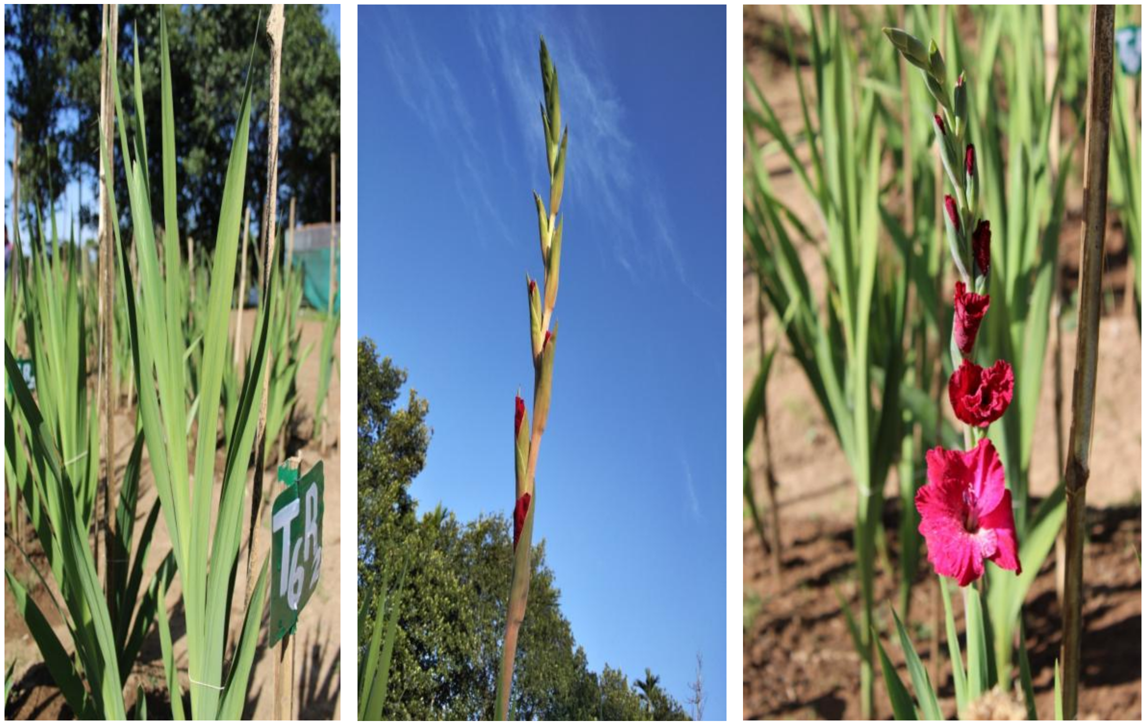

Plate 6. Spike initiation, colour break and 1st floret opening stages

4.2.2.3 Length of spike

The data pertaining to length of spike as influenced by different treatments has been presented in table 4.19. It is evident from the results that there was significant difference in length of spike as influence by foliar application of zinc and boron. In the first year of experiment, maximum length of spike was recorded from T_6 ($ZnSO_4$ 0.2% + H_3BO_3 0.2%) (85.20 cm) followed by T_4 (H_3BO_3 0.2%) (74.40 cm) which were statistically at par. Minimum length of spike was recorded in T_1 (control) with 72.83 cm. In the second year of experiment, similar results were recorded with maximum length of spike from T_6 ($ZnSO_4$ 0.2% + H_3BO_3 0.2%) (94.33 cm) and minimum from T_1 (control) (74.83 cm). The results from pooled data analysis showed that T_6 ($ZnSO_4$ 0.2% + H_3BO_3 0.2%) (89.77 cm) yielded maximum length of spike followed by T_4 (H_3BO_3 0.2%) (88.57 cm). Whereas, minimum length of spike was recorded in T_1 (control) (73.83 cm).

From the experimental results it is evident that foliar application of zinc and boron either in single or in combination at different concentration yielded longer length of spikes significantly. However, control treatment could not perform satisfactorily when compared to other treatments. The increased in length of spikes may be ascribe to the role of zinc been crucial component of almost 60 enzymes (Broadley, 2007) boron been involves in metabolism and transport of carbohydrates, regulation of meristematic tissue cell synthesis and growth regulatory metabolism (Skukla *et al*. 2009) and boron ensure effective sugar transportation within the plants (Aboyeji *et al*. 2019). Ultimately this lead to better growth and development and resulted to longer length of spikes. Similar findings were reported by Khalifa *et al*. (2011) that the foliar spraying of zinc sulphate or boric acid alone at all rates and as combinations significantly increased flowers characteristics. Foliar spraying with boron or zinc had a significant effect on increasing the length of flower stalk (Mohammed and Khalid, 2019).

4.2.2.4 Length of rachis

The experimental result for length of rachis has been presented in table 4.19. From the given result it is clear that there is significant difference between different treatments.

In the first year of experiment, maximum length of rachis was recorded from T_6 ($ZnSO_4$ 0.2% + H_3BO_3 0.2%) (42.60 cm) followed by T_8 ($ZnSO_4$ 0.4% + H_3BO_3 0.2%) (41.60 cm) and T_4 (H_3BO_3 0.2%) (41.13 cm) which were statistically at par with all other treatments except T_1 (Control) (35.52 cm). In the second year of experiment, similar results were recorded with maximum length of rachis from T_6 ($ZnSO_4$ 0.2% + H_3BO_3 0.2%) (54.43 cm) and minimum from T_1 (control) (38.87 cm). The results from pooled data analysis showed that T_6 ($ZnSO_4$ 0.2% + H_3BO_3 0.2%) (48.52 cm) yielded maximum length of rachis, whereas, minimum length of rachis was recorded in T_1 (control) (37.19 cm) which was significantly different from all other treatments.

From the inference it is evident that foliar application of zinc and boron either in single or in combination at different concentration yielded longer length of rachis significantly. This result is in close proximity with the length of spike and the attribution to this may be due to similar reasons. Similar findings were reported by Halder *et al.* (2007a) in gladiolus.

4.2.2.5 Number of florets per spike

Table 4.23 clearly expressed the experimental results pertaining to number of florets per spike which showed significant difference between treatments. In the first year of experiment, T_6 ($ZnSO_4$ 0.2% + H_3BO_3 0.2%) (14.53) recorded maximum number of florets per spike. Minimum number of florets per spike was recorded from T_1 (control) (13.07) followed by T_2 ($ZnSO_4$ 0.2%) and T_9 ($ZnSO_4$ 0.4% + H_3BO_3 0.4%) with same value (13.80) which were statistically at par. During second year, maximum was recorded from T_5 (H_3BO_3 0.4%) (17.13) and T_7 ($ZnSO_4$ 0.2% + H_3BO_3 0.4%) (17.13) which were significantly different from other treatments. Minimum was recorded from T_1 (control) (13.20) and also statistically different from all other treatments. Result of the pooled data showed maximum number of florets per spike in T_7 ($ZnSO_4$ 0.2% + H_3BO_3 0.4%) (15.67) closely followed by T_6 ($ZnSO_4$ 0.2% + H_3BO_3 0.2%) (15.60), T_5 (H_3BO_3 0.4%) (15.57) and T_8 ($ZnSO_4$ 0.4% + H_3BO_3 0.2%) (15.57) which were statistically at par. Minimum was recorded from control (13.13).

In the present study, it was observed that number of florets increased significantly in the second year compared to first year. This may be due to the difference in corms size and quality as the second year corms as compared to the first year which were not treated with zinc and boron. The significant difference between treatments may be attributed to the vital role of zinc and boron in plant morphology and metabolic activities which leads to ultimate increased on flower yield (Lahijie, 2012) and quality (Khosa *et al.*, 2011). These findings were in corroboration with the findings of Fahad et al. (2014) and Mohammed and Khalid (2019) in gladiolus.

4.2.2.6 Days to opening of floret

The data pertaining to days to opening of florets as influenced by different treatments has been presented in table 4.21. It is evident from the results that there was significant difference in days to opening of florets as influence by foliar application of zinc and boron. Pooled data analysis of 1st floret showed minimum from T_5 (H_3BO_3 0.4%) (75.10 days) and maximum in control (79.68 days). Days to opening of 3rd floret is in parallel with that of the 1st floret. Pooled data analysis revealed that minimum was observed from T_5 (H_3BO_3 0.4%) (76.40 days) and maximum. Days to opening of 5th floret also strictly follows the 1st and 3rd floret patterns. Pooled data analysis revealed that minimum days to opening of 5th floret was observed from T_5 (H_3BO_3 0.4%) (77.83 days).

Perusal of the experimental results indicate foliar application of zinc and boron either in single or in combination at different concentration resulted to early days to opening of florets significantly except T_9 ($ZnSO_4$ 0.4% + H_3BO_3 0.4%) this may be due to excess of zinc and boron in plant leading to slightly slower maturity as reported by Halder *et al*. (2007b) that subsequent addition of B and Zn beyond that level ($B_{2.0}Zn_{3.0}$ kg/ha) depressed the flower yield. On the other hand, the control treatment, showed late response to days to opening of florets. It is evident from the results that the sequence of opening of florets moves acropetally and uniformity in the sequence of flowering is observed across treatments. This earliness in opening of florets may be attributed to the role of zinc been crucial component of almost 60 enzymes (Broadley, 2007) which act as stimulatory and catalytic effects on metabolic processes and ultimately on promotes flowering characteristics (Lahijie, 2012) and (Khosa *et al*., 2011). Similar findings were reported by Khalifa *et al*. (2011) that the foliar spraying of zinc sulphate or boric acid alone at all rates and as combinations significantly increased flowers characteristics.

Table 4.21: Effect of zinc and boron on days to opening of florets

parameters	Days to opening of 1st floret			Days to opening of 3rd floret			Days to opening of 5th floret		
Treatment	**1st Year**	**2nd Year**	**Pooled**	**1st Year**	**2nd Year**	**Pooled**	**1st Year**	**2nd Year**	**Pooled**
T_1	79.87	79.50	**79.68**	81.33	80.93	**81.13**	82.93	82.27	**82.60**
T_2	77.93	77.58	**77.76**	79.40	78.80	**79.10**	80.93	79.93	**80.43**
T_3	76.47	76.13	**76.30**	77.87	77.40	**77.63**	79.13	78.93	**79.03**
T_4	76.67	77.23	**76.95**	78.17	78.47	**78.32**	79.53	79.60	**79.57**
T_5	76.07	74.13	**75.10**	77.47	75.33	**76.40**	78.80	76.87	**77.83**
T_6	75.27	75.50	**75.38**	76.67	76.73	**76.70**	78.07	78.00	**78.03**
T_7	78.80	78.37	**78.58**	79.87	79.53	**79.70**	80.27	80.80	**80.53**
T_8	77.60	76.17	**76.88**	78.73	77.20	**77.97**	80.87	78.40	**79.63**
T_9	78.80	79.17	**78.98**	79.93	80.20	**80.07**	81.47	81.73	**81.60**
Sem±	**0.92**	**0.59**	**0.55**	**0.85**	**0.58**	**0.52**	**0.77**	**0.55**	**0.47**
CD at 5%	**2.75**	**1.78**	**1.57**	**2.56**	**1.74**	**1.49**	**2.30**	**1.64**	**1.36**

4.2.2.7 Diameter of florets

The data pertaining to diameter of florets as influenced by different treatments has been presented in table 4.22. From the pooled data analysis, maximum diameter of 1st florets was observed from T_7 ($ZnSO_4$ 0.2% + H_3BO_3 0.4%) (11.67 cm) and minimum in control (10.35 cm). Diameter of 3rd floret is in parallel with that of the 1st floret. Pooled data analysis revealed maximum from T_7 ($ZnSO_4$ 0.2% + H_3BO_3 0.4%) (11.33 cm). Diameter of 5th floret also strictly follows the 1st and 3rd floret patterns. Pooled data analysis revealed that maximum diameter of 5th floret was observed from T_7 ($ZnSO_4$ 0.2% + H_3BO_3 0.4%) (11.09 cm) followed by T_5 (H_3BO_3 0.4%) (10.89 cm). Whereas, minimum was recorded from control (9.42 cm).

Perusal of the experimental results indicates that foliar application of zinc and boron either in single or in combination at different concentration yielded larger florets significantly. On the other hand, the control treatment, showed poor performance in diameter of florets when compared to others. It is evident from the results that the diameter of florets diminishes from base to top with the largest floret been the 1st floret as observed across treatments. The variation in diameter of florets between treatments may be attributed to the functions of zinc which act as stimulatory and catalytic effects on metabolic processes and ultimately on promotes flower yield (Lahijie, 2012) and quality (Khosa *et al*., 2011) and boron been effective in sugar transportation within plants (Aboyeji *et al*. 2019). As a result, the performance of plant is enhanced and due to which luxury growth on flower lamina is achieved and expressed larger diameter of florets. Similar findings were reported by Khalifa *et al*. (2011) that the foliar spraying of zinc sulphate or boric acid alone at all rates and as combinations significantly increased flowers characteristics.

Table 4.22: Effect of zinc and boron on diameter of florets

parameters	Diameter of 1st floret (cm)			Diameter of 3rd floret (cm)			Diameter of 5th floret (cm)		
Treatment	**1st Year**	**2nd Year**	**Pooled**	**1st Year**	**2nd Year**	**Pooled**	**1st Year**	**2nd Year**	**Pooled**
T_1	10.24	10.46	**10.35**	9.48	9.77	**9.63**	9.28	9.56	**9.42**
T_2	10.88	11.06	**10.97**	10.35	10.64	**10.50**	10.15	10.34	**10.25**
T_3	10.79	11.56	**11.17**	10.29	11.15	**10.72**	9.99	10.88	**10.44**
T_4	10.73	11.52	**11.13**	10.37	11.11	**10.74**	10.17	10.82	**10.50**
T_5	10.75	12.19	**11.47**	10.52	11.76	**11.14**	10.32	11.46	**10.89**
T_6	11.02	11.73	**11.37**	10.15	11.30	**10.73**	9.75	11.00	**10.38**
T_7	11.24	12.09	**11.67**	10.97	11.68	**11.33**	10.77	11.40	**11.09**
T_8	10.53	12.02	**11.28**	10.17	11.59	**10.88**	9.97	11.30	**10.63**
T_9	10.50	11.66	**11.08**	9.93	11.22	**10.58**	9.53	10.91	**10.22**
Sem±	**0.23**	**0.13**	**0.13**	**0.27**	**0.15**	**0.15**	**0.27**	**0.14**	**0.15**
CD at 5%	**0.70**	**0.38**	**0.38**	**0.81**	**0.44**	**0.44**	**0.80**	**0.43**	**0.44**

4.2.2.8 Self life

The experimental result for self life has been presented in table 4.23. It is evident from the results that there was significant difference in self life as influence by different treatment. In the first year of experiment maximum self life was recorded from T_7 ($ZnSO_4$ 0.2% + H_3BO_3 0.4%) (16.47 days) followed by T_4 (H_3BO_3 0.2%) (16.40 days) and T_8 ($ZnSO_4$ 0.4% + H_3BO_3 0.2%) (16.40 days) and T_6 ($ZnSO_4$ 0.2% + H_3BO_3 0.2%) (16.33 days), T_5 (H_3BO_3 0.4%) (16.13 days) and T_3 ($ZnSO_4$ 0.4%) (16.00 days) which were statistically at par. Minimum self life was recorded from T_1 (control) (13.73 days). During the second year of experiment, maximum self life was recorded from T_5 (H_3BO_3 0.4%) (17.98 days) followed by T_7 ($ZnSO_4$ 0.2% + H_3BO_3 0.4%) (17.91 days), T_8 ($ZnSO_4$ 0.4% + H_3BO_3 0.2%) (17.82 days) and T_6 ($ZnSO_4$ 0.2% + H_3BO_3 0.2%) (17.62 days) which were statistically at par. Minimum self life was recorded from T_1 (control) (14.20 days). From the pooled data analysis, maximum self life was recorded from T_7 ($ZnSO_4$ 0.2% + H_3BO_3 0.4%) (15.07 days) followed by T_8 ($ZnSO_4$ 0.4% + H_3BO_3 0.2%) (17.11 days), T_5 (H_3BO_3 0.4%) (17.06 days) and T_6 ($ZnSO_4$ 0.2% + H_3BO_3 0.2%) (16.98 days) which were statistically at par. Minimum self life was recorded from T_1 (control) (13.97 days).

It is evident from experimental results that foliar application of zinc and boron either in single or in combination at different concentration resulted to longer self life of gladiolus. On the other hand, poor self life was observed in control treatment. The self life of gladiolus spikes were influenced by other parameters as well. Number of florets and diameter of florets directly affects the self life of spikes. The larger diameter and higher number of florets resulted to longer self life as well. The prolonged self life in zinc and boron treated plants may be attributed to the role of zinc and boron which enhanced the flower yield

Table 4.23: Effect of zinc and boron on no. of florets per spike and self life

parameters	Number of florets per spike			Self life (days)		
Treatment	**1st Year**	**2nd Year**	**Pooled**	**1st Year**	**2nd Year**	**Pooled**
T_1	13.07	13.20	**13.13**	13.73	14.20	**13.97**
T_2	13.80	15.13	**14.47**	15.47	16.18	**15.82**
T_3	14.13	15.87	**15.00**	16.00	17.11	**16.56**
T_4	14.20	15.53	**14.87**	16.40	16.76	**16.58**
T_5	14.00	17.13	**15.57**	16.13	17.98	**17.06**
T_6	14.53	16.67	**15.60**	16.33	17.62	**16.98**
T_7	14.17	17.13	**15.65**	16.47	17.91	**17.19**
T_8	14.20	16.93	**15.57**	16.40	17.82	**17.11**
T_9	13.80	15.47	**14.63**	15.60	16.67	**16.13**
Sem±	**0.31**	**0.21**	**0.19**	**0.30**	**0.12**	**0.16**
CD at 5%	**0.93**	**0.63**	**0.54**	**0.89**	**0.37**	**0.46**

(Lahijie, 2012) and quality (Khosa *et al.*, 2011). Zinc provide defense against pathogens, decreased susceptibility to biotic and abiotic stresses (Cabot *et al*. 2019 and Noman *et al*. 2019) ultimately sustained flowering for longer duration. Similar findings were reported by Khalifa *et al*. (2011) that the foliar spraying of zinc sulphate or boric acid alone at all rates and as combinations significantly increased flowers characteristics.

4.2.3 Postharvest parameters

The results of postharvest studies as influences by different treatments exhibited significant variation with regards to postharvest qualities of cut spikes. The effect of foliar application of zinc and boron on the vase life of gladiolus in a standard vase solution was investigated in postharvest laboratory under normal room temperature and the results envisaged that most of the parameters are significantly influenced by different treatments.

4.2.3.1 Weight of spike

Data embodied in table 4.24 presents the effect of foliar application of zinc and boron on weight of spike. Significant variation as influenced by different treatment on changes in fresh weight of spikes was observed. The weight of spike on 1st day was recorded maximum from T_6 ($ZnSO_4$ 0.2% + H_3BO_3 0.2%) in both the years of experiment with 69.73g and 72.43g respectively. Results from pooled data shows maximum in T_6 ($ZnSO_4$ 0.2% + H_3BO_3 0.2%) (71.08g) which were statistically at par with all the treatment except the control. The results of the 3rd day is in parallel with the 1st day, Pooled data analysis show maximum from T_6 ($ZnSO_4$ 0.2% + H_3BO_3 0.2%) (80.22g). On the 6th day, similar results were observed, T_6 ($ZnSO_4$ 0.2% + H_3BO_3 0.2%) (82.58g) as best treatment. The results of the 9th day are in parallel with the readings of 1st, 3rd and 6th days,

Table 4.24: Effect of zinc and boron on weight of spikes

parameters	Weight of spike at 1st day (g)			Weight of spike at 3rd day (g)			Weight of spike at 6th day (g)			Weight of spike at 9th day (g)		
Treatment	**1st Year**	**2nd Year**	**Pooled**	**1st Year**	**2nd Year**	**Pooled**	**1st Year**	**2nd Year**	**Pooled**	**1st Year**	**2nd Year**	**Pooled**
T_1	62.67	65.00	**63.83**	71.80	74.13	**72.97**	73.40	75.73	**74.57**	64.00	66.33	**65.17**
T_2	67.97	70.60	**69.28**	77.10	79.73	**78.42**	79.10	81.73	**80.42**	70.10	72.73	**71.42**
T_3	68.20	70.87	**69.53**	77.33	80.00	**78.67**	79.53	82.20	**80.87**	70.80	73.47	**72.13**
T_4	69.47	72.10	**70.78**	78.60	81.23	**79.92**	80.53	83.17	**81.85**	71.63	74.27	**72.95**
T_5	63.87	66.67	**65.27**	73.00	75.80	**74.40**	75.07	77.87	**76.47**	66.53	69.33	**67.93**
T_6	69.73	72.43	**71.08**	78.87	81.57	**80.22**	81.23	83.93	**82.58**	72.53	75.23	**73.88**
T_7	67.60	70.27	**68.93**	76.73	79.40	**78.07**	78.97	81.63	**80.30**	70.30	72.97	**71.63**
T_8	66.97	69.50	**68.23**	76.10	78.63	**77.37**	78.50	81.03	**79.77**	69.83	72.37	**71.10**
T_9	67.63	70.03	**68.83**	76.77	79.17	**77.97**	79.03	81.43	**80.23**	70.17	72.57	**71.37**
Sem±	**1.66**	**1.65**	**1.17**	**1.66**	**1.65**	**1.17**	**1.60**	**1.58**	**1.13**	**1.62**	**1.61**	**1.14**
CD at 5%	**4.97**	**4.93**	**3.36**	**4.97**	**4.93**	**3.36**	**4.79**	**4.75**	**3.24**	**4.86**	**4.82**	**3.29**

T_6 ($ZnSO_4$ 0.2% + H_3BO_3 0.2%) (73.88g) recorded maximum which is statistically at par with other treatments except the T_1 (control) which recorded minimum weight with 65.17g.

From the experimental results, it was observed that foliar application of zinc and boron has significant difference on weight of spike. In general, it was observed that the changes in fresh weight of spikes showed sharp increased on the 3rd day from the initial weight and steadily increased further till 6th day, thereafter, the weight of spikes decreases sharply. Perusal from the experimental findings, inference may be made that pre harvest treatments have profound effects on post harvest characters. The treatment which performed well in field also performed well in post harvest studies. The fresh weight of spikes might have increased from better storage of photo assimilates in the spikes as micronutrient play significant role in the production of biomass (Cakmak, 2008). This finding is in line with the finding of Khalifa *et al*. (2011) in gladiolus.

4.2.3.2 Length of spike

Table 4.25 presents the effect of foliar application of zinc and boron on length of spike. Significant variation as influenced by different treatment on length of spikes was observed. The length of spike on 3rd day, results from pooled data shows minimum in T_1 (control) (82.83 cm) and maximum in T_6 ($ZnSO_4$ 0.2% + H_3BO_3 0.2%) (85.00 cm). On the 6th day, similar results were observed, maximum was recorded from T_6 ($ZnSO_4$ 0.2% + H_3BO_3 0.2%) (86.10 cm). The results of the 9th day are in parallel with the readings of 3rd and 6th days. Results of the pooled data analysis show T_6 ($ZnSO_4$ 0.2% + H_3BO_3 0.2%) (87.13 cm) recorded maximum and minimum length of spike was recorded from control (84.63 cm).

Table 4.25: Effect of zinc and boron on length of spikes

parameters	Length of spike at 3rd day (cm)			Length of spike at 6th day (cm)			Length of spike at 9th day (cm)		
Treatment	**1st Year**	**2nd Year**	**Pooled**	**1st Year**	**2nd Year**	**Pooled**	**1st Year**	**2nd Year**	**Pooled**
T_1	82.67	83.00	**82.83**	83.60	83.93	**83.77**	84.47	84.80	**84.63**
T_2	83.83	84.67	**84.25**	84.93	85.77	**85.35**	85.97	86.80	**86.38**
T_3	83.33	84.17	**83.75**	84.37	85.20	**84.78**	85.30	86.13	**85.72**
T_4	84.00	84.67	**84.33**	85.17	85.83	**85.50**	86.23	86.90	**86.57**
T_5	84.33	84.83	**84.58**	85.50	86.00	**85.75**	86.53	87.03	**86.78**
T_6	84.83	85.17	**85.00**	85.93	86.27	**86.10**	86.97	87.30	**87.13**
T_7	84.00	84.83	**84.42**	85.10	85.93	**85.52**	86.10	86.93	**86.52**
T_8	83.67	84.67	**84.17**	84.77	85.77	**85.27**	85.80	86.80	**86.30**
T_9	83.00	83.33	**83.17**	84.03	84.37	**84.20**	84.97	85.30	**85.13**
Sem±	**0.35**	**0.34**	**0.24**	**0.36**	**0.35**	**0.25**	**0.37**	**0.36**	**0.26**
CD at 5%	**1.04**	**1.02**	**0.70**	**1.07**	**1.04**	**0.72**	**1.11**	**1.08**	**0.74**

From the experimental results, it was observed that foliar application of zinc and boron has significant difference on length of spike. In general, it was observed that the length of spikes showed steady and uniform increased till 9th day of the study. Perusal from the experimental findings, inference may be made that pre harvest treatments have profound effects on post harvest characters. The treatment which performed well in field also performed well in post harvest studies. The length of spikes might have increased from better storage of photo assimilates in the spikes as micronutrient play significant role in the production of biomass (Cakmak, 2008). This finding is in line with the finding of Khalifa *et al*. (2011) in gladiolus.

4.2.3.3 Longevity of florets

Data embodied in table 4.26 presents the effect of foliar application of zinc and boron on longevity of florets. Significant variation as influenced by different treatment on longevity of florets was observed. The longevity of 1st florets was recorded maximum in T_3 ($ZnSO_4$ 0.4%), T_5 (H_3BO_3 0.4%) and T_6 ($ZnSO_4$ 0.2% + H_3BO_3 0.2%) with same value of 5.67 days. The longevity of 3rd florets is in parallel with the 1st florets, pooled data analysis show maximum from T_3 ($ZnSO_4$ 0.4%), T_5 (H_3BO_3 0.4%) and T_6 ($ZnSO_4$ 0.2% + H_3BO_3 0.2%) with same value of 6.67 days. The longevity of 5th florets as presented in table 4.26. it is clear from the results that minimum days to longevity of 5th florets was recorded from T_1 (control) with 6.33 days and maximum from T_3 ($ZnSO_4$ 0.4%), T_5 (H_3BO_3 0.4%), T_6 ($ZnSO_4$ 0.2% + H_3BO_3 0.2%) and T_9 ($ZnSO_4$ 0.4% + H_3BO_3 0.4%) with 8.00 days.

Perusal of the experimental result revealed that foliar application of zinc and boron has significant difference on longevity of florets. The longevity of 5th florets clearly expressed the effect of zinc and boron in post harvest qualities of

Table 4.26: Effect of zinc and boron on longevity of florets

parameters	Longevity of 1st floret (days)			Longevity of 3rd floret (days)			Longevity of 5th floret (days)		
Treatment	**1st Year**	**2nd Year**	**Pooled**	**1st Year**	**2nd Year**	**Pooled**	**1st Year**	**2nd Year**	**Pooled**
T_1	4.33	4.67	**4.50**	5.33	5.67	**5.50**	6.33	6.33	**6.33**
T_2	5.00	5.00	**5.00**	6.00	6.00	**6.00**	7.67	7.67	**7.67**
T_3	5.67	5.67	**5.67**	6.67	6.67	**6.67**	8.00	8.00	**8.00**
T_4	4.33	4.67	**4.50**	5.33	5.67	**5.50**	6.67	7.33	**7.00**
T_5	5.67	5.67	**5.67**	6.67	6.67	**6.67**	8.00	8.00	**8.00**
T_6	5.67	5.67	**5.67**	6.67	6.67	**6.67**	8.00	8.00	**8.00**
T_7	4.33	4.67	**4.50**	5.33	5.67	**5.50**	6.67	7.00	**6.83**
T_8	5.00	5.33	**5.17**	6.00	6.00	**6.00**	7.33	7.67	**7.50**
T_9	5.33	5.33	**5.33**	6.33	6.33	**6.33**	8.00	8.00	**8.00**
Sem±	**0.36**	**0.33**	**0.25**	**0.36**	**0.34**	**0.25**	**0.21**	**0.23**	**0.15**
CD at 5%	**1.09**	**0.99**	**0.71**	**1.09**	**1.03**	**0.72**	**0.63**	**0.68**	**0.45**

spikes. It is evident that the control treatment fails to prolong the longevity of 5^{th} florets. On the other hand, the longevity of 5^{th} florets was significantly prolonged by zinc and boron treatments. These may be attributed to the contribution of zinc and boron on the phytohormones (Lahijie, 2012) and photo assimilates (Aboyeji *et al*. 2019) which will regulate the metabolic activities and prolong flowering. These findings are in accordance with the reports of Khalifa *et al*. (2011) in gladiolus.

4.2.3.4 Days to opening of 50% florets

Days to opening of 50% florets as influenced by foliar application of zinc and boron were presented in table 4.27. In the first year of the experiment, minimum days to opening of 50% florets was recorded from T_1 (control) (4.00 days) and maximum from T_5 (H_3BO_3 0.4%) and T_6 ($ZnSO_4$ 0.2% + H_3BO_3 0.2%) with 5.00 days which could not reached the level of significance. During the second year of experiment, minimum was recorded from T_1 (control) (4.33 days) and maximum from T_6 ($ZnSO_4$ 0.2% + H_3BO_3 0.2%) (5.33 days) which was statistically at par with all other treatment except with T_1 (control). Pooled data analysis also showed similar trend with minimum from T_1 (control) (4.17 days) and maximum with T_6 ($ZnSO_4$ 0.2% + H_3BO_3 0.2%) (5.17 days). This variation may be attributed to the actions of zinc and boron which enhanced the flower quality (Khosa *et al*., 2011). Similar findings were reported by Singh and Prasad (2014) in gladiolus.

4.2.3.5 Number of florets opened at a time

Table 4.27 clearly expressed the experimental results pertaining to number of florets opened at a time which showed significant difference between treatments. In the first year of experiment, T_4 (H_3BO_3 0.2%) (8.00) recorded maximum while minimum was recorded from T_1 (control) (6.33) and T_8 ($ZnSO_4$

Table 4.27: Effect of zinc and boron on 50% florets opening, no. of florets and total no. of florets opened in vase

parameters	Days to opening of 50% florets			Number of florets opened at a time		
Treatment	**1st Year**	**2nd Year**	**Pooled**	**1st Year**	**2nd Year**	**Pooled**
T_1	4.00	4.33	**4.17**	6.33	6.00	**6.17**
T_2	4.67	5.00	**4.83**	6.67	7.00	**6.83**
T_3	4.67	4.67	**4.67**	7.33	7.33	**7.33**
T_4	4.33	5.00	**4.67**	8.00	7.67	**7.83**
T_5	5.00	5.00	**5.00**	7.33	7.67	**7.50**
T_6	5.00	5.33	**5.17**	7.00	6.67	**6.83**
T_7	4.33	4.67	**4.50**	7.00	7.00	**7.00**
T_8	4.33	4.67	**4.50**	6.33	7.00	**6.67**
T_9	4.67	4.67	**4.67**	7.00	7.33	**7.17**
Sem±	**0.35**	**0.29**	**0.22**	**0.44**	**0.39**	**0.29**
CD at 5%	**NS**	**0.86**	**0.65**	**1.31**	**1.17**	**0.84**

0.4% + H_3BO_3 0.2%) (6.33). During second year, maximum was recorded from T_4 (H_3BO_3 0.2%) and T_5 (H_3BO_3 0.4%) with 7.67 numbers whereas, minimum was recorded from T_1 (control) (6.00). Result of the pooled data showed maximum number of florets opened at a time in T_4 (H_3BO_3 0.2%) (7.78) followed by T_5 (H_3BO_3 0.4%) (7.50), T_3 ($ZnSO_4$ 0.4%) (7.33), T_9 ($ZnSO_4$ 0.4% + H_3BO_3 0.4%) (7.17) and T_7 ($ZnSO_4$ 0.2% + H_3BO_3 0.4%) (7.00) which were statistically at par. Minimum was recorded in T_1 (control) (6.17).

In the present study, it was observed that number of florets opened at a time increased significantly by foliar application of zinc and boron. These pre harvest treatment which promotes field parameters significantly influenced the post harvest studies as well. The presence of zinc and boron in cut spikes for post harvest studies increase the enzymatic and metabolic activities of spikes leading to greater absorption of water thus maintaining turgidity and delayed senescence. These findings are in accordance with Singh and Prasad (2014) and Khalifa *et al*. (2011) in gladiolus.

4.2.3.6 Solution uptake

The data pertaining to solution uptake as influenced by different treatments has been presented in table 4.28. It is evident from the results that there was significant difference in solution uptake as influence by foliar application of zinc and boron. During the first year of experiment, maximum solution uptake was recorded from T_6 ($ZnSO_4$ 0.2% + H_3BO_3 0.2%) (94.00 mL) followed by T_7 ($ZnSO_4$ 0.2% + H_3BO_3 0.4%) (91.67 mL) and T_5 (H_3BO_3 0.4%) (91.33 mL) which were statistically at par. Minimum solution uptake was recorded from T_1 (control) (78.00 mL) followed by T_2 ($ZnSO_4$ 0.2%) (80.00 mL) and T_9 ($ZnSO_4$ 0.4% + H_3BO_3 0.4%) (82.00 mL) which were statistically at par. During the second year of experiment, maximum solution uptake was recorded from T_5 (H_3BO_3 0.4%)

(98.33 mL) which was statistically at par with other treatments except T_1 (control) (80.33 mL) and T_9 ($ZnSO_4$ 0.4% + H_3BO_3 0.4%) (90.67 mL). Pooled data analysis revealed that maximum solution uptake was recorded from T_6 ($ZnSO_4$ 0.2% + H_3BO_3 0.2%) (95.83 mL) followed by T_5 (H_3BO_3 0.4%) (94.83 mL) and T_7 ($ZnSO_4$ 0.2% + H_3BO_3 0.4%) (94.50 mL) which were statistically at par. Minimum solution uptake was recorded from T_1 (control) (79.17 mL)

The results of the experiment revealed that there is a significant difference between different treatments. Pre harvest treatments of zinc and boron have profound effects on the post harvest qualities of gladiolus. Solution uptake also closely related to number of florets per spikes and vase life, the plants which performed well in other flowering parameters show higher solution uptake. This may be due to higher metabolic activities leading to higher moisture consumption and transpirational loses. The higher solution uptake ensures the spikes to maintained cellular turgidity and freshness which could delay senescence. This findings is supported by Singh and Prasad (2014) who reported that the best results regarding flower quality was obtained with treatment combination B3 Z3 (B 0.4% + Zn 0.4%).

4.2.3.7 Vase life

Vase life as influenced by different treatments has been presented in table 4.28. It is evident from the results that there was significant difference in vase life as influence by foliar application of zinc and boron. In the first year of experiment, maximum vase life was observed in T_6 ($ZnSO_4$ 0.2% + H_3BO_3 0.2%) (14.33 days) which was statistically at par with all other treatment except the T_1 (control) (12.67) which is minimum. During the second year of experiment, maximum vase life was recorded from T_5 (H_3BO_3 0.4%) (15.00 days) which is statistically at par with all treatment except T_1 (control) (13.00 days) which is minimum. Statistical analysis of the pooled data revealed that maximum vase life was observed from T_6 ($ZnSO_4$ 0.2% + H_3BO_3 0.2%) (14.50 days) and minimum was recorded from T_1 (control) (12.83 days). There was no significant difference between treatments except the control.

Perusal of the experimental results revealed that there are significant differences between different treatments with zinc and boron compared to control with regards to vase life of gladiolus spikes. Zinc and boron effects have significant difference over control but the concentrations have no significant difference between treatments. The prolonged self life in zinc and boron treated plants may be attributed to the role of zinc and boron which enhanced the flower quality (Khosa *et al*., 2011). Zinc provide defense against pathogens, decreased susceptibility to biotic and abiotic stresses (Cabot *et al*. 2019 and Noman *et al*. 2019) ultimately sustained flowering for longer duration. Micronutrient play significant role in the production of biomass (Cakmak, 2008) increased storage of photo assimilates in the spikes ultimately provide food for longer periods. Also boron been effective in sugar transportation within plants (Aboyeji *et al*. 2019) supplies the spikes with required food to sustained flowering.

Similar findings were reported by Khalifa *et al*. (2011) that the foliar spraying of zinc sulphate or boric acid alone at all rates and as combinations significantly increased flowers characteristics. Mohammed and Khalid (2019) also reported that spraying with boron or zinc had a significant effect on increasing the vase life of gladiolus. B and Zn at the rate of B2.0 Zn4.5 kg/ha exhibited the best performance and stretched the vase life of flower (Halder *et al.* 2007).

Table 4.28: Effect of zinc and boron on solution uptake and vase life

parameters	Solution uptake (mL)			Vase life (days)		
Treatment	**1st Year**	**2nd Year**	**Pooled**	**1st Year**	**2nd Year**	**Pooled**
T_1	78.00	80.33	**79.17**	12.67	13.00	**12.83**
T_2	80.00	96.00	**88.00**	13.67	14.33	**14.00**
T_3	83.00	97.33	**90.17**	14.00	14.67	**14.33**
T_4	88.00	96.67	**92.33**	14.00	14.33	**14.17**
T_5	91.33	98.33	**94.83**	13.67	15.00	**14.33**
T_6	94.00	97.67	**95.83**	14.33	14.67	**14.50**
T_7	91.67	97.33	**94.50**	13.33	14.67	**14.00**
T_8	89.33	95.33	**92.33**	13.67	14.67	**14.17**
T_9	82.00	90.67	**86.33**	13.67	14.33	**14.00**
Sem±	**1.48**	**1.02**	**0.90**	**0.37**	**0.29**	**0.23**
CD at 5%	**4.43**	**3.06**	**2.59**	**1.10**	**0.88**	**0.68**

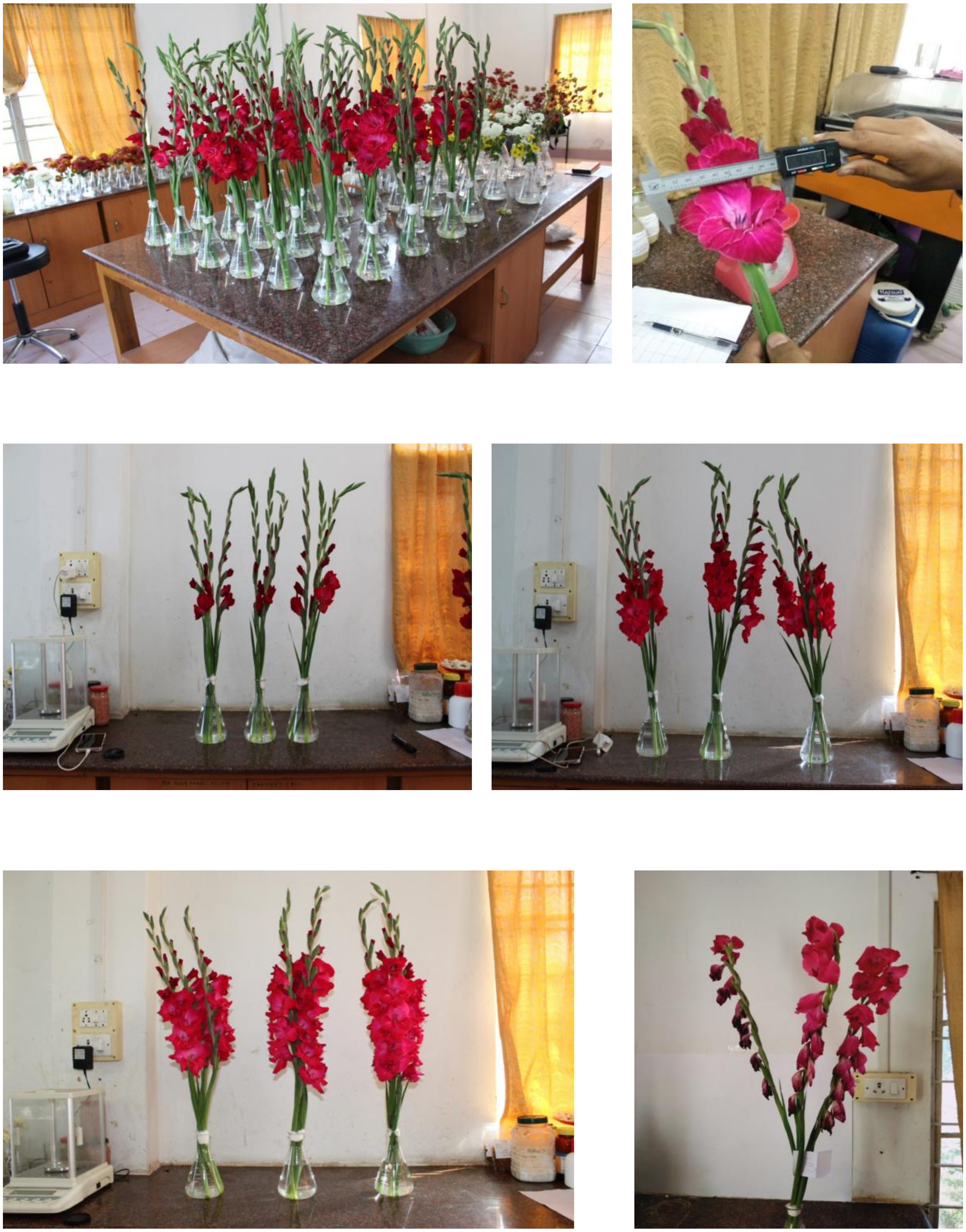

Plate 7. Postharvest studies showing different stages

4.2.4 Yield parameters

The availability of any flowers is determined by the availability of planting materials. In gladiolus, corms and cormels are the plant propagules for commercial cultivation of the crop. The successful production of gladiolus relies on the corms and cormels characters such as diameter and weight. The superior corms characters ensure successful production and quality produced. The number of corms and cormels determined the multiplication of the crop. The results of yield parameters as influences by different treatments are carefully investigated and the results envisaged are presented below.

4.2.4.1 Number of corms per hill

Number of corms per hill as influenced by different treatments has been presented in table 4.29. Perusal of the experimental results revealed that number of corms are least affected by the foliar application of zinc and boron. In the first year of experiment, maximum number of corms per hill was recorded from T_6 ($ZnSO_4$ 0.2% + H_3BO_3 0.2%) (1.27) followed by T_4 (H_3BO_3 0.2%) (1.20). Minimum was recorded from T_8 ($ZnSO_4$ 0.4% + H_3BO_3 0.2%) (1.00) and statistically at par with all the treatments except the T_6 ($ZnSO_4$ 0.2% + H_3BO_3 0.2%). During the second year, there was no significant difference between treatments. However, maximum was recorded from T_7 ($ZnSO_4$ 0.2% + H_3BO_3 0.4%) (1.27) and minimum from T_1, T_2, T_3, T_6 and T_9 with 1.07 numbers. Pooled data analysis showed that maximum was recorded from T_4 (H_3BO_3 0.2%) (1.20) followed by T_6 ($ZnSO_4$ 0.2% + H_3BO_3 0.2%) (1.17) and T_7 ($ZnSO_4$ 0.2% + H_3BO_3 0.4%). Whereas, minimum number of corms were recorded from T_1 (control), T_2 ($ZnSO_4$ 0.2%), T_3 ($ZnSO_4$ 0.4%), T_8 ($ZnSO_4$ 0.4% + H_3BO_3 0.2%) and T_9 ($ZnSO_4$ 0.4% + H_3BO_3 0.4%) all with 1.07 numbers and statistically it could not reached the level of significance. This result may be attributed to the fact that single corm is produced at the base of every plant and every mother corms produced normally a single plant and exceptionally more than one under favourable conditions. This variation in number of corms although insignificant may be due to the difference in zinc and boron concentration which regulates the growth and development of plants leading to formation of corms. Similar findings are reported by Fahad *et al.* (2014) who reported that number of corm per plant was not affected significantly by the foliar application of the micronutrients in gladiolus.

4.2.4.2 Weight of corms per hill

Weight of corms per hill as influenced by different treatments has been presented in table 4.29. Perusal of the experimental results revealed that weight of corms was significantly affected by the foliar application of zinc and boron. In the first year of experiment, maximum weight of corms per hill was recorded from T_4 (H_3BO_3 0.2%) (107.36g) and minimum from T_1 (control) (97.49g). During the second year of experiment, maximum weight of corms was recorded from T_5 (H_3BO_3 0.4%) (124.25g) followed by T_8 ($ZnSO_4$ 0.4% + H_3BO_3 0.2%) (124.03g), T_4 (H_3BO_3 0.2%) (123.50g) and T_7 ($ZnSO_4$ 0.2% + H_3BO_3 0.4%) (122.53g). Minimum was recorded from T_1 (control) (110.38g) followed by T_9 ($ZnSO_4$ 0.4% + H_3BO_3 0.4%) (111.23g) which were statistically at par. Pooled data analysis revealed that maximum weight of corms is recorded from T_4 (H_3BO_3 0.2%) (115.43g) followed by T_5 (H_3BO_3 0.4%) (114.75g) and T_8 ($ZnSO_4$ 0.4% + H_3BO_3 0.2%) (114.73g), whereas, minimum from T_1 (control) (103.94g) followed by T_9 ($ZnSO_4$ 0.4% + H_3BO_3 0.4%) (107.58g).

It is evident from the findings that pre-harvest treatments of zinc and boron have significant effects on the weight of corms. Perusal of the result revealed that weight of corms is influenced by the number of leaf, leaf area, plant heights and other field parameters as the treatments were in synchronizing terms with these parameters. The corms of gladiolus been the sink of photosynthesis, after flowering the photosynthates are directed towards the sink and stored there as food reserved for the next season growth. These may be attributed to the contribution of zinc and boron on the phytohormones (Lahijie, 2012) and photo assimilates (Aboyeji *et al*. 2019) which will regulate the metabolic activities and food storage. Moreover micronutrient play significant role in the production of biomass (Cakmak, 2008) increased storage of photo assimilates which ultimately leads to increased in weight of corms. These results were in accordance with the findings reported by Fahad *et al*. (2014) in gladiolus.

4.2.4.3 Diameter of corms

The data pertaining to diameter of corms per hill as influenced by different treatments has been presented in table 4.29. It is evident from the results that there was significant difference in the diameter of corms per hill as influence by foliar application of zinc and boron. During the first year of experiment, maximum diameter of corms was recorded from T_4 (H_3BO_3 0.2%) (7.40 cm) which is statistically at par with all other treatments except the T_1 (control) (6.21 cm) which was the minimum. During the second year of experiment, maximum was recorded from T_5 (H_3BO_3 0.4%) (7.53 cm) whereas, minimum was recorded from T_1 (control) (6.35 cm). Pooled data analysis revealed that minimum diameter of corms was recorded from T_1 (control) (6.28 cm). Maximum diameter of corms was recorded from T_4 (H_3BO_3 0.2%) (7.44 cm) closely followed by T_5 (H_3BO_3 0.4%) (7.43 cm).

The results of the experiment revealed that there is significant difference in the diameter of corms as influenced by different treatments. The leaves which are the sites of photosynthesis directly influenced the yield of corms which act as the

Table 4.29: Effect of zinc and boron on corms parameters

parameters	Number of corms per hill			Weight of corms per hill (g)			Diameter of corm (cm)		
Treatment	**1st Year**	**2nd Year**	**Pooled**	**1st Year**	**2nd Year**	**Pooled**	**1st Year**	**2nd Year**	**Pooled**
T_1	1.07	1.07	**1.07**	97.49	110.38	**103.94**	6.21	6.35	**6.28**
T_2	1.07	1.07	**1.07**	103.60	120.69	**112.15**	7.08	7.18	**7.13**
T_3	1.07	1.07	**1.07**	104.65	121.11	**112.88**	7.19	7.29	**7.24**
T_4	1.20	1.20	**1.20**	107.36	123.50	**115.43**	7.40	7.47	**7.44**
T_5	1.13	1.13	**1.13**	105.25	124.25	**114.75**	7.32	7.53	**7.43**
T_6	1.27	1.07	**1.17**	104.03	118.63	**111.33**	6.89	7.15	**7.02**
T_7	1.07	1.27	**1.17**	100.63	122.53	**111.58**	6.75	7.00	**6.87**
T_8	1.00	1.13	**1.07**	105.42	124.03	**114.73**	7.00	7.31	**7.15**
T_9	1.07	1.07	**1.07**	103.93	111.23	**107.58**	7.19	6.88	**7.03**
Sem±	**0.07**	**0.07**	**0.05**	**3.50**	**1.37**	**1.88**	**0.32**	**0.26**	**0.20**
CD at 5%	**0.22**	**0.21**	**0.15**	**10.48**	**4.11**	**5.41**	**0.95**	**0.77**	**0.59**

sink of photosynthesis. Therefore, the plants which showed better vegetative characters ultimately accumulates higher photosynthates this may have leads to larger and heavier corms. These results were in close conformity with the findings reported by Fahad *et al*. (2014) in gladiolus.

4.2.4.4 Number of cormels per hill

The data pertaining to number of cormels per hill as influenced by different treatments has been presented in table 4.30. It is evident from the results that there was significant difference in number of cormels per hill as influence by foliar application of zinc and boron. During the first year of experiment, maximum number of cormels per hill was recorded from T_4 (H_3BO_3 0.2%) (10.87) followed by T_2 ($ZnSO_4$ 0.2%) (9.20), T_1 (control) (9.00) and T_8 ($ZnSO_4$ 0.4% + H_3BO_3 0.2%) (8.93) which were statistically at par. Minimum was recorded from T_6 ($ZnSO_4$ 0.2% + H_3BO_3 0.2%) (4.07), T_7 ($ZnSO_4$ 0.2% + H_3BO_3 0.4%) (4.40) and T_3 ($ZnSO_4$ 0.4%) (5.33) which were statistically at par. In the second year of experiment, maximum number of cormels per hill was yielded from T_4 (H_3BO_3 0.2%) (10.87) whereas, minimum was recorded from T_7 ($ZnSO_4$ 0.2% + H_3BO_3 0.4%) (4.93). From the pooled data analysis, it is clear that maximum was yielded from T_4 (H_3BO_3 0.2%) (9.43) and minimum from T_7 ($ZnSO_4$ 0.2% + H_3BO_3 0.4%) (4.93).

4.2.4.5 Weight of cormels per hill

Table 4.30 clearly expressed the experimental results pertaining to weight of cormels per hill as influenced by different treatments. In the first year of experiment, T_2 ($ZnSO_4$ 0.2%) (5.07g) recorded maximum whereas, minimum was recorded from T_3 ($ZnSO_4$ 0.4%). During the second year of experiment, variation between the maximum T_5 (H_3BO_3 0.4%) (4.23g) and minimum T_1 (control)

Table 4.30: Effect of zinc and boron on cormels parameters

parameters	Number of cormels per hill			Weight of cormels per hill (g)		
Treatment	**1st Year**	**2nd Year**	**Pooled**	**1st Year**	**2nd Year**	**Pooled**
T_1	9.00	7.20	**8.10**	3.20	2.60	**2.90**
T_2	9.20	7.73	**8.47**	5.07	3.13	**4.10**
T_3	5.33	6.07	**5.70**	2.13	2.60	**2.37**
T_4	10.87	8.00	**9.43**	4.63	3.50	**4.07**
T_5	7.27	6.33	**6.80**	3.87	4.23	**4.05**
T_6	4.07	6.73	**5.40**	2.97	3.53	**3.25**
T_7	4.40	4.93	**4.67**	2.83	4.00	**3.42**
T_8	8.93	7.27	**8.10**	2.83	3.47	**3.15**
T_9	7.07	6.87	**6.97**	3.77	2.87	**3.32**
Sem±	**0.70**	**0.63**	**0.47**	**0.47**	**0.38**	**0.30**
CD at 5%	**2.11**	**1.88**	**1.36**	**1.42**	**1.15**	**0.88**

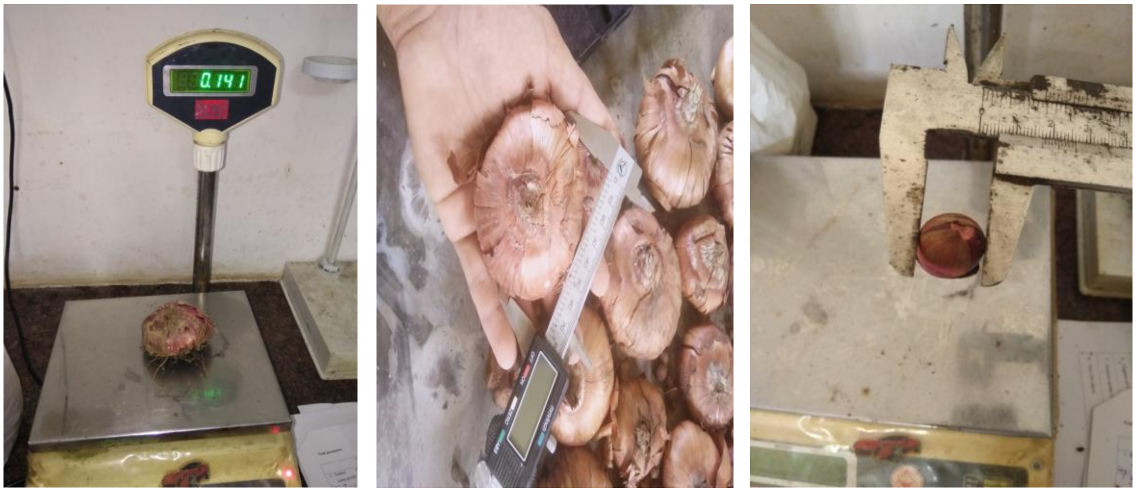

Plate 8. Corms and cormels studies

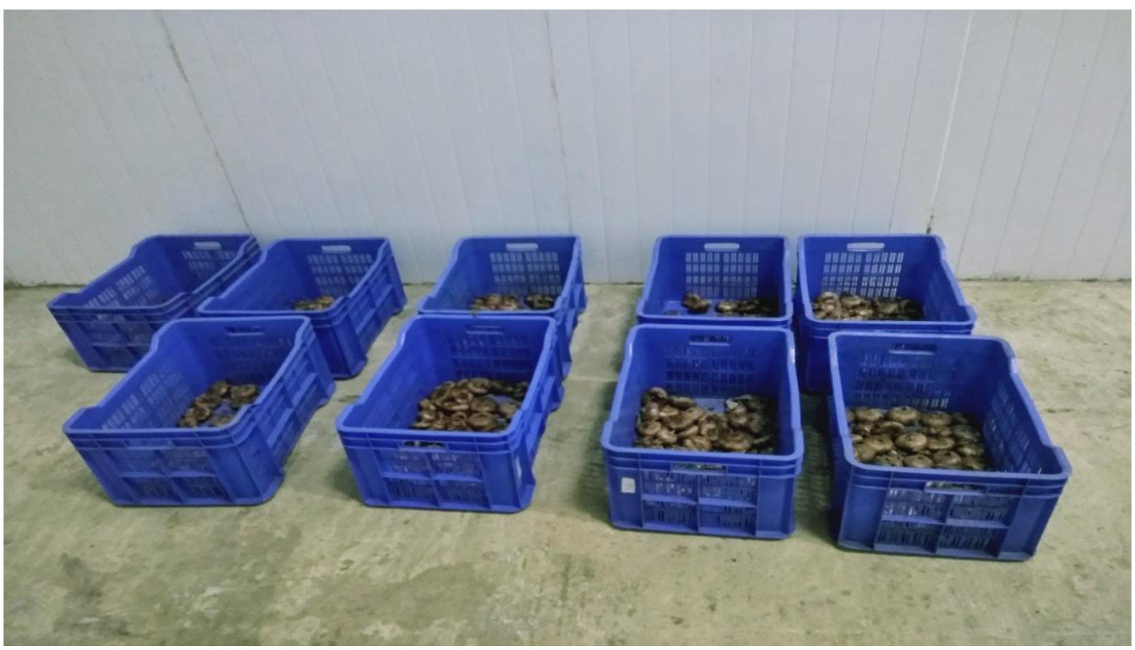

Plate 9. Cold storage of corms at Integrated Cold Chain Project (ICCP)-Mao, Manipur

(2.60g) was recorded which were significantly different. Pooled data analysis revealed that maximum weight of cormels were recorded from T_2 ($ZnSO_4$ 0.2%) (4.10g) and minimum from T_3 ($ZnSO_4$ 0.4%) (2.37g).

In the present study, it was observed that there were significant difference between treatments with regards to number of cormels and weight of cormels. However, the cormels performances were not consistent and variation between control and treatments were poorly established. The non-uniformity of cormels size and weight could be due to the non-consistency of cormels characters, as number of cormels does not ensure the weight advantages. Two numbers of cormels with good size gives better weight compared to many number of cormels with smaller size. Also it is observed that the corms which were exposed to the surface yielded more cormels, proper earthing up were given thought-out the investigation period, which may have resulted to less cormels yield comparatively. The cormels production may be greatly control by genotypic characters of plants, as a result the treatment effects could not be expressed indecently leading to sporadic and random yield. These findings were in corroboration with Reddy and Chaturvedi (2009) who reported that boron treatment show non significant results for yield parameters in gladiolus cv. Red Majesty.

4.3 Experiment No. 3

The third experiment entitled "**Studies on effect of different wrapping materials on vase life of gladiolus."** The results of postharvest studies as influences by different treatments exhibited significant variation with regards to postharvest qualities of cut spikes. The effect of different wrapping materials; newspaper, perforated plastic, non-perforated plastic, shrink wrap, butter paper, brown paper and control on the vase life of gladiolus in a standard vase solution was investigated in postharvest laboratory under normal room temperature and the results envisaged that most of the parameters are significantly influenced by different treatments. The results pertaining to various parameters are as under.

4.3.1 Fresh weight of spike

Data embodied in table 4.31 presents the effect of wrapping on fresh weight of spike. Significant variation as influenced by different treatment on changes in fresh weight of spikes was observed.

The fresh weight of spike on 1st day was recorded maximum from T_5 (Shrink wrap) (55.00 g and 54.67 g) in both the years of experiment respectively. Minimum was recorded from T_6 (Butter paper) (49.00 g) followed by T_7 (Brown paper) (50.00 g) and T_2 (Newspaper) (51.00 g) which were statistically at par in the first year of experiment. During the second year, minimum was recorded from T_7 (Brown paper) (50.33 g) followed by T_6 (Butter paper) (50.67 g) and T_2 (Newspaper) (51.00 g) which were statistically at par. Results from pooled data analysis shows minimum in T_6 (Butter paper) (49.83 g) followed by T_7 (Brown paper) (50.17 g) and T_2 (Newspaper) (51.17 g) which were statistically at par and maximum in T_5 (Shrink wrap) (54.83 g) followed by T_4 (Non-perforated plastic) (53.83 g), T_1 (control) (53.17 g) and T_3 (Perforated plastic) (53.00 g) which were statistically at par.

The fresh weight of spikes on the 3rd day, maximum was recorded from T_5 (Shrink wrap) (57.67 g) followed by T_4 (Non-perforated plastic) (57.00 g) and T_3 (Perforated plastic) (56.00 g) which were statistically at par. Minimum weight of spikes was recorded from in T_1 (control) (47.33 g). During the second year experiment, maximum was recorded from T_5 (Shrink wrap) (58.00 g) which is significantly different from all other treatments and minimum which was recorded from T_1 (control) (47.00 g). Pooled data analysis show maximum from T_5 (Shrink wrap) (57.83 g) which is significantly different from all other treatments and minimum which was recorded from T_1 (control) (47.17 g).

On the 6th day, the results were in parallel with the 3rd day results. In the first year, maximum weight of spikes was recorded from T_5 (Shrink wrap) (56.00 g) followed by T_3 (Perforated plastic) and T_4 (Non-perforated plastic) both with same value of 55.67 g which were statistically at par. Minimum was recorded from T_1 (control) (45.00 g). During the second year, maximum weight was recorded from T_5 (Shrink wrap) (56.33 g) and minimum was recorded from T_1 (control) (44.00 g). Pooled data analysis revealed T_5 (Shrink wrap) (56.17 g) as best treatment whereas, least performance in T_1 (control) (44.50g).

The results of the 9th day are in parallel with the readings of 3rd and 6th days. In the first year, maximum weight of spike was recorded from T_5 (Shrink wrap) (54.00 g) followed by T_4 (Non-perforated plastic) (53.00 g) and T_3 (Perforated plastic) (52.00 g) which were statistically at par. Minimum was recorded from T_1 (control) (37.33 g). In the second year, maximum weight of spike was recorded from T_3 (Perforated plastic) (52.67 g) followed by T_5 (Shrink wrap) (52.33 g) and T_4 (Non-perforated plastic) (51.00 g) and which were statistically at par. Results of the pooled data analysis show similar trends, maximum was recorded from T_5 (Shrink wrap) (53.17 g) followed by T_3 (Perforated plastic) (52.33 g) and T_4 (Non-perforated plastic) (52.00 g) and which were statistically at par. T_1 (control) (36.83 g) which recorded minimum weight of spikes.

Perusal of the experimental results suggests that wrapping has positive effects on the fresh weight of spikes. Fresh weight retention is known to be dependent on maintenance of moisture and carbohydrate level in petal cells. In the control treatment, the fresh weight of spikes was maximum on the 1st day of post harvest studies. This is due to the more number of opened florets on the first day itself. Since the spikes were left opened and exposed to environment, the florets opened during storage time and on the first day of post harvest studies, the spikes were already in good bloom and thereafter, the weight of spikes decreases till the 9^{th} day where sharp decrease was observed. On the other hand, the treated spikes show maximum weight gained on the 3^{rd} day of post harvest studies. In general, it was observed that the changes in fresh weight of spikes showed sharp increased on the 3^{rd} day and steadily decreased till the 9^{th} day. The decreased in weight of spikes is due to moisture lost from spikes and florets senescence. The wrapping of spikes acts as a barriers between the delicate spikes and the harsh environment. These create a micro-climate within the enclosed space, giving a modified atmospheric condition congenial for flowers (Farber *et al*., 2003). The treatment, T5 (Shrink wrap) which performed best may be due to the packaging film which modifies the internal atmosphere with high CO_2, low O_2 and high relative humidity as the spikes were well concealed and encapsulated by the shrink wrap (Farber *et al*., 2003). Similar findings were reported by Sharma *et al*. (2010) in Asiatic hybrid lily cv. 'Apeldoorn', Sahare (2011) in tuberose, (Joshi, 2012) in Gerbera and Mahawer *et al* (2019) in tuberose.

4.3.2 Length of spike

Table 4.32 presents the effect of wrapping on length of spike. Significant variation as influenced by different treatment on length of spikes was observed.

Length of spike on 1^{st} day during the first year of experiment, maximum was recorded from T_4 (Non-perforated plastic) (75.00 cm) which is statistically at par with T_3 (Perforated plastic) (74.67 cm), T_6 (Butter paper) (74.33 cm) and T_7 (Brown paper) (74.33 cm). Minimum was recorded from T_5 (Shrink wrap) (72.33 cm) followed by T_1 (control) (72.67 cm) which were statistically at par. During the second year, minimum was recorded from T_1 (control) (72.33 cm) followed by T_5 (Shrink wrap) (72.67 cm) which were statistically at par. Maximum was recorded from T_4 (Non-perforated plastic) (74.50 cm) followed by T_3 (Perforated plastic) (74.33 cm), T_7 (Brown paper) (74.00 cm), T_6 (Butter paper) (73.67 cm) and T_2 (Newspaper) (73.67 cm) which were statistically at par. Results from pooled data analysis shows minimum in T_5 (Shrink wrap) (72.50 cm) and T_1 (control) (72.50 cm) with same value. Maximum was recorded from T_4 (Non-perforated plastic) (74.75 cm) followed by T_3 (Perforated plastic) (74.50 cm) and T_7 (Brown paper) (74.17 cm) which were statistically at par.

Length of spikes on the 3rd day, during the first year of experiment, maximum was recorded from T_3 (Perforated plastic) (76.33 cm) closely followed by T_4 (Non-perforated plastic) (76.17 cm) which were statistically at par with all the treatment except the control which is minimum T_1 (control) (74.83 cm). During the second year experiment, maximum was recorded from T_3 (Perforated plastic) (76.83 cm) and T_4 (Non-perforated plastic) (76.83 cm) with same value followed by T_2 (Newspaper) (76.67 cm), T_5 (Shrink wrap) (76.50 cm) and T_7 (Brown paper) (76.50 cm) which were statistically at par. Minimum was recorded from T_1 (control) (74.83 cm). Pooled data analysis show maximum from T_3 (Perforated plastic) (76.58 cm) closely followed by T_4 (Non-perforated plastic) (76.50 cm) and minimum was recorded from T_1 (control) (74.80 cm).

On the 6th day, during the first year, maximum length of spikes was recorded from T_4 (Non-perforated plastic) and T_5 (Shrink wrap) both with same value of 76.00 cm which were statistically at par with all other treatments except T_1 (control) which is minimum (75.00 cm). During the second year, maximum length was recorded from T_5 (Shrink wrap) (76.83 cm) followed by T_3 (Perforated plastic) (76.33 cm) which were statistically at par and minimum was recorded from T_1 (control) (74.33 cm). Pooled data analysis revealed T_5 (Shrink wrap) (76.42 cm) followed by T_3 (Perforated plastic) and T_4 (Non-perforated plastic) with same value of 76.08 cm, whereas, least performance in T_1 (control) (74.67 cm).

The results of the 9th day are in parallel with the readings of 3rd and 6th days. In the first year, maximum length of spike was recorded from T_5 (Shrink wrap) (76.00 cm) followed by T_4 (Non-perforated plastic) (75.67 cm), T_6 (Butter paper) (75.67 cm) and T_3 (Perforated plastic) (75.50 cm) which were statistically at par. Minimum was recorded from T_1 (control) (74.67 cm) followed by T_2 (Newspaper) (74.83 cm) and T_7 (Brown paper) (74.83 cm) which were statistically at par. In the second year, maximum length of spike was recorded from T_5 (Shrink wrap) (76.17 cm) followed by T_4 (Non-perforated plastic) (75.75 cm) and T_3 (Perforated plastic) (75.67 cm) and which were statistically at par. Minimum was recorded from T_1 (control) (74.00 cm). Results of the pooled data analysis show similar trends, maximum was recorded from T_5 (Shrink wrap) (76.08 cm) followed by T_4 (Non-perforated plastic) (75.83 cm) and T_3 (Perforated plastic) (75.83 cm) and which were statistically at par and minimum length of spikes was recorded in T_1 (control) (74.33 cm).

Perusal of the experimental results suggests that wrapping has positive effects on the length of spikes. In general, it was observed that the changes in length of spikes showed sharp increased on the 3rd day and thereafter, there were no significant decreases on the length of spike. It was observed that wrapping has significant effect on the length of spikes when compared to control. The differences between treatments were marginal and some were at par with each other. T_5 (Shrink wrap) give the best performance with respect to length of spikes followed by T_4 (Non-perforated plastic) and T_3 (Perforated plastic) which were all equally good as these materials were less permeable to CO_2 and water vapour thus establish the optimal Equilibrium Modified Atmosphere (EMA) (Day, 2001). Also, newspaper and brown paper resulted in similar performance as the materials are very similar both been untreated papers. On the other hand, butter paper performed slightly superior to newspaper and brown paper, as the butter paper been treated, this give different permeability to gases and water vapour. All these packaging materials passively modify the atmosphere surrounding the spikes within a package (Farber *et al*., 2003) therefore, promote post harvest qualities of cut flowers. Similar findings supporting the positive effects of wrapping in flowers were reported by Singh *et al*. (2007a) in gladiolus, Sharma *et al*. (2010) in Asiatic hybrid lily cv. 'Apeldoorn' and Dastagiri *et al*. (2014) in Ornithogalum.

4.3.3 Length of rachis

Length of rachis as influence by different wrapping materials were presented in Table 4.33. From the results it is observed that length of rachis is in parallel with the length of spikes.

The length of spike on 1st day during the first year of experiment, maximum was recorded from T_3 (Perforated plastic) (35.00 cm) and minimum was recorded from T_1 (control) (33.00 cm). During the second year, minimum was recorded from T_1 (control) (32.83 cm) and T_5 (Shrink wrap) (32.83 cm) and maximum was recorded from T_4 (Non-perforated plastic) (34.17 cm). Pooled data analysis shows minimum in T_1 (control) (32.92 cm). Maximum was recorded from T_3 (Perforated plastic) (34.50 cm) followed by T_4 (Non-perforated plastic) (34.25 cm) which were statistically at par.

Length of spikes on the 3rd day, during the first year of experiment, maximum was recorded from T_2 (Newspaper), T_3 (Perforated plastic) and T_4

(Non-perforated plastic) with the same value of 35.83 cm whereas, minimum T_1 (control) (34.17 cm). During the second year experiment, maximum was recorded from T_2 (Newspaper) (36.17 cm) and T_5 (Shrink wrap) (36.17 cm) and minimum was recorded from T_1 (control) (34.33 cm). Pooled data analysis show maximum from T_2 (Newspaper) (36.00 cm) closely followed by T_3 (Perforated plastic) and T_4 (Non-perforated plastic) with same value of 35.92 cm which were all statistically at par and minimum was recorded from T_1 (control) (34.25 cm).

On the 6th day, during the first year, maximum length of rachis was recorded from T_5 (Shrink wrap) (35.33 cm) followed by T_4 (Non-perforated plastic) (35.17 cm) and statistically at par. Minimum was recorded in T_1 (control) (33.33 cm). During the second year, maximum length was recorded from T_5 (Shrink wrap) (35.17 cm) and minimum was recorded from T_1 (control) (32.83 cm). Pooled data analysis revealed T_5 (Shrink wrap) (35.25 cm) whereas, minimum in T_1 (control) (33.08 cm).

The results of the 9th day; in the first year, maximum length of rachis was recorded from T_5 (Shrink wrap) (33.33 cm) which was statistically at par with T_3 (Perforated plastic) (32.83 cm), T_6 (Butter paper) (32.83 cm) and T_7 (Brown paper) (32.67 cm) which were statistically at par. Minimum was recorded from T_1 (control) (29.83 cm). In the second year, maximum length of rachis was recorded from T_5 (Shrink wrap) (32.83 cm) and minimum in T_1 (control) (29.17 cm). Results of the pooled data analysis show similar trends, maximum was recorded from T_5 (Shrink wrap) (33.08 cm) followed by T_4 (Non-perforated plastic) (32.83 cm) and T_6 (Butter paper) (32.67 cm) and which were statistically at par and minimum length of rachis was recorded in T_1 (control) (29.50 cm).

Perusal of the experimental results suggests that wrapping has positive effects on the length of rachis. In general, it was observed that the length of rachis for the control treatment increased upto 3rd day and decreases thereafter. On the other hand, all the wrapping treatment increased and maintained till 6th day and slightly decreased thereafter on the 9th day. The findings may be concluded in accordance with the length of spikes. Similar findings supporting the positive effects of wrapping in flowers were reported by Singh *et al*. (2007a) in gladiolus, Sharma *et al*. (2010) in Asiatic hybrid lily cv. 'Apeldoorn' and Dastagiri *et al*. (2014) in Ornithogalum.

4.3.4 Days to opening of florets

Data embodied in table 4.34 presents the effect of wrapping on days to opening of florets. Significant variations as influenced by different treatment on opening of florets were observed.

Days to opening of 3rd floret strictly follows same results for both the years of experiment. Maximum days to opening of 3rd floret was recorded from T_4 (Non-perforated plastic) and T_5 (Shrink wrap) both with same value of 2.00 days followed by followed by T_3 (Perforated plastic) and T_6 (Butter paper) both with same value of 1.67 days, also T_2 (Newspaper) and T_7 (Brown paper) recorded same value with 1.33 days. all these treatments were statistically at par with each other. Minimum days to opening of 3rd floret was recorded from T_1 (control) (1.00 days) which was significantly different from the other treatments. Pooled data analysis showed that maximum days to opening of 3rd florets was recorded from T_4 (Non-perforated plastic) and T_5 (Shrink wrap) both with same value of 2.00 days followed by followed by T_3 (Perforated plastic) and T_6 (Butter paper) both with same value of 1.67 days and which were statistically at par. Minimum was recorded from T_1 (control) (1.00 days).

Days to opening of 5^{th} floret were in parallel with that of the 1^{st} floret. In the first years of experiment, T_5 (Shrink wrap) (3.00 days) recorded maximum which was statistically at par with all other treatment except the T_1 (control) (1.00 days) which was minimum. During the second year, maximum days to opening of 5^{th} florets was recorded in T_5 (Shrink wrap) (3.00 days) followed by T_4 (Non-perforated plastic) (2.67 days) and statistically at par, whereas, minimum was recorded from T_1 (control) (1.00 days). Pooled data analysis revealed that maximum days to opening of 5^{th} florets was recorded in T_5 (Shrink wrap) (3.00 days) followed by T_4 (Non-perforated plastic) (2.67 days) and T_6 (Butter paper) (2.50 days) which were statistically at par, \ Minimum was recorded from T_1 (control) (1.00 days).

Perusal of the experimental results suggests that wrapping has positive effects on days to opening of florets. In the control treatment, the florets were opened till 5^{th} florets on the first day itself. This may be due to the high rate of respirational loss of carbohydrates as well as transpirational loss of water from the spikes leading to opening of florets at the expense of vase life. On the other hand, the treated spikes show steady opening of florets in acropetal sequence which is desirable characters of vase life. This delayed opening of florets results to delayed senescence of that very opened florets which in return prolong vase life of spikes. The packaging film which modifies the internal atmosphere with high CO_2, low O_2 and high relative humidity ensure the keeping quality (Farber *et al*., 2003). Similar findings were reported by Sharma *et al*. (2010) in Asiatic hybrid lily cv. 'Apeldoorn' and Mahawer *et al* (2019) in tuberose.

4.3.5 Days to opening of 50% florets

Table 4.34 present the effect of wrapping on days to opening of 50% florets. Significant variation as influenced by different treatment on days to opening of 50% florets was observed.

In the first year of experiment, maximum days to opening of 50% florets was recorded from T_5 (Shrink wrap) (3.33 days) followed by T_4 (Non-perforated plastic) (3.00 days), T_3 (Perforated plastic) (3.00 days), T_6 (Butter paper) (2.67 days) and T_2 (newspaper) (2.67 days) which were statistically at par. Minimum was recorded from T_1 (control) (1.67 days). Similar reading were observed in the second year, maximum was recorded in T_5 (Shrink wrap) (3.33 days) followed by T_4 (Non-perforated plastic) and T_3 (Perforated plastic) both with same value at 3.00 days T_6 (Butter paper) (2.67 days) which were statistically at par. Minimum was recorded from T_1 (control) (1.67 days). Results from pooled data analysis shows maximum in T_5 (Shrink wrap) (3.33 days) followed by T_4 (Non-perforated plastic) and T_3 (Perforated plastic) both with same value of 3.00 days and statistically at par. Minimum was recorded from T_1 (control) (1.67 days).

Perusal of the experimental results suggests that wrapping has positive effects on days to opening of florets. In the control treatment, 50% florets were opened on 1.67 days. On the other hand, the shrink wrap, perforated and non-perforated plastics performed well, with the 50% florets opening on 3.33 days and 3.00 days respectively. Delayed to 50% flowering ensures prolonged vase life as the steady opening of florets in acropetal sequence which is desirable characters of vase life. This delayed opening of florets results to delayed senescence of that very opened florets which in return prolong vase life of spikes. The packaging film which modifies the internal atmosphere with high CO_2, low O_2 and high relative humidity ensure the keeping quality (Farber *et al*., 2003). Similar findings were reported by Sharma *et al*. (2010) in Asiatic hybrid lily cv. 'Apeldoorn' and Mahawer *et al* (2019) in tuberose.

4.3.6 Diameter of florets

The data pertaining to diameter of florets as influenced by different treatments has been presented in table 4.35. In the first year of the experiment, maximum diameter of 1st floret was recorded from T_5 (Shrink wrap) (8.57 cm) followed by T_4 (Non-perforated plastic) (8.47 cm) and T_6 (Butter paper) (8.40 cm) which were statistically at par whereas, minimum was recorded from T_1 (control) (8.27 cm). During the second year of experiment, maximum diameter of 1st floret was recorded from T_5 (Shrink wrap) (8.47 cm) and minimum was recorded from T_1 (control) (8.17 cm). From the pooled data analysis, maximum diameter of 1st floret was observed from T_5 (Shrink wrap) (8.52 cm) whereas, minimum was recorded in T_1 (control) (8.22 cm).

Diameter of 3rd floret is in parallel with that of the 1st floret. In the first years of experiment, maximum diameter was recorded from T_5 (Shrink wrap) (8.37 cm) followed by T_4 (Non-perforated plastic) (8.30 cm) and statistically at par whereas, minimum was recorded from T_1 (control) (7.90 cm). During the second year, maximum diameter of 3rd floret was recorded in T_5 (Shrink wrap) (8.30 cm) which was significantly different from all other treatments, minimum was recorded from T_1 (control) (7.87 cm). Pooled data analysis revealed that maximum diameter of 3rd floret was observed from T_5 (Shrink wrap) (8.33 cm) followed by T_4 (Non-perforated plastic) (8.18 cm). Minimum diameter of 3rd floret was recorded from control (7.88 cm).

Diameter of 5th floret also strictly follows the 1st and 3rd floret patterns. In the first year experiment, T_5 (Shrink wrap) (8.17 cm) recorded maximum and minimum diameter of 5th floret was recorded from control (7.43 cm). In the second year, maximum diameter of 5th floret was recorded from T_5 (Shrink wrap) (8.10 cm) and minimum diameter of 5th floret was recorded in T_1 (control) (7.37 cm). Pooled data analysis revealed that maximum diameter of 5th floret was observed from T_5 (Shrink wrap) (8.13 cm) which was significantly different from all other treatments and followed by T_4 (Non-perforated plastic) (7.98 cm). Whereas, minimum diameter of 5th floret was recorded from control (7.40 cm).

Perusal of the experimental results indicates that wrapping of spikes has positive effects and yield larger florets significantly. Though the 1st florets were almost uniformly gradient across treatment as the stored food and moisture in the spikes support the petals to fully developed and expressed sufficiently. However, the control treatment, showed poor performance in diameter of florets towards subsequent florets when compared to others. This may be ascribed to the moisture stress which restricts the development of petals fully. It is evident from the results that the diameter of florets diminishes from base to top with the largest floret been the 1st floret as observed across treatments. The variation in diameter of florets between treatments may be attributed to the packaging film which modifies the internal atmosphere with high CO_2, low O_2 and high relative humidity and increases the keeping quality (Farber *et al*., 2003). As a result, the performance of spikes is enhanced and due to which luxury growth on flower lamina is achieved and expressed larger diameter of florets. Similar findings were reported by Panicker *et al*. (2003) in chrysanthemum, Grover *et al*. (2005) in gladiolus and Kumar *et al*. (2012) in cut Rose cv. First Red

4.3.7 Longevity of florets

Data embodied in Table 4.36 presents the effect of wrapping on longevity of florets. Significant variations as influenced by different treatment on longevity of florets were observed.

The longevity of 1st florets was recorded maximum from T_4 (Non-perforated plastic) and T_5 (Shrink wrap) with same value of 4.00 days in both the years of experiment. Minimum was recorded from T_1 (control) (1.00) days in both the years. Results from pooled data analysis shows minimum from T_1 (control) (1.00 days) and maximum in T_4 (Non-perforated plastic) and T_5 (Shrink wrap) with same value of 4.00 days.

The longevity of 3rd floret was in parallel with the 1st floret, in both the years of experiment, T_4 (Non-perforated plastic) and T_5 (Shrink wrap) with same value of 5.67 days recorded as maximum. On the other hand, minimum was recorded in T_1 (control) (2.00 days) in both the years of experiment. Pooled data analysis show T_4 (Non-perforated plastic) and T_5 (Shrink wrap) with same value of 5.67 days as maximum and minimum in T_1 (control) (2.00 days).

The longevity of 5th floret also strictly follows the 1st and 3rd florets. The maximum days to longevity of 5th floret was recorded from T_5 (Shrink wrap) (6.00 days) followed by T_4 (Non-perforated plastic) (5.67 days) and were statistically at par for both the year during investigation. Minimum longevity of 5th floret was recorded from T_1 (control) (3.67 days).

Perusal of the experimental result revealed that wrapping has positive effect on longevity of florets significantly. From the results, it is evident that T_5 (Shrink wrap) give the best performance which is also at par with T_4 (Non-perforated plastic) as these materials were less permeable to CO_2 and water vapour thus establish the optimal Equilibrium Modified Atmosphere (EMA) (Day, 2001) therefore, sustained the longevity of florets for longer duration. Moreover all the treatments were significantly superior when compared to control as these packaging materials passively modify the atmosphere surrounding the spikes within a package (Farber *et al*., 2003) therefore, delayed senescence and promote post harvest qualities of cut flowers. Similar findings supporting the positive effects of wrapping in flowers were reported by Singh *et al*. (2007a) in gladiolus, Sharma *et al*. (2010) in Asiatic hybrid lily cv. 'Apeldoorn' and Dastagiri *et al*. (2014) in Ornithogalum.

4.3.8 Number of florets opened at a time

Table 4.39 clearly expressed the experimental results pertaining to number of florets opened at a time which showed significant difference between treatments. In the first year of experiment, T_4 (Non-perforated plastic) (5.67) recorded maximum followed by T_5 (Shrink wrap) (5.33) and T_3 (Perforated plastic) (4.63) which were statistically at par while minimum was recorded from T_1 (control) (3.33). During second year, maximum was recorded from T_4 (Non-perforated plastic) (5.67) followed by T_5 (Shrink wrap) (5.33) whereas, minimum was recorded from T_1 (control) (3.33). Result of the pooled data showed maximum number of florets opened at a time in T_4 (Non-perforated plastic) (5.67) followed by T_5 (Shrink wrap) (5.33) which were statistically at par. Minimum was recorded in T_1 (control) (3.33).

In the present study, it was observed that number of florets opened at a time increased significantly by wrapping effect. It is observed that all the wrapping treatments were significantly higher when compared with the control. The wrapping films minimized the lost of moisture from the spikes thus keeping the spikes fresh by maintaining turgidity and delayed senescence (Cazier *et al*., 2001). As a result the florets remained fresh for longer periods at the same time the subsequent florets opened and increased the number of florets opened at a time. These findings are in accordance with the reports of Grover *et al*. (2005), Alka *et al*. (2007) and Harsimran *et al*. (2018) in gladiolus.

4.3.9 Number of unopened florets

Table 4.39 clearly expressed the experimental results pertaining to number of unopened florets which showed significant difference between treatments. In the first year of experiment, T_4 (Non-perforated plastic) and T_5 (Shrink wrap) recorded minimum with the same number of unopened florets of 1.67 while maximum was recorded from T_1 (control) (4.33). During second year, minimum number of unopened florets was recorded from T_4 (Non-perforated plastic) (1.67) followed by T_5 (Shrink wrap) (2.00) which were statistically at par whereas, maximum was recorded from T_1 (control) (4.67). Result of the pooled data showed minimum number of unopened florets in T_4 (Non-perforated plastic) (1.67) followed by T_5 (Shrink wrap) (1.83) which were statistically at par. Maximum was recorded in T_1 (control) (4.50).

All treatment of wrapping materials performed well when compared to control as observed from the table 4.39. It was observed that numbers of unopened florets were minimized significantly by wrapping. The wrapping films minimized the lost of moisture from the spikes thus keeping the spikes fresh by maintaining turgidity and delayed senescence (Cazier *et al*., 2001) which metabolized more carbohydrates for the functions of florets and also reduces the moisture lost from the spikes. As a result the more number of florets could open. These findings are in accordance with the reports of Alka *et al*. (2007) and Harsimran *et al*. (2018) in gladiolus.

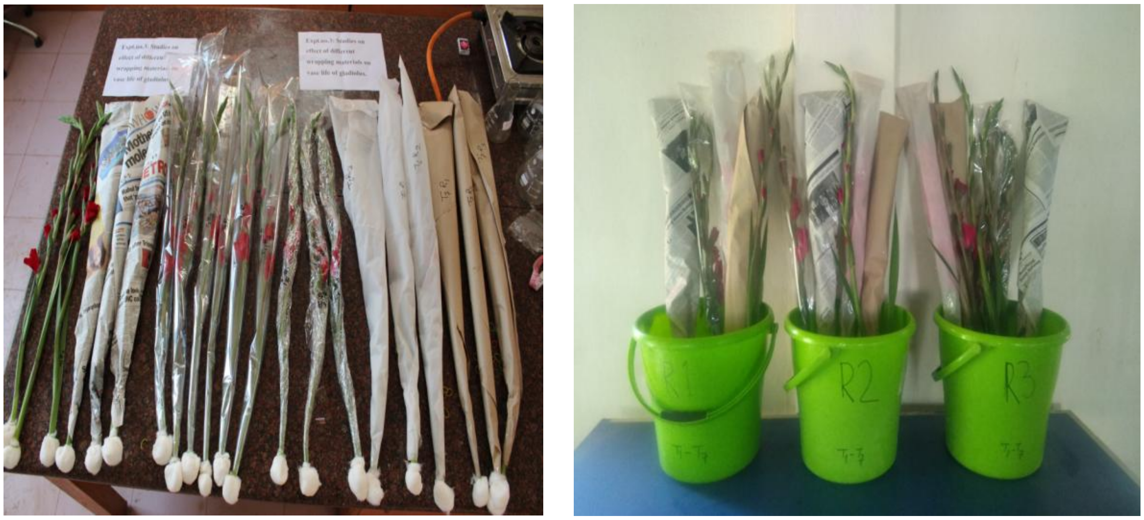

Plate 10. Wrapping and storage of treated spikes

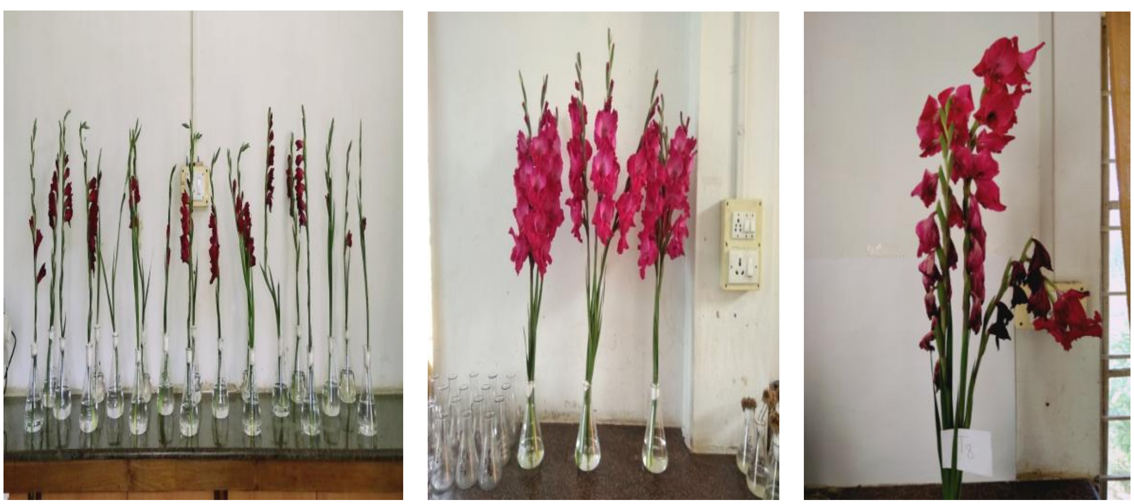

Plate 11. Vase life studies showing initial, full bloom and senescence stages

4.3.9 Water uptake

The data pertaining to water uptake as influenced by different treatments has been presented in table 4.37. It is evident from the results that there was significant difference in water uptake as influence by different wrapping materials. In the first year of experiment, maximum water uptake on 3rd day was recorded from T_5 (Shrink wrap) (28.33 g) followed by T_4 (Non-perforated plastic) (27.33 g) and were statistically at par. Minimum was recorded from T_1 (control) (15.67 g). During the second year, maximum water uptake was recorded from T_5 (Shrink wrap) (26.67 g) followed by T_4 (Non-perforated plastic) (25.67 g) and were statistically at par. Minimum was recorded from T_1 (control) (15.00 g). Pooled data analysis show that, maximum water uptake was recorded from T_5 (Shrink wrap) (27.50 g) followed by T_4 (Non-perforated plastic) (26.50 g) and were statistically at par. Minimum was recorded from T_1 (control) (15.33 g).

Similar trends were observed on the 6th days with a sharp decreased in volume. In the first year of experiment, maximum water uptake on 6th day was recorded from T_5 (Shrink wrap) (18.33 g) followed by T_4 (Non-perforated plastic) (16.33 g) whereas, minimum was recorded from T_1 (control) (6.67 g). During the second year, maximum water uptake was recorded from T_5 (Shrink wrap) (16.67 g) followed by T_4 (Non-perforated plastic) (15.33 g) whereas, minimum was recorded from T_1 (control) (6.33 g). Pooled data analysis show that, maximum water uptake was recorded from T_5 (Shrink wrap) (15.50 g) followed by T_4 (Non-perforated plastic) (15.83 g) and minimum was recorded from T_1 (control) (6.50 g).

Water uptake on 9th day strictly follows the 6th day pattern with decreased in volume. In the first year of experiment, maximum water uptake on 9th day was recorded from T_5 (Shrink wrap) (9.33 g) followed by T_4 (Non-perforated plastic)

(8.33 g) and were statistically at par. Minimum was recorded from T_1 (control) (5.33 g). During the second year, maximum water uptake was recorded from T_5 (Shrink wrap) (8.33 g) followed by T_4 (Non-perforated plastic) (7.67 g) and were statistically at par. Minimum was recorded from T_1 (control) (4.67 g). Pooled data analysis show that, maximum water uptake was recorded from T_5 (Shrink wrap) (8.83 g) followed by T_4 (Non-perforated plastic) (8.00 g) and were statistically at par. Minimum was recorded from T_1 (control) (5.00 g).

The results of the experiment revealed that there is a significant difference between different treatments. Water uptake also closely related to number of florets per spikes and vase life, the plants which performed well in other flowering parameters show higher solution uptake. This may be due to higher metabolic activities leading to higher moisture consumption and transpirational loses. The higher solution uptake ensures the spikes to maintained cellular turgidity and freshness which could delay senescence. Water uptake decreases with the advancement of days, this may be due to increased in number of florets senescence and membrane deterioration thus water uptake were reduces considerably (Cazier *et al*., 2001). These findings were supported by Jain *et al*. (2006) in cut flowers of rose cv. First Red also, Varu and Barad (2008) in tuberose

4.3.10 Water loss

The data pertaining to water loss as influenced by different treatments has been presented in table 4.38. It is evident from the results that there was significant difference in water loss as influence by different wrapping materials. In the first year of experiment, maximum water loss on 3rd day was recorded from T_5 (Shrink wrap) (20.67 g) followed by T_4 (Non-perforated plastic) (20.00 g) and T_3 (Perforated plastic) (19.00 g) which were statistically at par. Minimum was recorded from T_1 (control) (9.67 g). During the second year, maximum water loss was recorded from T_5 (Shrink wrap) (18.67 g) followed by T_4 (Non-perforated plastic) (17.67 g) and were statistically at par. Minimum was recorded from T_1 (control) (9.00 g). Pooled data analysis show that, maximum water uptake was recorded from T_5 (Shrink wrap) (19.67 g) followed by T_4 (Non-perforated plastic) (18.83 g) and were statistically at par. Minimum was recorded from T_1 (control) (9.33 g).

Similar trends were observed on the 6^{th} day with a decreased in volume. In the first year of experiment, maximum water loss was recorded from T_5 (Shrink wrap) (17.33 g) followed by T_4 (Non-perforated plastic) (15.33 g) whereas, minimum was recorded from T_1 (control) (5.67 g). During the second year, maximum water uptake was recorded from T_5 (Shrink wrap) (16.33 g) followed by T_4 (Non-perforated plastic) (14.33 g) whereas, minimum was recorded from T_1 (control) (5.33 g). Pooled data analysis show that, maximum water loss was recorded from T_5 (Shrink wrap) (16.83 g) followed by T_4 (Non-perforated plastic) (14.83 g) and minimum was recorded from T_1 (control) (5.50 g).

Water loss on 9^{th} day strictly follows the 6^{th} day pattern with decreased in volume. In the first year of experiment, maximum water loss was recorded from T_5 (Shrink wrap) (15.67 g) which was significantly different from all other treatments. Minimum was recorded from T_1 (control) (8.33 g). During the second year, maximum water loss was recorded from T_5 (Shrink wrap) (14.67 g). Minimum was recorded from T_1 (control) (7.67 g). Pooled data analysis show that, maximum water loss was recorded from T_5 (Shrink wrap) (15.17 g). Minimum was recorded from T_1 (control) (8.00 g).

The results of the experiment revealed that there is a significant difference between different treatments. It was observed that water uptake and water loss were closely related. The water loss on the 3^{rd} day were far less than the water uptake on the same day, on the 6th day it was observed that water uptake and water loss were close to equilibrium and on the 9th day, water loss was higher than water uptake. The higher water loss may be due to the more number of florets open and larger diameters of florets from the treated spikes as a result of higher metabolic activities leading to higher moisture consumption and transpirational loses. As the water loss surpassed the water uptake on the 9th day, the senescence of spikes and wilting of florets rapidly advances. These results were in close conformity with the reports of Jain *et al*. (2006) in cut flowers of rose cv. First Red and Varu and Barad (2008) in tuberose

4.3.11 Vase life

Vase life as influenced by different treatments has been presented in table 4.39. It is evident from the results that there was significant difference in vase life as influence by different wrapping materials. In the first year of experiment, T_5 (Shrink wrap) (12.00 days) recorded maximum vase life which is closely followed by T_4 (Non-perforated plastic) (11.67 days) which were statistically at par while, minimum was recorded from T_1 (control) (8.33 days). During second year, maximum vase life was recorded from T_4 (Non-perforated plastic) and T_5 (Shrink wrap) with same value of 11.67 days, whereas, minimum was recorded from T_1 (control) (7.67 days). Result of the pooled data showed maximum vase life in and T_5 (Shrink wrap) (11.83 days) followed by T_4 (Non-perforated plastic) (11.67 days) which were statistically at par. Minimum was recorded in T_1 (control) (8.00 days).

All treatment of wrapping materials performed well when compared to control as observed from the table 4.39. It was observed that vase life is greatly enhanced by wrapping. The best results were obtained from T_5 (Shrink wrap) and T_4 (Non-perforated plastic), these may be due to the packaging film which modifies the internal atmosphere with high CO_2, low O_2 and high relative humidity as the spikes were well concealed and encapsulated by the shrink wrap (Farber *et al*., 2003). Also all wrapping materials were significantly superior when compared to control as the wrapping films modified the atmospheric condition within the packaging resulting to longer vase life. The wrapping films minimized the lost of moisture from the spikes thus keeping the spikes fresh by maintaining turgidity and delayed senescence (Cazier *et al*., 2001) which metabolized more carbohydrates for the functions of florets and also reduces the moisture lost from the spikes. As a result florets senescence was delayed and prolongs vase life. These findings are in accordance with the reports of Mahawer *et al* (2019) cut spikes of tuberose cv. Suvasini where polypropylene gives the maximum vase life. Harsimran *et al*. (2018) reported in gladiolus that modified atmosphere (MA) storage in polypropylene (PP) packages exhibited higher vase life. Alka *et al*. (2007) also reported that Polypropylene packaged delayed the petal senescence and extended the vase life of the gladiolus cut spikes.

SUMMARY AND CONCLUSION

The present investigation entitled, **"Standardization of planting time, zinc and boron nutrition and vase life of *Gladiolus primulinus* cv. Candyman"** was carried out at Horticulture Farm, School of Agricultural Sciences and Rural Development, Medziphema, Nagaland, during the period from October 2016 to December 2018. During the investigation, three experiments were conducted *viz*., (1) Studies on effect of planting time on performance of gladiolus, (2) Studies on effect of zinc and boron on performance of gladiolus and (3) Studies on effect of different wrapping materials on vase life of gladiolus. The objectives of the studies were; (1) To identify the suitable season(s) for commercial production of gladiolus cv. Candyman under foothill condition of Nagaland. (2) To study the effect of zinc and boron on growth, flowering, yield, and postharvest quality of gladiolus cv. Candyman. (3) To study the effect of different wrapping materials on vase life of gladiolus cv. Candyman. The observations were recorded under growth parameters, flowering parameters, post harvest parameters and yield parameters.

The salient findings of all the three experiments were summarized below.

5.1 Experiment No. 1: Studies on effect of planting time on performance of gladiolus

5.1.1 Growth characters

The effect of planting time on growth characters of the gladiolus shows significant variation among treatments. Maximum number of leaves (9.57), length of leaf (63.53 cm), width of leaf (3.58 cm), leaf area (142.22 cm^2), leaf area index (1.8) and plant height (88.40 cm) were recorded from T_{10} (October planting).

T_6 (June planting) shows early sprouting (7.03 days) and first leaf emergence (9.70 days) with minimum number of leaves per plant (8.90) same with T_1 and T_7, minimum length of leaf (55.08 cm), width of leaf (3.18 cm), leaf area (122.32 cm^2), leaf area index (1.41) and plant height (73.47 cm).

5.1.2 Floral characters

Flowering parameters showed variations to different planting time. T_{10} (October planting) was considered as best time with maximum spike length (79.73 cm), rachis length (42.57 cm), number of florets per spike (14.80), diameter of 1^{st}, 3^{rd}, and 5^{th} florets (10.23, 10.03 and 9.77 cm respectively), days to withering of 1^{st}, 3^{rd}, and 5^{th} florets (4.70, 5.97 and 7.03 days respectively) and self life (15.07 days).

Flowering parameters showed variations to different planting time. Minimum days to spike emergence (61.80 days), days to colour break stage of 1^{st}, 3^{rd}, and 5^{th} florets (70.70, 71.50 and 72.30 respectively) and days to opening of 1^{st}, 3^{rd}, and 5^{th} florets (72.97, 73.77 and 74.57 respectively) were recorded in T_5. Length of spike was recorded minimum in T7 (69.57 cm) but length of rachis was in T_6 (33.97 cm). Minimum number of florets per spike (12.10), diameter of 1^{st}, 3^{rd}, and 5^{th} florets (9.13, 8.88 and 8.52 cm respectively) were recorded in T_7. Minimum self life was observed from T_4 (12.40 days).

5.1.3 Postharvest parameters

From the experimental findings during the period of postharvest studies, T_{10} (October planting) exhibit the best with respect to fresh weight of spikes on 6^{th} day (76.17 g), days to opening of 50% florets (5.17 days), number of florets opened at a time (7.17), longevity of 1^{st}, 3^{rd}, and 5^{th} florets (5.00, 6.33 and 7.50 days) and vase life (13.83 days).

T_6 recorded minimum fresh weight of spikes on 1^{st}, 3^{rd} and 6^{th} day (42.33, 49.67, 46.17g respectively) and Solution uptake (62.00 mL). Minimum diameter of 1^{st}, 3^{rd}, and 5^{th} florets (9.13, 8.88 and 8.52 cm respectively) were recorded in T_7. Number of florets opened at a time (5.00), longevity of 1^{st}, 3^{rd}, and 5^{th} florets (3.33, 4.67 and 5.83 days) and vase life (10.17 days) were recorded minimum in T_4.

5.1.4 Yield parameters

Maximum number of corms per hill (1.20), weight of corms per hill (85.17 g), diameter of corm (6.79 cm) and weight of cormels per hill (2.68 g) were recorded in T_{10}. Minimum diameter of corm (5.28 cm) and number of cormels per hill (6.57) and weight of cormels per hill (2.16 g) were recorded in T_6. Maximum number of cormels per hill (10.53) was recorded in T_9 and minimum weight of corms per hill was recorded in T_5 (71.90 g)

5.2 Experiment no. 2: Studies on effect of zinc and boron on performance of gladiolus

5.2.1 Growth characters

The effect of zinc and boron nutrition on growth characters of the gladiolus shows significant variations from the control treatments except in days to sprouting. Maximum number of leaves per plant (9.23) and length of leaf (68.02 cm) were recorded in T_5 (H_3BO_3 0.4%). Maximum leaf area (144.79 cm^2) and leaf area index (1.70) were recorded in T_4 (H_3BO_3 0.2%). Maximum plant height

(99.50 cm) and width of leaf (3.70 cm) was recorded in T_6 ($ZnSO_4$ 0.2% + H_3BO_3 0.2%).

5.2.2 Floral characters

Minimum days to spike emergence (63.54 days), days to colour break stage of 1^{st}, 3^{rd} and 5^{th} florets (72.42, 73.28 and 74.22 respectively), maximum length of spike (89.77 cm) and length of rachis (48.52 cm) were recorded in T_6 ($ZnSO_4$ 0.2% + H_3BO_3 0.2%). Maximum diameter of 1^{st}, 3^{rd}, and 5^{th} florets (11.67, 11.33 and 11.09 cm respectively), number of florets per spike (15.65) and self life (17.19 days) were recorded in T_7 ($ZnSO_4$ 0.2% + H_3BO_3 0.4%).

5.2.3 Postharvest parameters

Maximum fresh weight of spikes on 1^{st}, 3^{rd}, 6^{th} and 9^{th} day (71.08, 80.22, 82.58 and 73.88 g respectively), length of spikes on 3^{rd}, 6^{th} and 9^{th} day (85, 86.10 and 87.13 respectively), days to opening of 50% florets (5.17 days), solution uptake (95.83 mL) and vase life (14.50 days) were recorded in T_6 ($ZnSO_4$ 0.2% + H_3BO_3 0.2%). Maximum longevity of 1^{st}, 3^{rd} and 5^{th} florets (5.67, 6.67 and 8.00 days respectively) were exhibit in T_3 ($ZnSO_4$ 0.4%), T_5 (H_3BO_3 0.4%) and T_6 ($ZnSO_4$ 0.2% + H_3BO_3 0.2%). Number of florets opened at a time (7.83) was recorded in T_4.

5.2.4 Yield parameters

The effect of zinc and boron nutrition exhibits no significant difference in number of corms per hill. Maximum weight of corms per hill (115.43 g), diameter of corm (7.44 cm) and number of cormels per hill (9.43) were recorded in T_4 (H_3BO_3 0.2%).

5.3 Experiment No.3: Studies on effect of different wrapping materials on vase life of gladiolus

5.3.1 Post harvest parameters

Different packaging materials showed significant influence on various parameters under studied. The results of the study showed that among different treatment, T_5 (Shrink wrap) gives the best result with respect to changes in fresh weight of spikes on 1st, 3rd, 6th and 9th day (54.83, 57.83, 56.17 and 53.17 g respectively), length of spikes on 6th and 9th day (76.42 and 76.08cm), length of rachis on 1st, 6th and 9th day (35.33, 35.25 and 33.08 cm respectively), diameter of 1st, 3rd and 5th floret (8.52, 8.33 and 8.15 cm respectively), days to opening of 50 per cent florets (3.33 days), days to opening of 5th florets (3.00 days), longevity of 5th florets (6.00 days), water uptake and water loss with maximum on 3rd day (27.50 g and 19.67 g respectively) and vase life (11.83 days).

T_4 (Non-perforated plastic) gives the maximum number of florets opened at a time (5.67) and minimum number of unopened florets (1.67). Also T_4 and T_5 give equal results in days to opening of 3rd florets (2.00 days) and longevity of 3rd floret (5.67 days).

Conclusion

Based on the above summarized experimental results, it can be concluded that:

Experiment No.1: Based on the results of the present experiments, it has been found that October planting time is most favourable. Also February planting can be done with little compromise on vase life ensuring frequent irrigation. Moreover, September planting can be taken without much compromise on performance and qualities. However June planting should be avoided as it was found inferior in performance under foothill condition of Nagaland.

Experiment No.2: It is clear from the experimental results, the benefits of zinc and boron nutrition on performance of gladiolus. Foliar application of zinc and boron should be recommended in commercial cultivation of gladiolus especially in foothill condition of Nagaland. Based on the experimental results T_6 ($ZnSO_4$ 0.2% + H_3BO_3 0.2%) can be recommended. Moreover other treatments are also statistically at par. It can safely assume that lower doses of zinc and boron foliar application largely enhance the performance of the crop.

Experiment No.3: Therefore from this experiment we can conclude that Shrink wrap and Non-perforated plastic can be used for wrapping cut gladiolus spikes to enhance post harvest qualities. From the practical applicability, shrink wrap been more tedious during unpacking and liable to flower damage if not handle with care also been unable to re-use again makes a poor choice as compare to Non-perforated plastic which can be easily unwrapped and re-used again over time which is also equally efficient in keeping the spikes quality. It would be a logical conclusion to recommend Non-perforated plastic for commercial purposed.

Future line of work

Base on the present investigation, the following suggestion are made for future line of work to increased production and extend post harvest qualities of gladiolus.

1. Staggered planting in other cultivars can be studied and research can be focused on suitable months like February, August, September, October and November with fewer days in between planting time.
2. Different concentration of zinc and boron can be carried out along with other micronutrients. Standard dose of micronutrients may be calibrated and critical limits of phytotoxicity may be studied.
3. Different wrapping materials should be studied; focus should be on locally available materials like banana leaves and suitability for long distant transportation may be envisaged.
4. Wrapping along with pulsing + vase solution + germicide and their interaction effects is suggested.

REFERENCES

Aboyeji C, Dunsin O, Aruna O. Adekiya, 2019. Zinc sulphate and boron-based foliar fertilizer effect on growth, yield, minerals and heavy metal composition of groundnut (Arachis hypogaea L) Grown on an Alfisol. *Intern J of Agron*.1-7.

Aerts, R. and Chapin, F.S. III. 2000. The mineral nutrition of wild plants revisited: A re-evaluation of processes and patterns. *Adv. Ecol. Res*., **30**: 1-67.

Ahmad, I., A.M. Khattak, N. Ara and N.U. Amin. 2011. Effect of planting dates on the growth of gladiolus corms in Peshawar. *Sarhad J. Agric*. **27**(2): 195-199.

Al-Humaid, AI. (2004). Adaptation of some gladiolus cultivars to Al-Qassim environmental conditions. *Arab Gulf Journal of Scientific Research*. **22**. 248-256

Alloway, B.J. 2008. Zinc in soils and crop nutrition. Second edition, published by IZA and IFA, Brussels, Belgium and Paris, France.

Amery,1 J. H. Hamza,2, 3 and M. P. Fuller3 1 2011. Effect of Boron Foliar Application on Reproductive Growth of Sunflower (Helianthus annuus L.) M. M. *Al- International Journal of Agronomy*. **8**: 1-5

Amin, M.R., Tahmina, S., Mahasen, M., Mehraj H. and Jamal Uddin. 2014. Influence of Zinc Levels on Flowering and Production of Corm and Cormel of Yellow Gladiolus (*Gladiolus grandiflorus* l.). *Bangladesh Res.Pub. J.* **10**(1): 54-57.

Andreini, C., Banci, L., Bertini, I. and Rosato, A. 2006. Zinc through the three domains of life. *J. Proteome Res*., **5**(11): 3173-8.

Anonymous. 2015. Indian Horticulture Database - 2015. National Horticulture Board, Ministry of Agriculture and Farmers Welfare, Government of India, Gurugram.

APEDA. 2020. Floriculture. Ministry of Commerce and Industry, Government of India. http://www.apeda,gov.in/apedawebsite/SubHead_Products/Floriculture.ht.

Bagde MS, Golliwar VJ, Yadgirwar BM. and Wankhede MN. 2009 Effect of planting dates on flower quality and yield parameters of gladiolus. *J. of soils and crops*, **19**(2): 351-354.

Berger KC. and Truog E. 1940. Boron deficiencies as revealed by plant and soil test. *J.Am.Soc.Agron.* **32**: 297-301.

Beura, S. and Singh, R. 2003. Effect of storage temperature and wrapping material on postharvest life of gladiolus cultivar Her Majesty. *J. Ornam. Hort.,* **6**(4): 322-327.

Bose, T.K., Yadav, L.P., Pal, P., Parthasarathy, V.A. and Das, P. 2003. Commercial Flowers. Vol. 2. Naya Udyog, Kolkata, India.

Broadley, M.R., White, P.J., Hammond, J.P., Zelko, I. and Lux, A. 2007. Zinc in plants. *New Phytol*., **173**(4): 677-702.

Bulut, Y. 1994. A study of azalea (*Rhododendron simsi* Rheinhold Ambrosius) cuttings rooting under greenhouse conditions in Erzurum. Master Thesis.

A.Ü. Faculty of Agriculture, Department of Landscape Architecture, Erzurum.

Cabot C, Martos S, Llugany M, Gallego B, Tolrà R, Poschenrieder C. 2019. A role for zinc in plant defense against psathogens and herbivores. *Front. Plant Sci*.**10:** 1171-1186.

Cakmak I. 2000. Possible roles of zinc in protecting plant cells from damage by reactive oxygen species. *New Phytol*. **146**:185–205.

Cakmak, I. 2008. Enrichment of cereal grains with zinc: Agronomic or genetic biofortification? *Plant and Soil*, **302**: 1-17.

Cazier, I. B., Nilsson, T. and Gekas, V. (2001). Spatial modeling of gas exchange in cucumbers. *Acta Hort*., **552**: 591-594

Chanda, S., Barma, G. and Roychowdhury, N. 2000. Influence of different levels of nitrogen, phosphorous and potassium on growth and flowering of gladiolus. *Hort. J.,* **13**(1): 76-86.

D. Dastagiri, B.P. Sharma, Dr B.S. Dilta. 2014. Effect of wrapping materials and cold storage durations on keeping quality of cut flowers of *Ornithogalum thyrsoides* Jacq. *Indian Journal of Applied Research*, **4**(2): 4-6

Day, B. P. F. (2001). Modified atmosphere packaging of fresh fruits and vegetables. *Acta Hort.,* **553**: 585-590.

Eid, R.A., Khalifa, R.K.M. and Shaaban, S.H.A. 2010. Effect of foliar application of zinc and benzyladenine on growth, yield and chemical constituents of tuberose plants. *Research J. Agri. and Biol. Sci*., **6**(6): 732-743.

Elif Akpinar and Yahya Bulut. 2011. A study on the growth and development of some Gladiolus (Gladiolus L.) varieties planted in different time under the ecological conditions of Erzurum. *African Journal of Agricultural Research*. **6**(13): 3143-3148.

Epstein, E. 2000. The discovery of the essential elements. In: Kung, S.D. and Yang, S.F. (eds) Discoveries in plant biology, vol 3. World Scientific Publishing Co. Pte. Ltd, Singapore. pp 1-16.

Epstein, E. and Bloom, A.J. 2004. Mineral nutrition of plants: principles and perspectives. 2nd edn Sinauer Associates, Sunderland, MA.

Fahad, S. Masood Ahmad, Kh. Akbar Anjum M, and Hussain S. 2014. The Effect of Micronutrients (B, Zn and Fe) Foliar Applicationon the Growth, Flowering and Corm Production of Gladiolus (*Gladiolus grandiflorus* L.) in Calcareous Soils. *J. Agr. Sci. Tech.* **16**: 1671-1682

Farahat, M.M., Soad Ibrahim, M.M., Lobna Taha, S. and Fatma El-Quesni, E.M. 2007. Response of vegetative growth and some chemical constituents of *Cupressus sempervirens* L. to foliar application of ascorbic acid and zinc at Nubaria. *World J. Agri. Sci*., **3**(4): 496-502.

Farber, J. N., Harris, L. J., Parish, M. E., Beuchat, L. R., Suslow, T.V., Gorney, J. R., Garrett, E. H. and Busta, F. F. (2003). Microbiological safety of controlled and modified atmosphere packaging of fresh and fresh- cut produce. *Comprehensive Review in Food Science and Food Safety,* **2**: 142-158.

Farooq M. U., Iftikhar Ahmad And M. Aslam Khan 2004. Storage and Vase Life of Cut Rose Flowers as Influenced by Various Packing Materials. Int. *J. Agri. Biol*., **6**(2): 237-239

Ganesh S and Kannan M. 2013. Essentiality of micronutrients in flower crops: A review. *Journal of agriculture and allied science*. **2**(3): 52-57

Goldblatt, P. and Manning, J. 1998. Gladiolus in Southern Africa, Timber Press, Portland, Oregon.

Grover, J. K., Singh, K., Gupta, A. K. and Ashok K. 2005. Effect of pre-storage pulsing treatment on storage of gladiolus spikes under modified atmosphere. *Indian J. Plant Physiology*, **10**(3): 248-253.

Gunjan Sharma and Ranjan Srivastava. 2014. Postharvest Life of Cut Chrysanthemum Cultivars in Relation to Chemicals, Wrapping Material and Storage Conditions. *Tropical Agricultural Research*. **26**(1): 195 – 201

Halder N.K , Rafiuddin M , Siddiky MA , Gomes R , Begam KA. 2007. Performance of Gladiolus as influenced by boron and zinc. *Pakistan Journal of Biological Sciences*: PJBS **10**(4): 581-585

Halder, N. K., Ahmed, R., Sharifuzzaman, S. M., Anzu-Man-Ara Bagam, K. and Siddiky, M. A. 2007. Effect of Boron and Zinc Fertilization on Corm and Cormel Production of Gladiolus in Grey Terrace Soils of Bangladesh. *Int. J. Sustain. Crop Prod*. **2**(5): 85-89

Halder, N. K.; Siddiky, M. A.; Ahmed, R.; Sharifuzzaman, S. M.; Begum, R. A. 2007. Effect of boron and zinc fertilization on flower yield and quality of

Gladiolus in Grey Terrace Soils of Bangladesh. *Journal of Soil and Nature*. **1**(3): 40-45

Halder, N.K., Ahmed, R., Sharifuzzaman, S.M., Anzu-Man-Ara Bagam, K. and Siddiky, M.A. 2007b. Effect of boron and zinc fertilization on corm and cormel production of gladiolus in grey terrace soils of Bangladesh. *Int. J. Sustain. Crop Prod*., **2**(5): 85-89.

Halder, N.K., Rafiuddin, M., Siddiky, M.A., Gomes, R. and Begam, K.A.M.A. 2007a. Performance of gladiolus as influenced by boron and zinc. *Pakistan J. Biol. Sci.*, **10**(4): 581-585.

Harsimran Kaur ; Seema Bedi ; Kushal Singh. 2018. Studies on modified atmosphere storage of gladiolus (*Gladiolus* spp.) spikes. *Indian Journal of Agricultural Biochemistry*. . **31**(1): 71-75

Hatwar, G.P., Gondane, S.U., Urkude, S.M. and Gahukar, O.V. 2003. Effect of micronutrients on growth and yield of chilli. *Soils and Crops*, **13**: 123-125.

Hembrom, R., Anil K. Singh, Sisodia, A., Singh J, and Asmita 2015 Influence of Foliar Application of Iron and Zinc on Growth, Corm and Cormel Yield in Gladiolus cv American Beauty. *Environment & Ecology*. **33**(4): 1544-1546

Iftikhar Ahmad, John Martin Dole. 2014. Postharvest performance of cut marigold, rose, and sunflower stems as influenced by homemade and commercial floral preservatives *Turk. J., Agric.* **38**: 916-925

Iftikhar Ahmad, Muhammad Abid Yasin and Ahmad S. Khan. 2014. Planting Time, Cultivar and Preservative Effects on the Growth, Yield, Postharvest

Longevity and Water Relations of Gladiolus. *Philipp Agric Scientist*. **97**(1): 28–35

Ikram S., Khan. N. A, Mahsud A. S. S., and Saima Mumtaz. 2016. Flowering Quality of Polianthus tuberosa var. Fancy white as Affected by Planting Dates in Agro Metrological Conditions of Islamabad. *Science*, *Technology and Development.* **35**(1): 47-50

Ivanka Ivanova, Valeria Ivanova, Dimitar Dimitrov. 2016. Influence of planting date on growth and cut flower in gladiolus. *Mokslo darbai*. **7**(12): 142-145.

Jain, R., Bhalla, R., Gupta, Y. C., Thakur, K. S. and Thakur, R. 2006. Effect of wrapping materials and dry storage on post harvest quality of rose cv. First Red cut flowers. *J. Ornam. Hort.,* **9**(3): 192-195.

Jauhari, S., Srivastava, R. and Srivastava, P.C. 2005. Effect of zinc on growth, flowering, corm attributes, postharvest life and leaf and corm nutrient status in gladiolus cv. Red Beauty. *Prog. Hort*., **37**(2): 423-428.

Joshi, A. C. 2012. Post harvest study on gerbera (*Gerbera jamesonii*) cv. Stanza. Ph.D. (Hort.) Thesis submitted to Navsari Agricultural University, Navsari.

Jyoti Sharma, A. K. Gupta, Chandan Kumar and R. K. S Gautam. 2013. Influence of zinc, calcium and boron on vegetative and flowering parameters of gladiolus cv. Aldebran. *The Bioscan*. **8**(4): 1153-1158,

K. Vasanthakumar, Tewodros Bezu and Anteneh Bekele. 2015. Response of varieties and planting dates on growth and flowering of gladiolus (*Gladiolus grandiflorus* Andrews) under the ecological. conditions of

Haramaya University, Eastern Ethiopia. *Journal of Horticulture and Forestry*. **7**(5): 112-117.

Kamal Kishor Nagar, Ashuthos Mishra, Sushma S Patil. 2018. Studies on effect of planting dates and varieties on growth and quality in gladiolus (*Gladiolus hybridus* Hort.) under sub-humid zone of Rajasthans. *Universal Journal of Agricultural Research*. **6**(5): 160-164

Katiyar, P., Chaturvedi, O.P. and Katiyar, D. 2012. Effect of foliar spray of zinc, calcium and boron on spike production of gladiolus cv. Eurovision. *HortFlora Research Spectrum*, **1**(4): 334-338.

Kaushal S., B.S. Dilta, S.V.S. Chaudhary, B.P Sharma and Y.C. Gupta. 2014. Effect of planting dates on growth and flowering of China aster Callistephus chinensis (L) Nees .*International Journal of Farm Sciences* **4**(1): 60-71

Khalifa, R. K. M., S.H.A. Shaaban and Rawia A. 2011. Effect of foliar application of zinc sulfate and boric acid on growth, yield and chemical constituents of iris plants. Ozean *Journal of Applied Sciences*. **4**(2): 129-144

Khan, M.A., Ahmad, I. and Ziaf, K. 2004. Effect of various packing materials on storage and vase life of cut rose flowers. *Int. J. Biol. Biotech.,* **1**(4): 581-584.

Khosa SS. Younis A. Yameen S. and Riaj A. 2011. Effect of foliar application of micronutrients on growth and flowering of gerbera (Gerbera jamesonii). *American-Euraian J. Agri.Environ.Sci.,* **11**(5): 736-757.

Khutiya Kamsen. 2016. Effect of planting dates on growth, flowering and multiplication of gladiolus cv. 'Solan mangla'. M.Sc. Thesis. Dr. Y. S. Parmar university of horticulture and forestry, Nauni, Solan (H.P).

Kour R. 2009. Impact of date of planting on growth, flowering and spike yield of Gladiolus cv.White Prosperity. *International Journal of Agricultural Sciences,* **5**(2): 651-652

Kumar, A., Sood, A., Palni, L.M.S. and Gupta, A.K. 1999. *In vitro* propagation of *Gladiolus hybridus* Hort.: Synergistic effect of heat shock and sucrose on morphogenesis. *Plant Cell, Tissue and Organ Culture*, **57**: 105-112.

Kumar, J., Mirza, A. and Pal, K. 2012. Study on post-harvest life of cut rose cv. First Red as affected by different chemicals and wrapping materials. *HortFlora Res. Spectrum,* **1**(3): 263-266.

Lahijie, MK. 2012. Application of micronutrients $FeSO_4$ and $ZnSO_4$ on the growth and development of gladiolus variety Oscar. *Int., J. Agri. Crop Sci*., **4**(11): 718-720.

Lepcha, B., Nautiyal, M.C. and Rao, V.K. 2007. Variability studies in gladiolus under mid hill conditions of Uttarakhand. *J. Ornamental Hort.,* **10**(3): 169-172.

LN Mahawer, HL Bairwa, Laxman Jat, 2019. Response of passive storage duration and polymeric packaging films on postharvest life of Suvasini tuberose cut spikes. *Indian Journal of Horticulture* **76**(3): 516-521

Mahawar T.C., Mahawer L.N., Bairwa H.L. 2015. Response of storage duration, harvest stages and polymeric packaging films on post harvest life of gladiolus cut spikes cv. White Prosperity. *Indian Journal of Horticulture.* **72**(1): 100-106

Mahgoub, H.M., Rawia, A.E. and Abulila, H. 2006. Response of gladiolus grown in sandy soil to zinc and potassium fertilization. *J. Applied Sci. Research*, **2**(11): 899-903.

Makwana, R. J. 2009. Pulsing and cold storage techniques in rose. M.Sc.(Hort.) Thesis submitted to Navsari Agricultural University, Navsari.

Maurya, R and Kumar, A (2014) effect of micronutrients on growth and corm yield of gladiolus *Plant Archives* **14**(1): 529-531

Maurya, R., Kumar, A. and Maurya, R.K. 2018. Effect of Micronutrients on Flowering and Vase Life of Gladiolus (*Gladiolus grandiflorus* L.), *Int. J. Pure App. Biosci.* **6**(5): 498-501.

Meena, RK. Mahawer LN. and HL. Bairwa 2018. Effect of staggered planting date on growth, floral, bulb and economic parameters in Phule Rajani tuberose under subhumid southern plains of Rajasthan. *Indian J. Hort.* **75**(4): 662-666

Mifsuda, S. and Hamilton, AP. 2013. Preliminary observations from long-term studies of gladiolus for the Maltese Islands. *J. Pl. Taxonomy and Geography*, **68**(1): 51-56.

Minenhle Thwala, Paul K. Wahome, Tajudeen O. Oseni and Michael T. Masarirambi 2013 Effects of floral preservatives on the vase life of orchid (*Epidendrum radicans* l.) cut flowers. *J. Hort. Sci. & Ornamen. Plants*, **5**(1): 22-29

Mohammed Dawood Saleem Al-Sawaf and Khalid Hashim Abd Al-Anzi. 2019. Effect of spraying with boron, zinc and soaking with gibberellic acid and paclobutrazol in some flowering traits, corms and cormels yield for *gladiolus hybrida* plant (Traderhorn cultivar). *Plant Archives* **19**(2): 4492-4501

Munsi, P., Chakrabarty, S. and Roychowdhury, N. 2011. Effect of storage conditions and packaging supplemented with different solutions (wet packing) on vase life of *gladiolus* . *Acta Hort*. (ISHS) **886**: 351-357

Naik, D.V., Dhaduk, B.K., Jambhale, S.S. and Kapadia, D.B. 2009. Effect of different micronutrients in gladiolus cv. American Beauty. *J. Orn. Horti*., **12**(4): 274-277.

Neha Chopde, G. H. Borse, Ommala Kuchanwar and A. T. Ghodke. 2016. Effect of boron and manganese on growth and flowering of gladiolus. *Plant Archives* **16**(1): 471-473

Noman A, Aqeel M, Khalid N, Islam W, Sanaullah T, Anwar M, Khan S, Ye W, Lou Y. 2019. Zinc finger protein transcription factors: Integrated line of action for plant antimicrobial activity. *Microb. Pathog*. **132**: 141–149.

Padmalatha TG, Satyanarayana Reddy R. Chandrasekhar, A. Siva Shankar and Chaturvedi. 2013. Effect of pre planting soaking of corms with chemicals and plant growth regulators on dormancy breaking and corm and cormels production in gladiolus. *Int. J. Plant, Animal and Environ. Science*. **3**(1): 28-33.

Panicker, B., Vijaykumar, M., Arumugam, T. and Jawaharlal, M. 2003. Packing of chrysanthemum and its effect on post harvest behavior. *National*

Symposium on Recent Advances in Indian Floriculture held at the Kerala Agricultural University, Thrissur. pp: 364-365.

Patel, G. D., Patel, R. B., Patel, B. N., Singh, A. and Dhaduk, B. K. 2008. Effect of wrapping films and cold storage on post harvest life of spierlily (*Hymenocallis littoralis*). *J. Ornam. Hort.*, **11**(3): 224-227.

Patel, T. and Singh, A. 2009. Effect of different modified atmosphere packaging (MAP) films and cold storage temperature (5, 10 and 150C) on keeping quality of gerbera (*Gerbera jamesonii*) flowers. *Acta. Hort.,* **847**: 353-358.

Pavani, U.; Pratap, M.; Rao, A. M. 2*014.* Influence of planting dates and vase chemicals on post harvest quality of gladiolus *(Gladiolus grandiflorus L.). Journal of Research ANGRAU*. **42**(2): 43-45

Rajiv K., Singh G.N., Misra R.L. 2003. Effect of boron, calicum and zinc on gladiolus. *Journal of Ornamental Horticulture*. **6**(2): 104-106

Randhawa, G. S. and Mukhopadhyay, A. (1986). "Commercial Floriculture". In: *Floriculture in India*. pp. 344-426.

Reddy, A. G. K.; Chaturvedi, O. P. 2009. Effect of zinc, calcium and boron on growth and flowering in gladiolus cv. Red Majesty. *Crop Research (Hisar)* **38**(1/3): 135-137

Reddy, G.V.S. and Rao, M.B.N. 2012. Precision foliar application of zinc to improve the growth and yield of gladiolus on Proceeding of AIPA, India. 344-345.

Roychowdhury, N., Chakrabarty (Das), S. and Munsi, P. 2011. Influence of packaging material, storage condition and storage duration on vase life of tuberose 'Calcutta Double'. *Acta Hortic***.** **886**: 359-364

Saba Ambreen Memon, Abdul RaufBaloch, Muhammad AyubBaloch and Mahmooda Buriro. 2013. Effect of zinc sulphate and iron sulphate on the growth and flower production of gladiolus (*gladiolus hortulanus*) *Journal of Agricultural Technology*. **9**(6): 1621-1630

Saeed, T., Hassan, I., Jilani, G. and Abbasi, N.A. 2013. Zinc augments the growth and floral attributes of gladiolus and alleviates oxidative stress in cut flowers. *Scientia Horticulturae*, **164**: 124-129.

Sahare, H. A. 2011. Pre-storage pulsing, packaging and storage of tuberose (*Polianthes tuberosa* L.) cv. Prajwal. M.Sc.(Hort.) Thesis submitted to Navsari Agricultural University, Navsari.

Shalini Jhanji and Kiranjeet K. Dhatt. 2017. Effect of modified atmosphere packaging and storage duration on keeping quality of gladiolus spikes. *Indian J. Hort.* **74**(4): 596-600

Sharma JR, Gupta RB, Panwar RD. 2004. Growth, flowering and corm production of gladiolus cv. Friendship as influenced by foliar application of nutrients and growth regulators. *J Orn Hort*. **7**(3-4): 154-158

Sharma, B. P. Beshir, H. M. Chaudhary, S. V. S. Dilta, B. S. 2010. Effect of various wrapping materials and storage durations on post harvest life of Asiatic hybrid lily cv. Apeldoor. *Annals of Horticulture*. **3**(1): 69-74.

Sheikh M.Q. and Jhon A.Q. 2005. Response of planting dates and genotypes on vegetative and floral characters in gladiolus. *Journal of Ornamental Horticulture*. **8**(3): 219-221.

Shukla A, Durairaj G, Schneider J, Duan Z, Shadle T, and Bhaumik SR. 2009. Stimulation of mRNA export by an F-box protein, Mdm30p, in vivo. *J. Mol. Biol*. **389**(2): 238-247

Sinclair SA, Kramer U. 2012. The zinc homeostasis network of land plants. *Biochim. Biophys. Acta*.**1823**: 1553–1567.

Singh Alka, Kumar Pushpendra, Kumar Jitendra. 2007. Effect of packaging films for modified atmosphere storage at low temperature on petal senescence in gladiolus cut spikes. *Indian Journal of Crop Science.* **2**(1): 215-219.

Singh, A. K. Asmita, Anjana Sisodia and Raimani Hembrom. 2015. Effect of foliar application of zinc and copper on leaf nutrient content, growth and flowering in gladiolus (*Gladiolus* spp) cv. Pink Friendship. *Indian Journal of Agricultural Sciences*. **85**(7): 00–00

Singh, A., Kumar, J. and Kumar, P. (2007a). Effect of different films and cold storage durations on keeping quality of gladiolus cut spikes. *J. Ornam. Hort*., **10**(4): 235-239.

Singh, C.M., and Prasad,V. M. 2014. Effect of micro nutrients spray on growth, yield and flower quality of gladiolus cv. White prosperity. *HortFlora Research Spectrum,* **3**(4): 373-376.

Singh, J.P., Kumar, K., Katiyar, P.N. and Kumar, V. 2012. Influence of zinc, iron and copper on growth and flowering attributes in gladiolus cv. Sapna. *Prog. Ag.*, **12**(1): 138-143.

Singh, K., Singh, P. J. and Arora, J. S. (2003). Studies on dry refrigerated storage of gladiolus spikes. *J. Ornam. Hort*., **6**(2): 107-109.

Singh, K., Singh, R., and Kumar, R. (2008). Effect of different polymeric films on modified atmosphere storage of gladiolus cut spikes. *J. Ornam. Hort*., **11**(1): 49-53.

Sinha, P. and Roy, S.K. 2002. Plant regeneration through *in vitro* cormel formation from callus culture of *Gladiolus primulinus* Baker. *Plant Tissue cult*., **12**(2): 139-145.

Srivastava Ranjan, Kandpal Kavita, Jauhari Shiva. 2005. Effect of Pulsing Solution, Packaging Material and Storage Duration on Post-harvest Life of Gladiolus. *Journal of Ornamental Horticulture*. **8**(2): 115- 118.

Sudhakar, M and Ramesh Kumar, S. 2015. Studies on the influence of planting season and weather parameters on growth parameters of two different varieties of *G. grandiflorus* L. *The asian journal of horticulture*. **10**(1): 36-40.

Suman Kumari, B.S. Patel1 and L.N. Mahawer. 2011. Influence of gibberellic acid and planting date on growth and flowering in gladiolus cv. Yellow Frilled. *J. Hortl. Sci*. **6**(2): 114-117.

Takatsu, Y., Manabe, T., Kasumi, M., Yamada, T., Aoki, R., Inoue, E., Morinnaka, Y., Marubashi, W. and Hayashi, M. 2002. Evaluation of germplasm collection in wild gladiolus species of Southern Africa. *Breeding Research,* **4**: 87-94.

Tanya Thakur, K. K. Dhatt and Shahnawaz Ahmed. 2015. Effect of planting time on growth and flowering of Gladiolus. *Int.J.Curr.Res.Aca.Rev.* **3**(5): 145-152

Thakur T., and KK. Dhatt .2015. genotype × environment interaction of corm and cormel production in gladiolus. *The bioscan* **10**(2): 715-719

Thamaraiselvi, S. P., Jawaharlal, M., Ganga, M, and Varadhraju, N (2010). Packaging technology for long term storage of jasmine (*Jasminum sambac* Ait.) flowers. *J. Ornam. Hotr.*, **13**(3): 171-181.

Trupti Patel, Alka Singh, T. R. Ahlawat and D. B. Kapadiya. 2016. Effect of different polyfilms and storage temperatures on postharvest quality of gerbera (Gerbera jamesonii) cv. 'Savana Red'.*The bioscan*. **11**(1): 197-199

Umme Kulsum Shampa. 2013. In M.Sc. Thesis; Influence of bulb size and boron on growth and yield of tuberose , Sher-E-Bangla Agricultural University. 2013

Varu D. K., and A.V. Barad. 2008. Effect of different packing methods on vase life and quality of cut flowers in tuberose (*Polianthes tuberosa* L.) cv. Double. *Asian J. of Bio Sci.* **3**(1): 159-162

Verma, A. K., Gupta, Y. C., Dhiman, S. R. and Jain, R. (2006). Effect of dry storage on post harvest quality of chrysanthemum (*Demdronthema grandiflora* Tzevlev) cv. Snow Ball. *J. Ornam. Hort.*, **9**(1): 20-24.

Vijay, I. Rao, M. B. N. Vani, V. S. Viji, C. P. 2015. Effect of boron and iron on vegetative growth in three Gladiolus (*Gadiolus grandiflorus* L.) cultivars. *Environment and Ecology*. **33**(2): 717-721

Yashawanth DR., Chandrashekar SY., Ganapathi M And B. Hemla Naik.2017. Influence of micronutrients on growth parameters of gladiolus (*Gladiolus grandiflorus* l.) Cv. Summer Sunshine. *Trends in Biosciences*. **10**(3): 1050-1055.

Zubair, M., Ayub, G., Abdur Rab, Noor Ul Amin, Masood Ahmad And Neelam Ara. 2013 Preflowering growth of gladiolus in response to staggered planting. *Pak. J. Bot*., **45**(4): 1329-1338.

STANDARDIZATION OF PLANTING TIME, ZINC AND BORON NUTRITION AND VASE LIFE OF *Gladiolus primulinus* cv. CANDYMAN

Thesis

submitted to

NAGALAND UNIVERSITY

in partial fulfillment of requirements for the Degree

of

Doctor of Philosophy

in

HORTICULTURE (Floriculture and Landscape Architecture)

by

JONAH DAKHO

Admn. No. Ph – 201/15 Regn. No. 828/2019

Department of Horticulture

School of Agricultural Sciences and Rural Development,

Nagaland University, Medziphema Campus – 797 106

Nagaland

2020

SUMMARY AND CONCLUSION

The present investigation entitled, **"Standardization of planting time, zinc and boron nutrition and vase life of *Gladiolus primulinus* cv. Candyman"** was carried out at Horticulture Farm, School of Agricultural Sciences and Rural Development, Medziphema, Nagaland, during the period from October 2016 to December 2018. During the investigation, three experiments were conducted *viz*., (1) Studies on effect of planting time on performance of gladiolus, (2) Studies on effect of zinc and boron on performance of gladiolus and (3) Studies on effect of different wrapping materials on vase life of gladiolus. The objectives of the studies were; (1) To identify the suitable season(s) for commercial production of gladiolus cv. Candyman under foothill condition of Nagaland. (2) To study the effect of zinc and boron on growth, flowering, yield, and postharvest quality of gladiolus cv. Candyman. (3) To study the effect of different wrapping materials on vase life of gladiolus cv. Candyman. The observations were recorded under growth parameters, flowering parameters, post harvest parameters and yield parameters.

The salient findings of all the three experiments were summarized below.

5.1 Experiment No. 1: Studies on effect of planting time on performance of gladiolus

5.1.1 Growth characters

The effect of planting time on growth characters of the gladiolus shows significant variation among treatments. Maximum number of leaves (9.57), length of leaf (63.53 cm), width of leaf (3.58 cm), leaf area (142.22 cm^2), leaf area index (1.8) and plant height (88.40 cm) were recorded from T_{10} (October planting).

T_6 (June planting) shows early sprouting (7.03 days) and first leaf emergence (9.70 days) with minimum number of leaves per plant (8.90) same with T_1 and T_7, minimum length of leaf (55.08 cm), width of leaf (3.18 cm), leaf area (122.32 cm^2), leaf area index (1.41) and plant height (73.47 cm).

5.1.2 Floral characters

Flowering parameters showed variations to different planting time. T_{10} (October planting) was considered as best time with maximum spike length (79.73 cm), rachis length (42.57 cm), number of florets per spike (14.80), diameter of 1st, 3rd, and 5th florets (10.23, 10.03 and 9.77 cm respectively), days to withering of 1st, 3rd, and 5th florets (4.70, 5.97 and 7.03 days respectively) and self life (15.07 days).

Flowering parameters showed variations to different planting time. Minimum days to spike emergence (61.80 days), days to colour break stage of 1st, 3rd, and 5th florets (70.70, 71.50 and 72.30 respectively) and days to opening of 1st, 3rd, and 5th florets (72.97, 73.77 and 74.57 respectively) were recorded in T_5. Length of spike was recorded minimum in T7 (69.57 cm) but length of rachis was in T_6 (33.97 cm). Minimum number of florets per spike (12.10), diameter of 1st, 3rd, and 5th florets (9.13, 8.88 and 8.52 cm respectively) were recorded in T_7. Minimum self life was observed from T_4 (12.40 days).

5.1.3 Postharvest parameters

From the experimental findings during the period of postharvest studies, T_{10} (October planting) exhibit the best with respect to fresh weight of spikes on 6th day (76.17 g), days to opening of 50% florets (5.17 days), number of florets opened at a time (7.17), longevity of 1^{st}, 3^{rd}, and 5^{th} florets (5.00, 6.33 and 7.50 days) and vase life (13.83 days).

T_6 recorded minimum fresh weight of spikes on 1^{st}, 3^{rd} and 6^{th} day (42.33, 49.67, 46.17g respectively) and Solution uptake (62.00 mL). Minimum diameter of 1^{st}, 3^{rd}, and 5^{th} florets (9.13, 8.88 and 8.52 cm respectively) were recorded in T_7. Number of florets opened at a time (5.00), longevity of 1^{st}, 3^{rd}, and 5^{th} florets (3.33, 4.67 and 5.83 days) and vase life (10.17 days) were recorded minimum in T_4.

5.1.4 Yield parameters

Maximum number of corms per hill (1.20), weight of corms per hill (85.17 g), diameter of corm (6.79 cm) and weight of cormels per hill (2.68 g) were recorded in T_{10}. Minimum diameter of corm (5.28 cm) and number of cormels per hill (6.57) and weight of cormels per hill (2.16 g) were recorded in T_6. Maximum number of cormels per hill (10.53) was recorded in T_9 and minimum weight of corms per hill was recorded in T_5 (71.90 g)

5.2 Experiment no. 2: Studies on effect of zinc and boron on performance of gladiolus

5.2.1 Growth characters

The effect of zinc and boron nutrition on growth characters of the gladiolus shows significant variations from the control treatments except in days to sprouting. Maximum number of leaves per plant (9.23) and length of leaf (68.02 cm) were recorded in T_5 (H_3BO_3 0.4%). Maximum leaf area (144.79 cm^2) and leaf area index (1.70) were recorded in T_4 (H_3BO_3 0.2%). Maximum plant height

(99.50 cm) and width of leaf (3.70 cm) was recorded in T_6 ($ZnSO_4$ 0.2% + H_3BO_3 0.2%).

5.2.2 Floral characters

Minimum days to spike emergence (63.54 days), days to colour break stage of 1^{st}, 3^{rd} and 5^{th} florets (72.42, 73.28 and 74.22 respectively), maximum length of spike (89.77 cm) and length of rachis (48.52 cm) were recorded in T_6 ($ZnSO_4$ 0.2% + H_3BO_3 0.2%). Maximum diameter of 1^{st}, 3^{rd}, and 5^{th} florets (11.67, 11.33 and 11.09 cm respectively), number of florets per spike (15.65) and self life (17.19 days) were recorded in T_7 ($ZnSO_4$ 0.2% + H_3BO_3 0.4%).

5.2.3 Postharvest parameters

Maximum fresh weight of spikes on 1^{st}, 3^{rd}, 6^{th} and 9^{th} day (71.08, 80.22, 82.58 and 73.88 g respectively), length of spikes on 3^{rd}, 6^{th} and 9^{th} day (85, 86.10 and 87.13 respectively), days to opening of 50% florets (5.17 days), solution uptake (95.83 mL) and vase life (14.50 days) were recorded in T_6 ($ZnSO_4$ 0.2% + H_3BO_3 0.2%). Maximum longevity of 1^{st}, 3^{rd} and 5^{th} florets (5.67, 6.67 and 8.00 days respectively) were exhibit in T_3 ($ZnSO_4$ 0.4%), T_5 (H_3BO_3 0.4%) and T_6 ($ZnSO_4$ 0.2% + H_3BO_3 0.2%). Number of florets opened at a time (7.83) was recorded in T_4.

5.2.4 Yield parameters

The effect of zinc and boron nutrition exhibits no significant difference in number of corms per hill. Maximum weight of corms per hill (115.43 g), diameter of corm (7.44 cm) and number of cormels per hill (9.43) were recorded in T_4 (H_3BO_3 0.2%).

5.3 Experiment No.3: Studies on effect of different wrapping materials on vase life of gladiolus

5.3.1 Post harvest parameters

Different packaging materials showed significant influence on various parameters under studied. The results of the study showed that among different treatment, T_5 (Shrink wrap) gives the best result with respect to changes in fresh weight of spikes on 1st, 3rd, 6th and 9th day (54.83, 57.83, 56.17 and 53.17 g respectively), length of spikes on 6th and 9th day (76.42 and 76.08cm), length of rachis on 1st, 6th and 9th day (35.33, 35.25 and 33.08 cm respectively), diameter of 1st, 3rd and 5th floret (8.52, 8.33 and 8.15 cm respectively), days to opening of 50 per cent florets (3.33 days), days to opening of 5th florets (3.00 days), longevity of 5th florets (6.00 days), water uptake and water loss with maximum on 3rd day (27.50 g and 19.67 g respectively) and vase life (11.83 days).

T_4 (Non-perforated plastic) gives the maximum number of florets opened at a time (5.67) and minimum number of unopened florets (1.67). Also T_4 and T_5 give equal results in days to opening of 3rd florets (2.00 days) and longevity of 3rd floret (5.67 days).

Conclusion

Based on the above summarized experimental results, it can be concluded that:

Experiment No.1: Based on the results of the present experiments, it has been found that October planting time is most favourable. Also February planting can be done with little compromise on vase life ensuring frequent irrigation. Moreover, September planting can be taken without much compromise on performance and qualities. However June planting should be avoided as it was found inferior in performance under foothill condition of Nagaland.

Experiment No.2: It is clear from the experimental results, the benefits of zinc and boron nutrition on performance of gladiolus. Foliar application of zinc and boron should be recommended in commercial cultivation of gladiolus especially in foothill condition of Nagaland. Based on the experimental results T_6 ($ZnSO_4$ 0.2% + H_3BO_3 0.2%) can be recommended. Moreover other treatments are also statistically at par. It can safely assume that lower doses of zinc and boron foliar application largely enhance the performance of the crop.

Experiment No.3: Therefore from this experiment we can conclude that Shrink wrap and Non-perforated plastic can be used for wrapping cut gladiolus spikes to enhance post harvest qualities. From the practical applicability, shrink wrap been more tedious during unpacking and liable to flower damage if not handle with care also been unable to re-use again makes a poor choice as compare to Non-perforated plastic which can be easily unwrapped and re-used again over time which is also equally efficient in keeping the spikes quality. It would be a logical conclusion to recommend Non-perforated plastic for commercial purposed.

Future line of work

Base on the present investigation, the following suggestion are made for future line of work to increased production and extend post harvest qualities of gladiolus.

1. Staggered planting in other cultivars can be studied and research can be focused on suitable months like February, August, September, October and November with fewer days in between planting time.
2. Different concentration of zinc and boron can be carried out along with other micronutrients. Standard dose of micronutrients may be calibrated and critical limits of phytotoxicity may be studied.
3. Different wrapping materials should be studied; focus should be on locally available materials like banana leaves and suitability for long distant transportation may be envisaged.
4. Wrapping along with pulsing + vase solution + germicide and their interaction effects is suggested.