Kurdistan Regional Government
Ministry of Higher Education & Scientific Research
University of Sulaimani
College of Agricultural Sciences

EFFECT OF BIOFERTILIZERS AND CARBOLIZER ON GROWTH AND VASE LIFE OF GERBERA PLANT

A Thesis

Submitted to the Council of the College of Agricultural Sciences at the University of Sulaimani in Partial Fulfillment of the Requirements for the Degree of Master of Science in

Horticulture

[Ornamental Plants]

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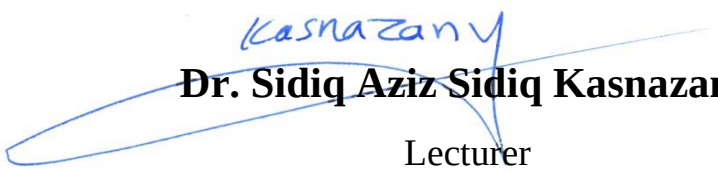

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Dedication

I WOULD LIKE TO DEDICATE THIS THESIS TO:

MY DEAR FATHER

MY MOTHER’S SOUL

MY DEAR SISTERS AND BROTHERS

MY LOVELY NIECE AND NEPHEW

MY ALL FRIENDS

AND TO ALL WHOM I LOVED.....

HEMN

Acknowledgement

Foremost, I want to give my thanks and grateful to Almighty God for the wisdom and good health he imparted me in order to finish this research.

This thesis ended by helping and supporting of many individuals. I would like to express my sincere thanks to all of them.

I would like to express my sincere gratitude to the Kurdistan Regional Government, Ministry of Higher Education and Scientific Research and Presidency of Sulaimani University. Thanks to Dr. Karzan Tofiq Mahmood the Dean of the College of Agricultural Sciences and Dr. Sidiq Aziz Sidiq Kasnazany, the Head of Horticulture Department, for supporting and facilitating everything related to the accomplishment of this thesis.

Also, I would like to express my special gratitude and thanks to my supervisor Dr. Sawsan Abdulla Abdul Latif for her support, advices, guidance, valuable comments, suggestions, knowledge and expertise that benefitted me much in the completion and success of this study.

I am honestly grateful to Dr. Muhamad Mustafa Alawi for his efforts to provide the biofertilizer inoculants and carbolizer etc.

My thanks and appreciations also go to my best friends Anwar Muhammed, Aram Akram, Hawar Halshoy, Ayub Karim, Hewa Abdullah, Omer Abdulqadr, Muhammed Sabir, Awara Rasul, Hawre Zahir, Goran Muhamad, Shvan Salih, Muhammed Mahmud, Mustafa Koja, and others who willingly helped me out with their abilities.

I have special thanks to Dr. Jalal Boskani that helped me to give some suggestion about plant protection, and I am really gratitude to Dr. Zaid Alhakim for his efforts to provide the distilled water. Thanks to Mr. Salam Mahmud who helped me in field experiment. My thanks go to examining committee for accepting my thesis.

Summary

This Study was conducted in a plastic house at the field of the Department of Horticulture. College of Agricultural Sciences, University of Sulaimani, during the growing seasons 2015 to 2016, to study the effect of biofertilizers and carbolizer on the growth and storage of *Gerbera jamesonii* cv. Stanza. This experiment was designed according to the Randomized Complete Block Design (RCBD) as factorial with three replications. Comparison among means was done using LSD (Least Significant Difference) test ($P \leq 0.05$). The experiment consisted of two factors; the first factor was bio-inoculant included four levels [without inoculation (A_0), inoculation with bacteria (*Azotobacter chroococcum* and *Bacillus subtilus*) (A_1), fungal inoculation with mycorrhiza (*Glomus mosseae*) (A_2) and inoculation with both bacteria and mycorrhiza (A_3)].

The second factor was liquid organic fertilizer (carbolizer) included three levels (B_0 control, B_1 1.5, B_2 2.5 $ml.L^{-1}$). The experimental results were summarized as follow:

Effects of bio-inoculants showed that the combination of both mycorrhiza and bacteria (A_3) were significant, increasing in vegetative growth characteristics; includes leaf chlorophyll intensity (44.99 spad unit), leaf area (1305.00 cm^2), number of offsets.$plant^{-1}$ (6.52), and percentage of leaf dry matter (28.59%). Moreover, they increased concentration of mineral elements N (4.95%), P (0.45%), K (4.39%), Fe (141.70 $mg.kg^{-1}$), and Zn (35.29 $mg.kg^{-1}$), in gerbera leaves. Also, this treatment showed significant increasing in flowering characters include length of flower stalk (52.35 cm), diameter of flower stalk (9.53 mm), capitulum diameter (17.34 cm), percentage of flower dry matter (17.58%), anthocyanin concentration in flower petals (32.39 $mg.100g^{-1}$), number of flowers during the study period (46.45) and vase life (28.52 days). Additionally, the same treatment showed significant increasing in root characters include length of main root (43.28 cm), diameter of main root (3.24 mm), root surface area (86.05 cm^2), N (4.51%), P (0.60%), K (4.64%) and root dry matter (18.41%).

Foliar spray with carbolizer especially at concentration 2.5 $mg.L^{-1}$ (B_2) had a significant effect in most vegetative growth characters, includes leaf chlorophyll intensity (44.72 spad unit), leaf area (1302.6 ds^2), number of offsets.$plant^{-1}$ (6.06), and percentage of leaf dry matter (26.92%). Also, it increased the concentration of mineral elements in gerbera leaves like N (4.31%), P (0.38%), K (4.05%), Fe (136.26 $mg.kg^{-1}$) and Zn (29.45 $mg.kg^{-1}$). Besides it increased significantly all characters of flowering includes length of flower stalk (48.83 cm), diameter of flower stalk (9.10 mm), capitulum diameter (15.80 cm), percentage of flower dry matter (16.06%), anthocyanin concentration in flower petals (30.11 $mg.100g^{-1}$), number of

flowers during the study period (42.25) and vase life (26.72 days). Furthermore, the same level of carbolizer showed significant increases in root characteristics such as the length of main root (39.27 cm), diameter of main root (2.98 mm), root surface area (82.14 cm^2), N (4.23%), P (0.59%), K (4.84%) and root dry matter (16.72%).

The interaction between the experimental factors (biofertilizers and carbolizer) significantly enhanced vegetative, root and floral growth characteristics, especially (A_3 x B_2).

The wet storage of gerbera cut flowers with concentrations of aluminum sulfate (0, 100, 150 and 200 $mg.L^{-1}$) at 8±2 ºC for 10 and 20 days significantly influenced vase life of flowers after storage, especially at concentration of aluminum sulfate (150 $mg.L^{-1}$) and storage for 10 days.

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List of Abbreviations

AEFB	Aerobic Endospore Forming Bacteria
$Al_2(SO_4)_3$	Aluminum sulfate
AM	Arbuscular Mycorrhiza (Endomycorrhizae)
AMF	Arbuscular Mycorrhizal Fungi
$CaCo_3$	Calcium Carbonate
Co_2	Carbon Dioxide
$dS.m^{-1}$	Deci-Siemens per meter
ERM	Extra Radical Mycelium
GPS	Global Positioning System
PGPR	Plant Growth Promoting Rhizobacteria
PGPR's	Plant Growth Promoting Rhizomicro-organisms
RH	Relative Humidity
SA	Soil Application
USA	United States of American

CHAPTER ONE
INTRODUCTION

As cut flowers is one of the most commercial production items and globally produced (Kendirli and Cakmak, 2007). Some countries, like the developing ones, depend largely on its production for economical contributions and new employment opportunities (Hassan, 2005). *Gerbera jamesonii* is one of the most important flowering plants that are used worldwide for cut flowers production, as it ranks the fifth grade among the main flowering plants and comes after rose, chrysanthemums, carnations and tulips (Gowda, 2009). Netherland produces 420 million stem of gerbera per year (Sudhagar and Phil, 2013). In the United States of America, gerbera ranked second for quantity sale from 2010 to 2013 (Hanks, 2015).

Robert Jameson, a Scotsman, first discovered gerbera daisies while operating a gold mine near Barberton in the Transvaal area of South Africa in 1880, and the genus gerbera, named in the honor of German naturalist, Traugott Gerber (Kessler, 1999 and Meman and Dabhi, 2006). Gerbera belongs to the family Asteraceae (Compositae), It is produces attractive flowers known as 'head' or capitulum, the plants has short rhizomatous stem, perennial herbs (Singh *et al*., 2014). Flower colors of gerbera have a wide range (red, white, yellow etc.), and red cultivars are the most widespread ones in markets by consumers (Şirin, 2011).

To improve the growth and production of the cut flowers, different types of chemicals, organic and biofertilizers were used. Biofertilizers which is known as "microbial inoculants", these are the products containing the living cells (Mainly bacteria and fungi) that naturally activate the microorganisms found in the soil, restoring the soil fertility and improving physical, chemical and biological properties of the soil (Stevenson, 1959 and Vessey, 2003). These essential substances are the biostimulants, which act as growth booster by inflicting the positive effects on plant nutrition and crop protection against stress and diseased conditions (Asghar *et al.*, 2002).

Two of the most important and beneficial root-interactive microbes are the arbuscular mycorrhizal fungi (AMF) and the plant growth promoting rhizobacteria (PGPR), (Perotto and Bonfante, 1997). Arbuscular mycorrhizal fungi (AMF) associated with plant roots have paramount importance in horticulture as colonization of roots by AM fungi has been shown to improve growth and productivity of several crops (Javaid *et al.*, 1994 and Pasqualini *et al.*, 2007) by increasing nutrient elements uptake. Besides, inoculation of crop plants with certain strains of PGPR at an early stage of development improves biomass production through direct effects on root and shoots growth (Das *et al*., 2013). Furthermore, AMF interaction with

certain PGPR has been reported to enhance the activity of AMF and consequently plant growth (Sumana *et al*., 2003).

Liquid organic fertilizers are derived from natural sources, and are found to be viable alternatives for fertilizing input for agricultural crops due to its high level of micro and macro elements, vitamins, fatty acid, also rich in growth regulators (Crouch and Staden, 1993). As indicated by (prolina) Carbolizer is one of the liquid organic fertilizers, which is extracted 100% from natural rocks and herbs, and helps plants with healthy and good growth.

Postharvest life of most cut flowers can be extended by a range of technologies; flowers can be stored for a longer period at low temperature. There are two methods of cold storage, wet and dry. Wet method is short-term storage, in which cut stems are dipped in water (Kumar, 2012).

In the case of vase life of cut flowers, it is maintained by using preserved solutions. Aluminum sulfate $Al_2 (SO_4)_3$ treatments has been recommended for maintaining vase life of several cut flowers (De Stigter, 1981 and Van Doorn, 1997). This is based, at least in part, on its action as an antimicrobial agent in the vase solution (Halevy and Mayak, 1981).

This study was done to investigate:

1. Different biofertilizers (*Glomus mosseae, Azotobacter chroococcum* and *Bacillus subtillus*).
2. Organic liquid fertilizer (Carbolizer) on the growth and cut flower storage of *Gerbera jamesonii* cv. Stanza.
3. Aluminum sulfate on the cut flower storage of *Gerbera jamesonii* cv. Stanza.

BIO-INOCULANTSCHAPTER TWO
LITERATURE REVIEW

2.1 Cut Flower Production Overview

Cut flowers cultivation is a subdivision of ornamental plant production having the largest part either in production or economic value (Anonymous, 2000). Flowers not only supplies aesthetical beauties, but also have become a commercial object. Today, flower production is a branch of agricultural cultivation in several countries and can contribute to national economies by providing millions of dollars (Bulut, 1994). In the early 20^{th} century and mainly after the Second World War, production of cut flowers gained importance in the world. For this reason, rapid developments and changes have occurred in the cut flower production, storage, classification and marketing. In these views, new techniques and technologies are used in the cut flower industry from production to consumption (Ozkan *et al*., 1997; Sayin *et al*., 2002 and Boran, 2008).

The cut flowers world market is 5.7 billion dollars, and the market dominated by Netherlands which accounts for about (54%) of exports in 2005. The other top exporters are Colombia (16%), Ecuador (6%) and Kenya (6%). The main import destinations for cut flower exports are to EU countries. The largest country destination is Germany (18%) followed by UK (17%) and the USA (16%) (Hornberger *et al*., 2007).

2.2 Pre-Harvest and Harvesting of Cut Flowers

Pre-harvest environmental conditions and cultural practices affect postharvest life of cut flower. The stage of growth and development of the flower determines postharvest life, and flower senescence depends primarily on inherent carbohydrate level and biophysical condition of the plant. At the same time, the genetic makeup of the species or cultivars also influences the postharvest life of flowers. The specific pre-harvest factors affecting the vase life of cut flowers are genetic factors (cultivars with resistance to bacterial infection, high carbohydrate content, low ethylene producer or low sensitivity to ethylene), environmental factors (temperature, light period/ intensity and relative humidity) and agronomic factors (soil, fertilizer, nutrition and irrigation) (Dahal, 2013).

Despite of, cut flowers must be harvested at the correct stage of development. Harvesting prematurely may prevent subsequent bud opening, while harvesting too late may reduce vase life and increase the chances of damage from ethylene and mechanical injury (Kelly, 1991). Minimum harvest maturity for most cut flowers is the stage at which harvested buds can be

opened fully and have satisfactory display life after distribution. Many flowers are presently harvested when the buds are starting to open (rose and gladiolus), although others are normally fully open or near to full open (chrysanthemum and carnation). Flowers for local markets are generally harvested much more open than those intended for storage and/or long-distance transport. Additionally, harvesting time affect cut flower as well, flowers are preferably harvested in the early morning, because temperatures are lower, plant water content is higher, and a whole day is available for processing the cut flowers (Reid, 2002a).

Gerbera was harvested in the early morning when two outer rows of disc florets have been opened, when the pollen grains could be seen (Pettersen and Gislerod, 2003). Gerberas are grown in the open field in tropical and sub-tropical regions, but in temperate regions, they are cultivated in greenhouse (protected condition) to protect against frost and undesirable climate (Sankaran *et al*., 2008).

2.3 *Gerbera jamesonii* L.

Gerbera is a beautiful perennial plant. It is used as cut flower, garden plant and it makes a good showing in exhibitions and floral arrangements because of its numerous colors and shapes. *Gerbera jamesonii* L. Family (Asteraceace) commonly known as Transvaal Daisy or Barberton Daisy is a tender perennial having brilliantly colored disc-shaped flowers and leafless stalks, however among the leading cut flower crops in the international trade (Bellubbi *et al*., 2015). Singh *et al*. (2014) reported that gerbera produces attractive flowers known as 'head' or capitulum. The plants are short stem perennial herbs. Leaves are radial, petiolate, lanceolate, deeply lobed, sometimes leathery, narrower at the base and wider at the tip and arranged in a rosette fashion at the base (short stem). *Gerbera jamesonii* is one of the most important cut flowers worldwide (Teeri *et al*., 2006 and Bhatia *et al*., 2009).

Flowers are available in a wide range of colors, including yellow, orange, pink, crimson, red, purple, and white (Emongor, 2004). The inflorescence of *Gerbera hybrida* are composed of two different types of florets (Ray and Disc) that are tightly packed into a condensed, radially organized capitulum (Kotilainen *et al*., 2000).

The most inexpensive way to produce gerberas is from seed obtained from reputable seed companies throughout the United States. However, plants propagated from seed are usually not true to type and may vary greatly in flower color. Seed should be germinated in an artificial growing medium. Should be transplanting seedlings to small pots as soon as the first true leaves appear. Seedlings can be grown in small pots until they are large enough to transplant into flower beds. Desired cultivars can be obtained by dividing parent plants. One-

year-old plants consisting of multiple plants (crowns) can be dug and divided during the spring (Tjia and Black, 2003). It is generally propagated by division of suckers or clumps. Propagation by division of suckers or clumps gives the same type of the plants but the multiplication rate is very low (Son *et al.*, 2011).

Gerbera are grown throughout the world in a wide range of climatic conditions in the year (Sudhagar and Phil, 2013). It is one of the most important trade flowers in the international market, mainly in European countries such as the Netherlands, Germany, France and Italy and also Israel, Colombia and United States of America. Its commercial relevance is confirmed by the amount of money involved in the productive chain of this species. In the California State (USA), over 60 million units of gerbera flower are produced, which generate an income of 30 million dollars a year. In Europe, the sales in the Netherlands exceed 100 million units with value superior than 100 million Euro (Chung *et al*., 2001 and Teeri *et al*., 2006).

2.4 Biofertilizers

Biofertilizers come from the words of bio which means living and fertilizer which means a substance to make soils more fertile. Simply, biofertilizer referred to as the use of living organisms (bacteria, fungus… etc.) to increase the soil fertility, or refer to the added microbial inoculants to the soil. It can be easily found that biofertilizers are identified as plant extract, composted urban wastes, and various microbial mixtures with unidentified constituents, and chemical formulations supplemented with organic compounds (Subba Rao, 1998; Sharma *et al*., 2004; Singh and Purohit, 2011). Biofertilizers comprised of nitrogen fixers, phosphate dissolvers and available potassium (Ezz *et al.*, 2011). This groups of bacteria and fungi are solubilize the unavailable forms of inorganic-P like tricalcium, iron, aluminum and rock phosphates into soluble forms by release of a variety of organic acids like succinic, citric, malic, fumaric, glyoxalic and gluconic acids (Venkateswarlu *et al.*, 2007).

However biofertilizers are used extensively as an eco-friendly approach to minimize the use of chemical fertilizers, improve soil fertility status and for enhancement of crop production by their biological activity in the rhizosphere. Application of beneficial microbes in agricultural practices started 60 years ago and there is now increasing evidence that these beneficial microbial populations can also enhance plant resistance to adverse environmental stresses (water and nutrient deficiency and heavy metal contamination), the majority of plants growing under natural conditions are associated with mycorrhizae, mycorrhizal colonization of roots results in an increase in root surface area for nutrient acquisition, the extrametrical fungal hyphae can extend several centimeters into the soil and absorb large amounts of nutrients for

the host root (Wua *et al*, 2004). A gram of soil can contain up to 30 m of arbuscular mycorrhiza fungal extraradical hyphae (Smith and Read, 1997). The extra radical mycelium (ERM) of mycorrhizal fungi constitutes an important pathway for the translocation of energy-rich photoassimilates from plant to soil. Because of the large surface of the mycelium, and its provision of carbon, the extra radical mycelium potentially constitutes an important site for interactions with other microorganisms in soils. These physical associations between bacteria and fungi were influenced by hyphal vitality and fungal strain. The degree of attachment of bacteria to living or dead hyphae may reflect the ecological niche differentiation of these bacteria, and consequently their trophic relationship to the mycorrhizal fungi. Carbohydrates of mycelial origin, mainly in the form of glucose, acetate and formiate, were identified in exudates from an AM fungus. Mycelial exudates promoted the occurrence of certain bacteria, further supporting the view that specific interactions may occur between some bacteria and AM fungi (Toljander, 2006).

Mycorrhiza is a mutualistic association between fungi and higher plants. Different types of mycorrhizae occur, distinguished by their morphology and to a certain extent, in their physiology. These include ectomycorrhizae and endomycorrhizae, symbiotic association of plant roots with VA-fungi often result in enhanced plant growth because of increased acquisition of phosphorus (P) and other immobile mineral nutrients. VA-fungi are known to be effective in increasing nutrient uptake, particularly phosphorus and biomass accumulation of many crops in low phosphorus soil (Turk *et al.*, 2006). While both types penetrate the plant roots, ectomycorrhizae spread their hyphae between root cells, while endomycorrhizae hyphae penetrate root cells, mycorrhizae also benefit plants indirectly by improving soil structure of the soil, AM hyphae excrete gluey, sugar-based compounds called glomalin, which helps to bind soil particles, and make stable soil aggregates. Which improve soil structure, and improves air and water infiltration (Contra costa, 2003).

Plant growth promoting rhizobacteria (PGPR) are beneficial bacteria which have the ability to colonize the roots and either promotes plant growth through direct action or via biological control of plant diseases (Kloepper and Schroth, 1978). They are associated with many plant species and are commonly present in varied environments. Strains with PGPR activity, belonging to genera *Azoarcus*, *Azospirillum*, *Azotobacter*, *Arthrobacter*, *Bacillus*, *Clostridium*, *Enterobacter*, G*luconacetobacter*, *Pseudomonas*, and *Serratia*, have been reported (Hurek and Reinhold-Hurek, 2003).

Also among, biofertilizers benefiting the crop production is *Azotobacter* strains play a key role in harnessing the atmospheric nitrogen through its fixation they have been also reported

to improve fertility condition of the soil. Aerobic bacteria belonging to the genus *Azotobacter* represent a diverse group of free-living diazotrophic (with the ability to use N_2 as the sole nitrogen source) microorganisms commonly occurring in soil. The genus *Azotobacter* includes 6 species, with *Azotobacter chroococcum* most commonly inhabiting various soils all over the world (Mahato *et al*, 2009). *Azotobacter chroococcum,* a gram negative bacterium belonging to the family *Azotobacteraceae* of the proteobacteria is a coherent group of aerobic, free living diazotrophs able to fix atmospheric nitrogen in nitrogen free. Several properties of *Azotobacter* are most specifically noted for their nitrogen fixing ability but they have also been noted for their ability to produce different growth hormones (IAA and other auxins, such as gibberllins and cytokinins), vitamins and siderophores. *Azotobacter* is capable of converting nitrogen to ammonia, which in turn is taken up by the plants (Prajapati *et al.*, 2008). *Azotobacter* spp. can also produce antifungal compounds to fight against many plant pathogens (Jen-Hshuan, 2006).

Diversified populations of aerobic endospore forming bacteria (AEFB), viz., species of Bacillus, occur in agricultural fields and contribute to crop productivity directly or indirectly. Physiological traits, such as multilayered cell wall, stress resistant endospore formation, and secretion of peptide antibiotics, peptide signal molecules, and extracellular enzymes, are ubiquitous to these bacilli and contribute to their survival under adverse environmental conditions for extended periods of time. Species of *Bacillus* is known to promote plant growth. The principal mechanisms of growth promotion include production of growth stimulating phytohormones, solubilization and mobilization of phosphate, siderophore production, antibiosis, i.e., production of antibiotics, inhibition of plant ethylene synthesis, and induction of plant systemic resistance to pathogens (Gutierrez-Manero *et al*., 2001; Whipps, 2001; Idris *et al*., 2007 and Richardson *et al*., 2009).

Increased root colonization by AM fungi was observed when coinoculated with a range of PGPR including *Azotobacter chroococcum* and *Bacillus spp*., *Bacillus subtilus* promoted the establishment of the AM fungus Glomus intraradices and increased plant biomass as well as tissue contents of nitrogen and phosphorus (Toro *et al*., 1997; Gamalero *et al*., 2004 and Artursson *et al*., 2006).

2.5 Effect of Biofertilizers on Vegetative Growth of Cut Flower Plants

Wang *et al*. (1993) showed in their study on the inoculation of *Gerbera jamesonii* with two arbuscular mycorrhizal fungi (AMF), *Glomus intraradices* and *Glomus vesiculiferum.* That shoots dry weight of *Gerbera jamesonii* significantly increasing with AMF inoculated

treatments. Gerbera inoculated with *Glomus intraradices* and *G. vesiculiferum* gave the higher shoot dry weight (31.5% and 25.1%) than the control at week 8, 17.0% and 9.4% higher at week 12, and 27.7% and 18.0% higher at week 16. The positive effect of AMF increased with increasing the plantlet age, were reached to highest absolute value at the end of the experiment.

Selvaraj *et al*. (2008) showed when study the effects of arbuscular mycorrhizal (AM) fungus, *Glomus mosseae*, and some plant growth promoting rhizomicro-organisms (PGPR's) on the growth of *Begonia malabarica* that single inoculation with *Glomus mosseae* or dual inoculation with *Glomus mosseae* and *Bacillus coagulans* significantly enhanced the total dry weight of plants.

Shanan and Higazy (2009) revealed when studied the influence of N-biofertilization on enhancing growth and improving flowering of *Matthiola incana*. For this purpose, two pot experiments were performed over the two successive seasons 2007/2008-2008/2009.Biofertilization with *Azotobacter*, *Azospirillum* and *Cyanobacteria* filtrates increased significantly plants height, number of leaves per plant, and leaf area as compared to control.

Long *et al*. (2010) found that *Zinnia elegans* when inoculated with four arbuscular mycorrhizal fungi (AMF) for example; *Gigaspora margarita*, *Gigaspora rosea*, *Glomus intraradices*, and *Glomus mosseae*, either singly or a mixture of two species of *Gigaspora* and *Glomus*. That *Glomus* significantly enhanced the leaf size and the shoot biomass.

Prasad *et al*. (2012) observed that the inoculation of *Chrysanthemum indicum* L. by arbuscular mycorrhizal fungi (AMF) *Glomus mosseae* and *Acaulospora laevis* and phosphate solubilizing bacteria (*Pseudomonas fluorescens*) with superphosphate significantly increased the leaf area of all treated plants as compared to control plant. That the maximum leaf area (38.12±1.98 cm^2) was found in the medium concentration of superphosphate with the combination of two AM fungi *(Glomus mosseae* and *Acaulospora laevis*) and solubilizing bacteria (*Pseudomonas fluorescens*).

Karishma *et al*. (2013) showed in their study the effect of co-inoculation of *arbuscular mycorrhizal* fungi (AMF) i.e. *Glomus mosseae* and *Acaulospora laevis* with phosphate solubilizing bacteria *Pseudomonas fluorescens* in the presence of different doses of superphosphate (low, medium, high) under polyhouse condition on growth establishment and flowering response of gerbera. That biomass of all the inoculated plants of *Gerbera jamesonii* Bolus increased significantly in terms of shoot fresh and dry weight with all the levels of

superphosphate at the flowering stage. Maximum increase in shoot biomass (fresh and dry) was recorded in the dual combination of *Glomus mosseae* and *Pseudomonas fluorescens* at lower concentration of superphosphate, also showed that maximum leaf area of gerbera was found in the lower concentration of superphosphate with *G. mosseae* and *P. fluorescens* treatment.

Ali *et al.* (2014) carried out an experiment to study the effects of different bio-fertilizer on the growth and flower quality characteristics of *Gladiolus grandiflorus* L., biofertilizer treatments containing N-fixer bacteria *Azotobacter*, *Azospirillum*, *Rhizobium* and phosphorus solubilizing bacteria with control under greenhouse conditions, the results showed that all of the vegetative growth and yield were accomplished successfully by the application of biofertilizers. Qasim *et al*. (2014) showed in their study on the effect of microbial inoculation with *Azotobacter, Azospirillum* and *Rhizobium* bacteria on the growth and production of gladiolus "White Prosperity" under field conditions, that all treatments differed significantly in respect to leaf biomass; both of fresh and dry weights of leaves per plant were significantly increased as compared to the control. However, the maximum fresh and dry weights of leaves per plant (20.63 g and 9.08 g), were obtained with *Azospirillum* followed by which containing *Azotobacter* (18.45 g and 7.43 g), respectively. Plants grown of control treatment depicted the lowest leaf fresh and dry weight (11.16 g and 4.01 g). Roshanpour *et al*. (2014) showed when studied the effects of plant growth promoter bacteria on biomass and yield of *Ocimum basilicum*, the treatments were *Azotobacter chroococcum*, *Azospirillum lipoferum*, *Bacillus circulans* and control. The highest dry weight of plant was obtained with the combined application of each three bacteria.

Bohra and Kumar (2014) refers in their study on the effect of organic manures (poultry manure, vermicompost) and bio-inoculantss (mycorrhiza, trichoderma) on vegetative and floral attributes of Chrysanthemum cv. Little Darling, during 2010-2011.That maximum plant height (30.17 cm), number of primary and secondary branches (3.78 and 19.78) respectively, plant spread (28.53 cm) and number of leaves per plant (184.33) were recorded in mycorrhiza and vermicompost at all stages of plant growth.

2.6 Effect of Biofertilizers on Cut Flower Quality

Wang *et al*. (1993) reported that the inoculated *Gerbera jamesonii* with two arbuscular mycorrhizal (AM) fungi, *Glomus intraradices* and *Glomus vesiculiferum. Gerbera jamesonii* productivity was evaluated by the number of flowers, capitulum diameter, stem length, and

stem diameter, AM-inoculated gerbera plants produced highest number and diameter of flowers than non-inoculated gerbera.

Sohn *et al*. (2003) found that plant growth and flower quality of *Chrysanthemum morifolium* in response to the arbuscular mycorrhizal fungi (AMF) inoculation were examined, fresh weight, width and height of flowers in AMF inoculation were generally higher than those in control. Long *et al*. (2010) found that inoculation of *Zinnia elegans* with *Glomus mosseae* was more effective than *Glomus intraradices* in increasing the number and size of flowers; both of mycorrhizal inoculants were significantly different with control.

Shanan and Higazy (2009) showed in study the effect of N-biofertilization on enhancing the growth and flowering of *Matthiola incana*, that biofertilization with *Azotobacter*, *Azospirillumn* and C*yanobacteria* filtrates, enhanced the flowering quality in terms of florets number and diameter, fresh and dry weights of inflorescences.

Garmendia and Mangas (2012) indicated in study of the effects of two arbuscular mycorrhizal fungi (*Glomus mosseae* and *Glomus intraradices*) on cut flower yield of rose under greenhouse conditions that lower production was positively influenced by *Glomus mosseae* inoculation where the maximum value of basal diameters and flower length were associated with inoculated with *Glomus spp*.

Karishma *et al*. (2013) carried out an experiment to study the effect of co-inoculation of *arbuscular mycorrhizal* fungi (AMF) i.e. (*Glomus mosseae* and *Acaulospora laevis*) with phosphate solubilizing bacteria *Pseudomonas fluorescens* in the presence of different doses of superphosphate (low, medium, high) under polyhouse condition on growth establishment and flowering response of gerbera. Plants inoculated by (*G. mosseae, A. laevis* and *P. fluorescens)* with all superphosphate concentrations showed the highest numbers of flowers followed by *Glomus mosseae* and *Pseudomonas fluorescens*.

Khalaf (2013) explained in the study of the effect of bio vaccine (*Azospirillium brasilense*, *Glomus mossea* and *Glomus intrardices*), the organic fertilizer (decomposed sheep wastes), and the interaction between them on *Dianthus caryophyllus* during fall season of 2011 and spring season of 2012 that the mixture treatments bacteria (*Azosprillium brasilen*se) and Mycorrhiza fungi, which gave the significant highest values of flower diameter (66.42 mm and 54.75 mm) , flowers content of anthocyanin's pigment (35.3 mg and 29.3 mg), vase life (10.33 days and 9.17 days), and the percent of dry content in the flowers (28.07% and 24.59%).

Bohra and Kumar (2014) carried out an experiment to study the effect of organic manures (poultry manure, vermicompost) and bio-inoculantss (mycorrhiza and trichoderma) on vegetative and floral attributes of Chrysanthemum cv. Little Darling, during 2010-2011 and explained that the application of mycorrhiza and vermicompost resulted higher number of flowers per plant (70.56) and average yield (635.01 flower/m^2) as compared to control which gave least numbers of flowers per plant was (49.56), average yield (446.01 flower/m^2), and maximum stalk length (7.80 cm) compared to control (5.89 cm). While the influences diameter of *Chrysanthemum* was maximum (3.60 cm) when application of AMF with poultry manure and minimum in control (3 cm).

Kumari *et al*. (2015) carried out an experiment to study the effect of different strains of *Bacillus* and *Pseudomonas* and their combination in the screen-house on growth, flowering and nutrient content of *Chrysanthemum*, during the two successive seasons of 2011-2012 and 2012-2013. The interaction effect of *Bacillus* and *Pseudomonas* strains on the flower size (4.72 cm, 4.54 cm), number of days taken for first flowering from bud initiation (12.33 days, 11.67 days) and number of days taken for bud initiation (62.00 days, 61.67 days), was found to be significant compared with control in both the years.

2.7 Effect of Biofertilizers on Root Growth of Cut Flower Plants

Manoly and Nasr (2008) conducted an experimental study to evaluate the response of *Dahlia pinnata* plants grown in sandy calcareous soil to three biofertilizers namely biogenic, phosphorene and active dry yeast during season of 2006-2007 and 2007-2008, the number and fresh weight of tuberous roots of dahlia cut flower were significantly increased due to the different biofertilizer treatments compared to control treatment in both seasons, the highest numbers and weights of root were obtained by using the treatment of three biofertilizers mixed which increased the number of tuberous roots by 22.1% in the first season, and 22.6% in the second season, and increased the weight by 29.2% in the first season and 34.4% in the second season compared to the control treatment.

Prasad *et al*. (2012) conducted an experiment to study the effect of arbuscular mycorrhizal fungi (*Glomus mosseae* and *Acaulospora laevis*) and phosphate solubilizing bacteria (*Pseudomonas fluorescens*) with different levels of superphosphate on *Chrysanthemum indicum* L., after 100 days of inoculation, the percentage of mycorrhizal root colonization and AM spore number increased significantly in all treated plants compared to control. Maximum percentage of root colonization was present in combination of A. *laevis* and P. *fluorescens* (93.48±2.95%).

Karishma *et al*., (2013) studied the effect of co-inoculation of arbuscular mycorrhizal fungi (AMF) i.e. (*Glomus mosseae* and *Acaulospora laevis*) and phosphate solubilizing bacteria *Pseudomonas fluorescens* in the presence of different doses of superphosphate (low, medium and high), on growth of gerbera, the highest increase in root length of gerbera was observed in low concentration of superphosphate with G. *mosseae,* A. *laevis* and P. *fluorescens* treatment, the consortium treatment (G. *mosseae,* A. *laevis* and P. *fluorescens*) showed maximum increase in root biomass followed by G. *mosseae* and P. *fluorescens* with a lower concentration of superphosphate.

2.8 Effect of Biofertilizers on Nutrient Uptake of Cut Flower Plants

Biofertilizers play a very significant role in improving soil fertility by fixing atmospheric nitrogen, solubilizing insoluble soil phosphates and producing plant growth substances in the soil. They are in fact being promoted to harvest the naturally available, biological system of nutrient mobilization (Venkatashwarlu, 2008). Arbuscular mycorrhizas fungi (AMF) constitute a key functional group of soil biota that can greatly contribute to crop productivity and ecosystem sustainability in new plant production strategies. AM fungi are able to establish a symbiotic interaction with the root organs 80% of plant families. They do not only improve the growth of plants through increased uptake of available soil phosphorus and other non-labile mineral nutrients essential for plant growth, they also have 'non-nutritional' effects in stabilizing soil aggregates, preventing erosion, and in alleviating plant stress caused by biotic and abiotic factors (Smith and Read, 2008).

Dufault *et al*. (1990) reported that the mycorrhizal inoculation improves the phosphorus and potassium uptake which results in improved flower quality in gerbera. Wen and Chang (1995) reported that colonization by mycorrhizal fungi increases the vase life of cut *Gerbera jamesonii* L., one possibility can be enhanced nutrient absorption by colonized roots and enhanced metabolic exchanges between both partners, the second possibility may be due to vigorous, stronger and turgid inoculated plants as compared to control, it also may be due to better water and nutrient absorption especially nitrogen, potassium, zinc and copper.

Selvaraj *et al*. (2008) showed that the leaf content of phosphorus, potassium, zinc, copper and iron were maximum in *Begonia* plant when treated with *Glomus mosseae, Bacillus coagulans and Trichoderma viride* (27.14 mg.plant^{-1}, 15.2 mg.plant^{-1}, 507.2 µg.plant^{-1}, 89.2 µg.g^{-1}, and 94.2 µg.g^{-1}), respectively, while the content of above elements were lowest in un-inoculated plants.

Shanan and Higazy (2009) showed that the highest of N, P and K content in leaves and inflorescences of *Matthiola incana* were recorded when adding a mixture of N-biofertilization and cyanobacterial filtrate. Karishma *et al*. (2013) conducted an experiment to study the effect of co-inoculation of *arbuscular mycorrhizal* fungi (AMF) i.e. (*Glomus mosseae* and *Acaulospora laevis*) and phosphate solubilizing bacteria *Pseudomonas fluorescens* in the presence of different doses of superphosphate (low, medium, high) on growth establishment and flowering response of gerbera. The P content in shoots and roots significantly increased in all the treated plants as compared to control at the flowering stage of gerbera. The low concentration of superphosphate with G. *mosseae,* A. *laevis* and P. *fluorescens* showed maximum P content in shoots. Similarly, in roots, maximum P uptake was observed in *G. mosseae,* A. *laevis* and P. *fluorescens*.

Airsang *et al*. (2014) studied the influences of a phosphate solubilizing bacterium (*Pseudomonas striata)* and Arbuscular mycorrhizal fungi (AMF) fungus (*Glomus mosseae*) on the growth of *Glycine max* "LSb1", thy discovered that inoculated plants in sterilized soil produced significantly higher growth, dry matter, nodule number, N, P and K uptake in shoot, a moderate or lower growth response was observed in the plants in unsterilized soil. On the contrary, un-inoculated plants in sterilized garden soil did not show better growth or N, P and K uptake. Shi *et al.* (2015) showed the effects of three levels of soil water contents (4.5%, 9.0%, and 15.8%) w/w, and three AM inoculation treatments (*Glomus mosseae*, *Glomus etunicatum* and non-inoculated) on *Plantago minuta,* shoot growth, N and K concentrations were significantly higher the plants inoculated with *Glomus mosseae* than non-inoculated plants.

2.9 Effect of Carbolizer on Growth and Production of Plants

Organic fertilizers include solid organic fertilizers (farm yard manure, green manure and compost) as well as liquid organic fertilizers (plant extracts, compost watery extracts, compost leachate, compost teas, liquid manures and manure teas) (Bioherb, 1994). However, liquid organic fertilizers like poultry manure and compost tea have been found it is contain nitrogen mainly in inorganic form like ammonia (Price and Duddles, 1984; Gross *et al.*, 2008).

Albayati (2016) showed that carbolizer is one of the liquid organic fertilizers, which is extracted 100% from natural rocks and herbs and sprayed on the leaves as CO_2 gas or absorbed as carbon element via stomata. It increases concentration of CO_2 around the plant ambient, despite that carbolizer contains necessary nutrients for plant growth, the benefits

gained by the application of this product are: providing a source of energy for a good and healthy plant growth through improving photosynthesis and vigorous immune system, and could absorb a great deal of nutrients from soil, besides that, it decreases water needed by the plant, and increases leaf green color, as well as enhancing metabolism of carbon by 15-40%, reducing growth duration and raising the ratio of dry matter, improving the crop aspects, increasing postharvest life of the crop, and is being used as a minimize the using of chemical fertilizers as it is not harmful to the environment, carbolizer treatment showed a significant increase in leaf area of cowpea plant which is (218.2 dcm^2.plant^{-1}), this is in comparison with the control plant which gave (169.6 dcm^2.plant^{-1}).

Mohammed, (2016) in their study the effects of mycorrhizae, foliar spray with α-Tocoferol and carbolizer on growth, yield of Tamatillo plant *physalis pruinosa* L., that the triple interaction among study factors (mycorrhiza, foliar spray with carbolizer and foliar spray with α-Tocoferol 300 mg.L^{-1}) gave the significant highest value of the most of study parameters include plant height (184.00 cm), number of leaves (628.00 leaves), leaf area (1706.47 dcm^2.plant^{-1}), chlorophyll density (61.86 spad unit), fresh weight (3.19 kg.plant^{-1}) and dry weight (472.60 g.plant^{-1}) of the vegetative parts, leaves content of N (3.18%), P (0.44%), K (3.28%) and Fe (191.07 mg.kg^{-1} dry weight).

2.10 Postharvest of Cut Flowers

Floriculture is an emerging and fast expanding globalized market, as a result studies on postharvest handling of cut flowers occupy an essential position. The term postharvest is applicable for processes happening to flowers after detachment from mother plant. Postharvest may include physical (temperature, humidity), chemical (vase solutions, floral preservatives) or biological (optimal harvest) factors capable of delay in senescence. Temperature and optimal harvest maturity stage are important factors for control of quality loses in cut flowers (Hvoslef-Eide, 2008; Shahri and Tahir, 2011).

Maintaining the freshness of cut flowers and other ornamentals required an understanding of the factors that lead to their deterioration. Understanding these factors allows us to develop and implement optimum postharvest handling technologies. Factors such as: variety, pre-harvest factors, nutrient supply, water supply, air embolism, bacteria plugging, hard water, water quality, growth tropisms, temperature, light and mechanical damage affect postharvest of cut flowers. Besides, ethylene plays a central role in the senescence of many cut flowers (Reid, 2002b). In gerbera cut flower, wilting can be considered as one of the main postharvest disorders which may lead to stem break that occurs 10 cm below capitulum. As well as,

blockage of xylem vessels due to bacterial or microorganisms accumulation is another contributing factor leading to quality loss (Mar *et al.*, 2011). Dufault *et al*. (1990) developed postharvest information on field-grown gerbera which is affected by plant nutrition and spacing during production.

2.11 Effect of Aluminum Sulfate on Vase Life of Cut Flowers

Prolong of vase life is one of the most important factors for the quality of cut flowers. Senescence of cut flowers is induced by several factors like water stress (Sankat and Mujaffar, 1993), carbohydrate depletion (Ketsa, 1989), microorganisms (Witte and van Doorn, 1991) and ethylene effects (Wu *et al.*, 1991). One of the greatest problems in postharvest flower physiology is the blockage of the vascular system, due to air or bacterial growth, which reduces water uptake and blocks xylem vessels leading to water stress (Van Meetern *et al*., 2001). Antimicrobial compound treatment inhibits bacterial proliferation and suppresses the decrease in hydraulic conductance in *Gerbera jamesonii* cut flower. These findings support the opinion that vascular occlusion is mainly due to bacterial proliferation (Mittelheuser and Van Steveninck, 1969 and Zagory and Reid, 1986).

Quality maintenance is an important parameter in the evaluation of cut flower quality, for both domestic and export markets. Many investigators mentioned that some substances play an important role in extending vase life and maintaining the quality of cut flowers, when added to preservative solutions. The use of aluminum sulfate as a germicide in floral preservation is recommended by (Nowak *et al*., 1990) reported that the color, form and longevity were increased in flowers were treated with aluminum sulfate. The role of aluminum sulfate in increasing the vase life of cut flowers is not limited to lowering the pH of vase solution. Its antimicrobial in the preservative or vase solution (Liao *et al*., 2000). In commercial preservative solutions, aluminum sulfate has been proven, shown to maintain the vase life of several cut flowers and is applied as an antimicrobial compound (Ichimura *et al*., 2006). Aluminum sulfate decreases bacteria multiplication improves water uptake and acidifies preservative solution (Hassanpour *et al*., 2004). Ichimura and Ueyama (1998) reported that aluminium sulphate extended vase life and improved water relation of rose cut flowers by antimicrobial effect.

Since $Al_2 (SO_4)_3$ acts as a germicide, thereby encouraging continuous water transport through the cut stem by inhibiting the vascular blockage and delaying the increase in membrane permeability. This corroborates the result of (Shobha and Gowda, 1994) in cut *Calendula* flowers. In case of $Al_2 (SO_4)_3$, the maximum water loss (55.56 g) was observed in the scapes

which held in solution without $Al_2(SO_4)_3$ and the minimum water loss (47.11 g) was found in 0.75 mM $Al_2(SO_4)_3$ solution. Meanwhile, $Al_2(SO_4)_3$ increases the water uptake, it might act to inhibit vascular blockage by suppressing microbial growth (Jamil *et al*., 2016). Some workers reported that stem blockage is the major cause of water deficit and wilting of cut flowers (Rogers, 1973).

2.12 Storage of Cut Flowers

Storage of flowers is a vital practice of postharvest handling and management of flowers. It is due to saving energy and making possible long term shipment. The storage may have done by different methods including cold storage (wet and dry), controlled atmospheric storage, modified atmospheric storage, low pressure storage, etc. The cold storage of cut flowers facilitates the adjustment of flowers and other planting material supplies against the market demand and enables the accumulation of large quantities of flowers. Low temperature treatment during storage or shipment period reduces the entire metabolism in the tissue, slows down the respiration. Cold storage is the common method of storing cut flowers. It is necessary to maintain a stable and uniform temperature. In wet storage, flowers are stored with their base dipped in water or preservative solution for a short time. The lower-most leaves are removed from the stems in order to avoid wetting and subsequent decay (Senapati *et al*., 2016).

The relatively brief postharvest life of most cut flowers and potted flowering plants can be extended by a range of technologies. Studies have shown that vase life is negatively correlated with respiration after harvest, so prompt cooling to the lowest safe storage temperature is a key to long-distance transport of these perishable crops, and these techniques have not proved commercially useful in the marketing of many cut flowers. Low temperatures are also important in managing the effect of other factors contributing to early senescence, including water loss, the effects of ethylene, leaf yellowing, and the growth of diseases, (Jiang and Reid, 2012). The controlled atmosphere based on reduction of respiration rates, conservation of respirable substrates during storage, and delay in ethylene-triggered changes cause senescence. It involves the use of increased level of CO_2 and decreased levels of O_2 in the atmosphere, low storage temperature and prevention of the build-up of endogenous ethylene (Kumar, 2012). Cold storage also helps to regulate the market supply in case of surplus production, 'holding-over' for small duration to get good prices, use of economical refrigerated sea transportation, and stock for commercial consignments when supplies are inadequate (Nowak *et al*., 1990).

The rates of development and senescence of cut flowers are strongly influenced by temperature (Kofranek and Reid, 1980). Several researchers have shown the negative effects of improper storage temperatures on vase life of a range of cut flowers. Warm storage temperatures accelerate water loss, so it is possible that wet storage helps by replacing lost water. However, it has been shown that the reduction of cut flower vase life during storage is highly correlated with respiration at the storage temperature (Cevallos and Reid, 2001).

The problems of mold injury and ethylene damage in cut flower storage may be reduced through proper low temperature control. Now, the general factors of respiration and maturation that cause the aging and breakdown of flowers in storage must be considered. Control of these factors is of primary importance in facilitating successful long-term storage (Fischer, 1950).

CHAPTER THREE
MATERIALS AND METHODS

3.1 Location

A field experiment was conducted to investigate the effects of biofertilizers and Carbolizer on growth and vase life of *Gerbera jamesonii* cv.Staza, during the period 2015 to 2016. It has been practiced in a greenhouse at the College of Agricultural Sciences, University of Sulaimani, Kurdistan region, Iraq, with GPS reading of 35º 32'14" N, 45º 21'97" E, and an altitude of (743.40 M) above sea level. The field experiment was laid down in a factorial Randomized Complete Block Design (RCBD) with three replications. However, for storage experiment, flowers were treated in a (RCBD) of four treatments with three replications. Treatments applied as vase solutions were: aluminum sulfate [$Al_2 (SO_4)_3$] (0, 100, 150 and 200 $mg.L^{-1}$).

3.2 Soil Characteristics of the Experiment Site

Some physical and chemical properties of the soil under the experimental plots after applied 8 m^3 of manure and 3 m^3 of sandy loam during the study period were shown in table (3.1).

Table 3.1 The main physical and chemical properties of the experiment location soil.

Soil properties*	Units	The values
Sand	$g.kg^{-1}$	435.70
Silt		244.50
Clay		319.80
Texture		Sandy clay loam
EC	$d.ms^{-1}$	1.03
pH		7.87
Organic matter	$g.kg^{-1}$	28.90
Total nitrogen		10.20
Available phosphorus		0.03
Soluble potassium		0.08

*Data were analyzed in the Central Laboratories of College of Agriculture, University of Baghdad.

3.3 The Greenhouse Preparation and Seedling Planting

The greenhouse area plotted and the soil, manure and sandy loam mixed by rotivator on August 27, 2015, and the plots were prepared mechanically. The seedlings imported from Iran and had 3-4 true leaves. Seedlings received on seed trays then transplanted each one in plastic

pots with a diameter of (10 cm), containing agricultural components (peatmoss and perlite), then protected in a small glass house for two weeks before planting in the permanent place (greenhouse). Seedlings were planted in prepared plot in the greenhouse and the planting area was divided into three blocks and each block was sub-divided into (12) plots with (1 m) width and (1.20 m) length, and in each plot six seedlings were planted on September 22, 2015, on both sides of the plot. The distances among the plants and the lines were (40x40 cm), number of seedlings was generally (216).

Agricultural practices was carried out for all replications, such as weeding and hoeing the surface of the soil, in order to ventilate the soil and removing dry leaves from the bottom of the plant, then washing the dust from the leaves with water. Plants were irrigated using drip irrigation system as needed. The greenhouse was sprayed and covered with calcium carbonate ($CaCO_3$) to protect plants from the heat of sunlight and lower the temperature. Ventilation of the greenhouse was done by opening the doors and slots. Also, air cooler and heater were used to adjust the temperature in the greenhouse in both high and low temperature conditions. Atmospheric condition inside the greenhouse had been measured by recording maximum and minimum temperatures and relative humidity. Temperature and humidity inside the greenhouse during the study were shown in table (3.2).

Table 3.2 Some meteorological data inside greenhouse during the study period (2015 -2016).

Month	Max. Temp. (℃)	Min. Temp. (℃)	Max. Humidity (%)	Min. Humidity (%)
September, 2015	37.58	15.32	31.00	10.00
October	36.85	14.19	68.42	14.8
November	31.90	7.20	82.30	16.96
December	34.22	4.10	87.63	21.63
January, 2016	34.99	4.68	91.19	29.44
February	38.29	5.11	85.20	15.67
March	38.92	5.60	87.00	13.42
April	40.94	7.60	86.40	12.67

3.4 Treatments

The factorial experiment included two factors:

1. Biofertilizers including two types of bacteria (*Azotobacter chroococcum* and *Bacillus subtilus*) and arbuscular mycorrhizal fungi (*Glomus mosseae*).
2. Three levels of organic liquid fertilizer (Carbolizer), (0, 1.5, 2.5 $mg.L^{-1}$).

3.5 Inoculation of Biofertilizers

Biofertilizer inoculants which bacteria (*Azotobacter chroococcum* and *Bacillus subtilus*) and arbuscular mycorrhizal fungi (*Glomus mosseae*) with peat moss carrier used with the seedlings of *Gerbera jamesonii* cv. Stanza, for each plant 31 g bacteria and 40 g mycorrhiza, in this experiment put inoculants in the bottom of the hole before planting (Soil Aplication), to ensure proper contact of the roots to the biofertilizers, seedling roots were cleaned from peat moss around the root tips, before putting the seedlings in their holes (Simarmata, 2013). Also, to achieve 100% inoculation, three days after the first inoculation (Soil Application) plants were injected with liquid inoculant bacteria (16 ml.plant^{-1}), which of the biofertilizers brought from Ministry of Sciences and Technology, Center of Agricultural Research, Laboratories of Biotechnology, Alzaafarania, Baghdad.

3.6 Preparation of Bacterial Inoculant

1. Preparation of 1 litter of nutrient solution, (25 g) of nutrient broth was dissolved in one litter of distilled water and sterilized by using autoclave with the pressure of 1.5 bars at temperature (121℃) for 15 minutes before adding bacteria.
2. Adding (6 cm^3) of bacteria to the cultural media (liquid nutrient broth) and shaken for (15) minutes.
3. Then the bacterial culture putted in an incubator at (28℃*)* for 72 hours.
4. After inoculation period (3 g) of sugar and (2 g) of Arabic gum were added to the bacteria suspension shake it for 30-60 minutes. The bacteria inoculant ready to use.

Table 3.3 Percentage of Root Mycorrhizal Infection

Samples were taken from roots and determined by (Kormanik *et al.,* 1980)*

Treatments	Mycorrhizal infection (%)
Glomus mosseae alone	79%
Bacteria and Mycorrhiza	83%

*The percentages of root mycorrhizal infection were counted in the laboratories of Directorate of Biology Research/Agricultural Research Center/Ministry of Sciences and Technology/Baghdad.

3.7 Carbolizer Applications

Foliar spraying of carbolizer was done in five times. The first application was at plant growth initiation, the second was after three weeks from the first application, the third was three weeks after the second spray, the fourth was before three weeks from last application and the fifth was at plant flowering stage. Carbolizer components were shown in Table (3.4).

Table 3.4 Some properties of liquid organic fertilizer (Carbolizer)*.

Ec (Dsm^{-1})	pH	Nitrogen (N)%	Phosphorus (P)%	Potassium (K)%	Calcium (Ca)%	Carbon (C)%	Sulfur (S)%
43.4	8.60	6.6	0.50	0.34	4.5	20	2

*Data were analyzed in the Laboratories of Directorate of Water and Environment /Ministry of Sciences and Technology/Baghdad.

3.8 Storage of Flowers

Wet storage: *Gerbera jamesonii* cv. Stanza was harvested when two outer rows of disc florets have been opened, when the pollen grains could be seen. Flowers were harvested early in the morning at the same times the flowers put in distilled water directly, and then transferred to laboratory. Before treatment, the stalks were recut, so that all flowers reach a height of (35 cm) and probable air emboli gets removed. To determine the effect of storage period on vase life, different vase solutions: aluminum sulfate [$Al_2 (SO_4)_3$] (0, 100, 150 and 200 $mg.L^{-1}$) were applied. Then the gerbera flowers were stored in refrigerator at temperature 8 ± 2℃ for 10 and 20 days. After storage, the flowers were placed in vases containing only distilled water and change this distilled water after every three days. Cut the gerbera flowers and kept in a glasshouse with a maximum and minimum temperature of 25 ± 2℃ and 16 ± 2℃, respectively; relative humidity (RH) of 45 ± 5 %, and sun light 10-12 $h.day^{-1}$. The vase life was recorded as wilting of the flower petals or excessive bending of the scape.

3.9 Statistical Analysis

The data have been analyzed statistically by using computer through Statistical Social Science program (SAS, 2001), and mean of comparisons treatments were done by LSD (Least Significant Difference) and ($P \leq 0.05$) which was claimed by (SAS, 2001).

3.10 Studied Parameters

3.10.1 Vegetative growth

3.10.1.1 Leaf chlorophyll intensity (Spad unit)

Was measured as SPAD units using digital monitor chlorophyll meter (SPAD 502 PLUS).

3.10.1.2 Leaf area (ds^2)

Measured by Leaf area meter (ADC-Area Meter AM300).

3.10.1.3 Number of offsets.plant^{-1}

Counted of offsets for each plant.

3.10.1.4 Leaf dry matter (%)

Determined by taking the fresh weight of leaf and dried at 65˚C in a forced-air oven for 72 hrs, until the weight is Stable, then it was weighed again and percentage of DM was calculated as follow:

Dry matter (%) = $\frac{\text{dry weight of leaves}}{\text{fresh weight of leaves}} \times 100$.

3.10.1.5 Concentration of nitrogen in leaves (%)

Samples were taken from leaves and determined by Micro-Kjeldahl (Page *et al.,* 1982)

3.10.1.6 Concentration of phosphorus in leaves (%)

Samples were taken from leaves and determined by Spectrophotometer (Page *et al.,* 1982).

3.10.1.7 Concentration of potassium in leaves (%)

Samples were taken from leaves and determined by Flamephotometer (Erwin and Houba, 2004).

3.10.1.8 Concentration of iron in leaves (mg.kg^{-1})

Samples were taken from leaves and determined by (Atomic Absorption Spectrophotometer).

3.10.1.9 Concentration of zinc in leaves (mg.kg^{-1})

Samples were taken from leaves and determined by (Atomic Absorption Spectrophotometer)

3.10.2 Floral growth

3.10.2.1 Flower dry matter (%)

The same method indicated in 3.10.1.4 was applied

3.10.2.2 Length of flower stalk (cm)

Measured 2 *cm* above soil surface to the neck of the capitulum by using measuring tape.

3.10.2.3 Diameter of flower stalk (mm)

Measured at (1-2 cm) above the cut site by using electronic caliper.

3.10.2.4 Capitulum diameter (cm)

Measured during full open of inflorescences, and then calculated the farthest distance between the points by using electronic caliper.

3.10.2.5 Anthocyanin concentration in ray florets ($mg.100g^{-1}$)

Samples were taken from ray florets and determined by Spectrophotometer (Ranganna, 1977), method II.

3.10.2.6 Numbers of flowers during the study period

3.10.2.7 Vase life of flower (day)

Starting from harvesting to time at which flowers were showing symptoms of petal wilting or curling, stem bending ($\geq 90^{\circ}$) or breaking (Gerasopoulos and Chebli, 1999; Yagia *et al*., 2014).

3.10.3 Root growth

3.10.3.1 Length of main roots (cm)

Measured by measuring tape.

3.10.3.2 Diameter of main roots (mm)

Measured by electronic caliper.

3.10.3.3 Root surface area (cm^2)

Measured by measuring digimizer software version 4.5.

3.10.3.4 Root dry matter (%)

The same method indicated in 3.10.1.4 was applied

3.10.3.5 Concentration of nitrogen in root (%)

Samples were taken from root and determined by Micro-Kjeldahl (Page *et al.*, 1982).

3.10.3.6 Concentration of phosphorus in root (%)

Samples were taken from root and determined by Spectrophotometer (Page *et al.*, 1982).

3.10.3.7 Concentration of potassium in root (%)

Samples were taken from root and determined by Flame photometer (Erwin and Houba, 2004).

CHAPTER FOUR
RESULTS AND DISCUSSION

4.1 Effect of Biofertilizers and Carbolizer on the Vegetative Growth Characteristics of *Gerbera jamesonii* Cv. Stanza

4.1.1 Leaf chlorophyll intensity (spad unit)

The effect of biofertolizers on leaf chlorophyll intensity of *Gerbera jamesonii* cv. Stanza is shown in Table (4.1) which clearly explains significant effect of different bio-inoculant on leaf chlorophyll intensity of gerbera. Leaf chlorophyll intensity increased in all treated plants as compared to control, the maximum value was observed in dual inoculation of (fungi and bacteria) A_3 (44.99 spad unit), compared to control which showed least leaf chlorophyll intensity (37.40 spad unit).

Table 4.1 Effect of biofertilizers, carbolizer and their interactions on the leaf chlorophyll intensity (spad unit) of *Gerbera jamesonii* cv. Stanza.

Concentration of carbolizer (B)	Biofertilizers (A)				Effect of carbolizer (B)
	A_0 Control	A_1 Bacteria	A_2 Mycorrhiza	A_3 (Bacteria*Mycorrhiza)	
B_0 0.0 ml.L^{-1}	32.38 e*	36.92 cd	36.26 cd	39.89 bcd	36.85 b
B_1 1.5 ml.L^{-1}	38.87 bcd	41.64 a-d	39.45 bcd	45.88 ab	41.46 a
B_2 2.5 ml.L^{-1}	40.96 bcd	45.86 ab	43.08 abc	48.98 a	44.72 a
Effect of (A)	37.40 c	41.48 ab	39.60 b	44.99 a	
L.S.D 0.05	**A**	4.43			
	B	3.84			
	AB	7.68			

*The values in each column, row and their interactions followed by the same letters are not significantly different from each other according to Least Significant Difference Test ($P \leq 0.05$).

However, the effect of carbolizer with different levels on leaf chlorophyll intensity of gerbera was significant. The highest value (44.72 spad unit) was obtained from concentration of (2.5 ml.L^{-1}), and it wasn't significantly with (1.5 ml.L^{-1}). Both concentrations were significantly different with control (36.85 spad unit).

The interaction between biofertilizers and different levels of carbolizer was significant. The highest leaf chlorophyll intensity (48.98 spad unit) was recorded with (A_3xB_2), while the lowest value (32.38 spad unit) was obtained from control treatment. The results may be due to

that organic liquid fertilizer (Carbolizer) and biofertilizars were significant effect on all vegetative growth characteristics of *Gerbera jamesonii* cv. Stanza, significantly increased in leaf chlorophyll intensity. The beneficial effect of nitrogen in Table (4.4) on photosynthetic pigments as observed in this study might be due to its role of increasing the rates of photochemical reduction. Chlorophyll contents are one of the most important criteria to determine the health of the plant, because chlorophyll contents are directly related to physiological activities to manufacture food (Richardson and Simpson, 2011).

The previous results agreement with (Zare *et al*., 2015) showed that maximum chlorophyll content in *Stevia rebaudiana* was obtained by using organic matter together with *Glomus mosseae*. Aseri *et al*. (2008) indicated that the combined treatment of *Azotobacter chroococcum* and *Glomus mosseae* to be the most effective factor in total chlorophyll concentration of *Punica granatum* seedlings. Whereas, Yadav and Aggarwal (2015) reported that the increasing in total chlorophyll content in *Arachis hypogaea* L. after treating with *Glomus mosseae*, *Trichoderma viride* and *Pseudomonas fluorescens* may be due to increasing in uptake of phosphorus. Although, foliar application of carbolizer increases green color of plants and contains N, P, K, Ca, C and S that helps to build more chlorophyll rates. The results agreement with (Mohammed, 2016) showed that the triple interaction among (mycorrhiza, carbolizer and α-Tocoferol 300 $mg.L^{-1}$) on *Physalis pruinosa* L., gave the highest significant value of chlorophyll intensity.

4.1.2 Leaf area (ds^2)

Inoculation of *Gerbera jamesonii* cv. Stanza with bio-inoculants (Mycorrhiza fungi x Bacteria) and different levels of carbolizer significantly increased of vegetative growth characteristics over control. As shown in Table (4.2) the bioinoculation had a significant effect on leaf area of *Gerbera jamesonii* cv. Stanza. The highest leaf area was observed in the dual combination of fungi and bacteria A_3 (1305.00 ds^2) and it was not differed significantly with *Glomus mosseae* alone (A_2). Both concentrations were significantly different with non-inoculated treatments A_0 (692.30 ds^2).

The different levels of carbolizer significantly increased leaf area. The highest leaf area of gerbera (1302.60 ds^2) was obtained from (B_2), while the lowest value (680.40 ds^2) was obtained from (B_0). The interaction treatments affected significantly on leaf area of gerbera. The highest leaf area (1524.00 ds^2) was observed from (A_3xB_2). While, the lowest value (353.30 ds^2) was obtained from control treatments (A_0xB_0).

Table 4.2 Effect of biofertilizers, carbolizer and their interactions on the leaf area (ds^2) of *Gerbera jamesonii* cv. Stanza.

Concentration of carbolizer (B)	Biofertilizers (A)				Effect of carbolizer (B)
	A_0 Control	A_1 Bacteria	A_2 Mycorrhiza	A_3 (Bacteria*Mycorrhiza)	
B_0 0.0 ml.L^{-1}	353.30 d*	618.00 cd	776.80 bcd	973.70 abc	680.40 b
B_1 1.5 ml.L^{-1}	645.10 cd	1068.80 abc	1166.20 abc	1417.40 a	1074.40 a
B_2 2.5 ml.L^{-1}	1078.60 abc	1270.50 ab	1337.10 ab	1524.00 a	1302.60 a
Effect of (A)	692.30 b	985.70 ab	1093.40 a	1305.00 a	
L.S.D 0.05	**A**	358.58			
	B	310.54			
	AB	621.08			

*The values in each column, row and their interactions followed by the same letters are not significantly different from each other according to Least Significant Difference Test ($P \leq 0.05$).

This may be due to that biofertilizers are important source for supplementing plant nutrients such as N, P, K and increases nutritional elements especially those playing a great role in the formation and constancy of chlorophyll and increase vegetative growth (Habib and Zhagloul, 2012). The results were agreement with (Albayati, 2016) explained that carbolizer treatment significantly increased leaf area of Cowpea plant

In spite of that, carbolizer has a role of CO_2 and the activate carbon metabolism and increase their outputs that lead to build a strong vegetative structure of the plants and promotion of plant hormones that stimulate the division and cell elongation as well as to increase the concentration of CO_2 which is necessary to the respiration and energy production and then produce new cells, leading to an increase in plant growth (Taiz and Zeiger, 2010).

4.1.3 Number of offsets.plant^{-1}

The results in Table (4.3), it is clarified that the bio-inoculants (*Glomus mosseae* and bacteria) with different levels of carbolizer significantly increased the number of offsets per plant in all treated plants as compared to control plants. However, the highest number of offsets.plant^{-1} (6.52) was obtained under A_3 (*Glomus mosseae* and bacteria) followed by (A_2) containing *Glomus mosseae* alone (5.15). Plants grown in control treatment (A_0) depicted the lowest number of offsets per plant (3.85).

Effect of different levels of carbolizer significantly increased the number of offsets.plant^{-1}. The highest number of offsets.plant^{-1} (6.06) was obtained from (2.5 ml.L^{-1}), while the lowest value (4.06) was obtained from (B_0) control plants.

Table 4.3 Effect of biofertilizers, carbolizer and their interactions on the number of offsets.plant^{-1} of *Gerbera jamesonii* cv. Stanza.

Concentration of carbolizer (B)	Biofertilizers (A)				Effect of carbolizer (B)
	A_0 Control	A_1 Bacteria	A_2 Mycorrhiza	A_3 (Bacteria*Mycorrhiza)	
B_0 0.0 ml.L^{-1}	3.00 h*	3.94 gh	4.00 g	5.33 de	4.06 c
B_1 1.5 ml.L^{-1}	3.89 gh	4.22 fg	5.00 def	6.77 ab	4.97 b
B_2 2.5 ml.L^{-1}	4.67 efg	5.67 cd	6.44 bc	7.45 a	6.06 a
Effect of (A)	3.85 c	4.61 b	5.15 b	6.52 a	
L.S.D 0.05	**A**	0.56			
	B	0.48			
	AB	0.97			

*The values in each column, row and their interactions followed by the same letters are not significantly different from each other according to Least Significant Difference Test ($P \leq 0.05$).

It was found that the maximum number of offsets (7.45) was found in the highest concentration of carbolizer (B_2) with the combination of *Glomus mosseae* and bacteria (A_3), while the lowest value (3.00) was obtained from control (A_0xB_0).

Increasing the number of offsets with biofertilizers inoculation may be due to microorganisms lead to obtain better plant growth and productivity by producing of promoting growth regulators (gibberellin and auxins), vitamins, amino acids, polypeptides, anti-phytopathogens and polymers especially exopolysaccharides (De Mulé *et al*., 1999). Mahdi *et al*. (2010) reported that the activity of phytohormones like cytokinin and indole acetic acid was significantly higher in plants inoculated with AM. Higher hormone production resulted better growth and development of the plant, or may be due to the effect of carbolizer role of (CO_2) and the activated carbon metabolism to increase their outputs that lead to build a strong vegetative structure of the plants and promotion hormones of plant that stimulate the division and cell elongation as well as to increase the concentration of CO_2 which is necessary to the respiration and energy production and then will from new cells, leading to an increase in plant growth (Taiz and Zeiger, 2010).

4.1.4 Leaf dry matter (%)

The results in Table (4.4) show that the gerbera leaf dry matter had been significantly increased with bioinoculation (fungi and bacteria) over control. The (A_3) treatment gave the highest leaf dry matter (28.59%) followed by *Glomus mosseae* alone A_2 (27.06%), while the lowest leaf dry matter (23.21%) was obtained from non-inoculated plants.

Effect of different levels of carbolizer significantly increased leaf dry matter of gerbera. The highest leaf dry matter (26.92%) was obtained from (B_2), while the lowest leaf dry matter (24.56%) obtained from (B_0) control.

The interaction between biofertilizers and carbolizer were affected significantly on leaf dry matter of gerbera. The highest (29.33%) and lowest values (20.94%) were recorded from (A_3xB_1) and (A_0xB_0), respectively.

Table 4.4 Effect of Biofertilizers, Carbolizer and their interactions on the percentage of leaf dry matter (%) of *Gerbera jamesonii* cv. Stanza.

Concentration of carbolizer (B)	Biofertilizers (A)				Effect of carbolizer (B)
	A_0 Control	A_1 Bacteria	A_2 Mycorrhiza	A_3 (Bacteria*Mycorrhiza)	
B_0 0.0 ml.L^{-1}	20.94 h*	23.65 g	25.95 de	27.72 bc	24.56 b
B_1 1.5 ml.L^{-1}	23.88 fg	25.33 ef	27.07 cd	29.33 a	26.40 a
B_2 2.5 ml.L^{-1}	24.83 d	25.95 de	28.15 abc	28.73 ab	26.92 a
Effect of (A)	23.21 d	24.98 c	27.06 b	28.59 a	
L.S.D 0.05	**A**	0.85			
	B	0.73			
	AB	1.47			

*The values in each column, row and their interactions followed by the same letters are not significantly different from each other according to Least Significant Difference Test ($P \leq 0.05$).

Increase in dry matter with increase in liquid organic carbolizer may be related to promote some physiological activities in the plant. According to (prolina) liquid organic carbolizer improves photosynthesis, enhances metabolism of carbon by 15-40% and raises ratio of dry matter, hence results in better plant growth. Vafadar *et al*. (2014) reported that the increasing of chlorophyll which could allow to better rate of photosynthesis relies on two factors: first, a greater C sink below ground due to the two symbionts (rhizobacteria and arbuscular mycorrhizae) and second, by the improved nutrition of the host plants.

The increase in fresh weight of leaves might be attributed to the nutrient accumulation in the leaves (Kumar and Haripriya ,2010). Some bacteria in the inoculated treatments not only fix

the nitrogen, but also solubilized the phosphorus in the soil, activated the plant growth hormones, natural enzymes, antibiotics and different compounds, that enhanced the vegetative growth (Astaraei and Koocheki, 1997). Nitrogen an essential component of protein, nucleic acid and many important substances like chlorophyll, which are required for vegetative growth and might be responsible for increase in dry matter accumulation in leaves (Dahiya *et al*., 2001). The soil bacteria belonging to the genera *Bacillus* and Fungi are more common. The major microbiological means by which insoluble Phosphorus compounds are mobilized by the production of organic acids, accompanied by acidification of the medium. The organic and inorganic acids convert tricalcium phosphate to di-and- monobasic phosphates with the net result of an enhanced availability of the element to the plant (Yazdani *et al.*, 2009)

4.1.5 Concentration of nitrogen in leaves (%)

The data in Table (4.5) showed that inoculated plants with biofertilizers were affected significantly on concentration of nitrogen in leaves of *Gerbera jamesonii* cv. Stanza. The highest N% (4.95) was obtained from dual inoculated plants (A_3) followed by inoculation with bacteria alone A_1 (3.78%), while the lowest N% (2.44) was achieved from uninoculated plants.

Table 4.5 Effect of biofertilizers, carbolizer and their interactions on the concentration of nitrogen (%) in leaves of *Gerbera jamesonii* cv. Stanza.

Concentration of carbolizer (B)	Biofertilizers (A)				Effect of Carbolizer (B)
	A_0 Control	A_1 Bacteria	A_2 Mycorrhiza	A_3 (Bacteria*Mycorrhiza)	
B_0 0.0 ml.L^{-1}	1.93 g*	2.68 f	2.66 f	3.96 e	2.81 c
B_1 1.5 ml.L^{-1}	2.59 f	4.11de	3.70 e	5.16 b	3.89 b
B_2 2.5 ml.L^{-1}	2.81 f	4.55 c	4.17 cd	5.72 a	4.31 a
Effect of (A)	2.44 d	3.78 b	3.51 c	4.95 a	
L.S.D 0.05	**A**	0.25			
	B	0.22			
	AB	0.43			

*The values in each column, row and their interactions followed by the same letters are not significantly different from each other according to Least Significant Difference Test ($P \leq 0.05$).

The maximum nitrogen concentration in gerbera leaves due to application of different levels of carbolizer was found at highest level application B_2 (4.31%), while the minimum N% (2.81) was obtained from control (B_0).

The interactions among (biofertilizers and carbolizer) were significant effects on percentage of nitrogen in gerbera leaves compared with all other interactions, the highest N% (5.72) was obtained from (A_3xB_2), while the lowest N% (1.93) was obtained from (A_0xB_0).

Microbial inoculations significantly increased nitrogen content as compared with the control treatment. This could be attributed to the rapid absorption of these elements by plant surface (spray with carbolizer) and their translocation in the plant. The microorganisms were used as biofertilizers in gerbera plants include the free living and associative nitrogen fixing (*Azotobacter chroococcum*), phosphate solubilizing rhizobacteria (*Bacillus subtilus*) and the mycorrhizal fungi (*Glomus mosseae*) are capable to mobilize non-available nutrients from soil and transporting them to and through plant roots, e.g. phosphorus (Hayman and Mosse, 1971) isolated culture of *Azotobacter* fixes about 10 *mg* $N.g^{-1}$ of carbon source under *invitro* conditions (Arun, 2007). Mycorrhizal fungi contribute in nutrition of host plant, absorbing and supplying it with mineral elements, like phosphorus, nitrogen and potassium in various inorganic or even organic compounds (Rishi *et al*., 2007). These results are in line with the findings of (Youssef and Talaat, 2003) reported that biofertilizers may be increase the total nitrogen percentage in rosemary plants which in turns increased the protein contents.

This may be due to that soil micro-organisms play a significant role in regulating the dynamics of organic matter decomposition and the availability of plant nutrients such as N, P and S (Chen, 2006). Moreover, biofertilizers promote root system expansion in the host plant (Barea *et al*., 2005), and also this helps plants to absorb more available nutrient elements. Salisbury and Ross, (1992) showed that the highest N, P and K content of leaves of *Matthiola incana* was recorded in adding a mixture of N-biofertilization and *Cyanobacterial* filtrate (Shanan and Higazy, 2009).

4.1.6 Concentration of phosphorus in leaves (%)

Results depicted in Table (4.6) clearly showed significant effect of different bio-inoculants on percentage of phosphorus in leaves of *Gerbera jamesonii* cv. Stanza. Concentration of phosphorus was increased in the plants treated as compared to control and maximum P (0.45%), observed in dual inoculation of (*Glomus mosseae* and bacteria) compared to control which showed least P% (0.19). However, the effect of carbolizer with different levels significantly increased phosphorus concentrations in gerbera leaves compared to control. The highest P% (0.38) was obtained from (B_2), and it was not differed significantly with (B_1). Both concentrations were significantly different with control B_0 (0.28%).

Table 4.6 Effect of biofertilizers, carbolizer and their interactions on the concentration of phosphorus (%) in leaves of *Gerbera jamesonii* cv. Stanza.

Concentration of carbolizer (B)	Biofertilizers (A)				Effect of Carbolizer (B)
	A_0 Control	A_1 Bacteria	A_2 Mycorrhiza	A_3 (Bacteria*Mycorrhiza)	
B_0 0.0 ml.L^{-1}	0.10 f*	0.29 cde	0.35 bcd	0.39 abc	0.28 b
B_1 1.5 ml.L^{-1}	0.22 e	0.33 b-e	0.39 abc	0.48 a	0.36 a
B_2 2.5 ml.L^{-1}	0.25 de	0.37 bc	0.40 ab	0.49 a	0.38 a
Effect of (A)	0.19 c	0.33 b	0.38 b	0.45 a	
L.S.D 0.05	**A**	0.05			
	B	0.05			
	AB	0.10			

*The values in each column, row and their interactions followed by the same letters are not significantly different from each other according to Least Significant Difference Test ($P \leq 0.05$).

The dual interaction between biofertilizers and different levels of carbolizer was significant. The highest concentration of phosphorus in leaves of gerbera (0.49%) was recorded with (A_3xB_2) and it was not differed significantly with (A_3xB_1), while the lowest P% (0.10) was obtained from (A_0xB_0).

This increasing may be related to the enhancement in uptake of nutrient elements might be due to the production of nutrient-solubilizing enzymes by microorganisms, and ability of AM. Fungal hyphae towards uptake of immobile ions, besides increasing the root surface area by tapping larger soil volume (Kothari *et al*., 1991; Li *et al*., 1991 and Aseri *et al*., 2008). The phosphate solubilizing bacteria (Strains from the genera *Bacillus*) used in this study as inoculants simultaneously increases P uptake by the plant and crop yield. The principal mechanism for mineral phosphate solublization is the production of organic acids and acid phosphatases play a major role in the mineralization of organic phosphorous in soil (Rodríguez and Fraga, 1999) and became available for absorption by the plants were sprayed with carbolizer that found beneficial as compared to control (water spray). This increase in characters of vegetative growth of gerbera plants in this study may be mainly due to the additional availability of macro and micro nutrients.

4.1.7 Concentration of potassium in leaves (%)

The amount of potassium in leaves of gerbera significantly increased in inoculated plants as compared to control as shown in Table (4.7), the increase of potassium content in leaves to

(4.39%) were found to be maximum in the plants treated with *Glomus mosseae* and bacteria (A_3) followed by bacteria alone A_1 (3.54%), as compared to control (A_0) which showed least K% (2.56).

The concentration of potassium in gerbera leaves was significantly affected by different levels of carbolizer. The higher K% (4.05) was obtained from (2.5 $ml.L^{-1}$) and it was not differed significantly with B_1 (3.61%), while the lowest K% (2.63) obtained from control.

The interaction between (biofertilizers x carbolizer) had significant effect on concentration of potassium in gerbera leaves (4.77%) which was obtained from ($A3xB_2$) and it was not differed significantly with A_3xB_1 (4.68), while the lowest value (1.81%) was obtained from (A_0xB_0).

Table 4.7 Effect of biofertilizers, carbolizer and their interactions on the concentration of potassium (%) in leaves of *Gerbera jamesonii* cv. Stanza.

Concentration of carbolizer (B)	**Biofertilizers (A)**				**Effect of carbolizer (B)**
	A_0 **Control**	**A_1** **Bacteria**	**A_2** **Mycorrhiza**	**A_3** **(Bacteria*Mycorrhiza)**	
B_0 **0.0 $ml.L^{-1}$**	1.81 e*	2.34 d	2.39 d	3.70 ab	2.63 b
B_1 **1.5 $ml.L^{-1}$**	2.49 cd	3.84 ab	3.40 bcd	4.68 a	3.61 a
B_2 **2.5 $ml.L^{-1}$**	3.46 bc	4.43 ab	3.55 bc	4.77 a	4.05 a
Effect of (A)	2.56 c	3.54 b	3.08 bc	4.39 a	
L.S.D 0.05	**A**	0.62			
	B	0.53			
	AB	1.07			

*The values in each column, row and their interactions followed by the same letters are not significantly different from each other according to Least Significant Difference Test ($P \leq 0.05$).

Dufault *et al*. (1990) reported that the mycorrhizal inoculation improves the phosphorus and potassium uptake which results in improved flower quality in gerbera. The microorganisms are used as biofertilizers in wheat broadly include the free living and associative nitrogen fixing and phosphate solubilizing rhizobacteria and the mycorrhizal fungi are capable of mobilizing non-available nutrients from soil and transporting them to and across plant roots, (Hayman and Mosse, 1971). These results are in accordance with (Chaitra, 2006) in *Calistephus chinesis* cv. Kamini and **(**Airadevi, 2012) in *Chrysanthemum coronarium* L. plant.

4.1.8 Concentration of iron in leaves (mg.kg^{-1})

The results in Table (4.8) clearly showed significant effect of different bio-inoculants on percentage of iron in leaves of *Gerbera jamesonii* cv. Stanza. Concentration of iron was increased in treated plants as compared to control and maximum iron concentration was observed in treatment of combined (*Glomus mosseae* and bacteria) A_3 (141.70 mg.kg^{-1}), compared to control which showed least iron concentration (111.57 mg.kg^{-1}).

However, the effect of carbolizer with different levels on iron concentrations in gerbera leaves showed that the highest iron concentration (136.26 mg.kg^{-1}) was obtained from (B_2), and it was not differed significantly with (131.71 mg.kg^{-1}). Both concentrations were significantly different with control B_0 (116.68 mg.kg^{-1}).

Table 4.8 Effect of biofertilizers, carbolizer and their interactions on the concentration of iron (mg.kg^{-1}) in leaves of *Gerbera jamesonii* cv. Stanza.

Concentration of carbolizer (B)	Biofertilizers (A)				Effect of carbolizer (B)
	A_0 Control	A_1 Bacteria	A_2 Mycorrhiza	A_3 (Bacteria*Mycorrhiza)	
B_0 0.0 ml.L^{-1}	96.91g*	115.59 f	123.26 ef	130.98 cde	116.68 b
B_1 1.5 ml.L^{-1}	116.57 f	129.51 de	136.78 bcd	143.98 ab	131.71 a
B_2 2.5 ml.L^{-1}	121.24 ef	133.95 cd	139.69 bc	150.14 a	136.26 a
Effect of (A)	111.57 d	126.35 c	133.24 b	141.70 a	
L.S.D 0.05	**A**	5.63			
	B	4.87			
	AB	9.75			

*The values in each column, row and their interactions followed by the same letters are not significantly different from each other according to Least Significant Difference Test ($P \leq 0.05$).

The interaction between biofertilizers and different levels of carbolizer was found to be significant. The highest concentration of iron in gerbera leaves (150.14 mg.kg^{-1}) was recorded with (A3xB2), while the lowest iron concentration (96.91 mg.kg^{-1}) was obtained from control. Increasing of Fe in gerbera leaves may be due to the effects of mycorrhizae and carbolizer on growth of gerbera. This results agreement with (Mohammed, 2016) reported that he triple interaction treatment between the study factors (mycorrhiza, foliar spray with carbolizer and foliar spray with α-Tocoferol 300 mg.L^{-1}) on Tamatillo plant *Physalis pruinosa* L, significantly gave the highest value of the most of study parameters for leaves content from N, P, K and Fe.

4.1.9 Concentration of zinc in leaves (mg.kg^{-1})

It is clear from data in Table (4.9) that the effect of bioinoculation on percentage of zinc in leaves of gerbera differed significantly. The highest zinc concentration in leaves (35.29 mg.kg^{-1}) was obtained in (A_3). Plants grown in control treatment (A_0) gave the lowest zinc concentration in leaves (21.21 mg.kg^{-1}). The effect of different levels of carbolizer significantly increased the concentration of zinc in gerbera leaves. The highest zinc concentration in leaves (29.45 mg.kg^{-1}) was obtained from (B_2), while the lowest value (23.93 mg.kg^{-1}) was obtained from (B_0).

Table 4.9 Effect of biofertilizers, carbolizer and their interactions on the concentration of zinc (mg.kg^{-1}) in leaves of *Gerbera jamesonii* cv. Stanza.

Concentration of carbolizer (B)	Biofertilizers (A)				Effect of carbolizer (B)
	A_0 Control	A_1 Bacteria	A_2 Mycorrhiza	A_3 (Bacteria*Mycorrhiza)	
B_0 0.0 ml.L^{-1}	19.92 f*	20.15 ef	24.28 ed	31.39 c	23.93 c
B_1 1.5 ml.L^{-1}	21.63 ef	23.23 ed	27.02 d	35.62 ab	26.88 b
B_2 2.5 ml.L^{-1}	22.08 ef	24.81 ed	32.04 bc	38.86 a	29.45 a
Effect of (A)	21.21 c	22.72 c	27.78 b	35.29 a	
L.S.D 0.05	**A**	2.30			
	B	1.99			
	AB	3.99			

*The values in each column, row and their interactions followed by the same letters are not significantly different from each other according to Least Significant Difference Test ($P \leq 0.05$).

It was found that the maximum zinc concentration in leaves (38.86 mg.kg^{-1}) was found in the higher concentration of carbolizer with the combination of *Glomus mosseae* and bacteria (A_3xB_2), while the lowest value (19.92 mg.kg^{-1}) were obtained from (A_0xB_0).

Increasing of concentration of nutrients including Fe and Zn may be due to the application of organic fertilizers which raise microbial activity in the soil, and effects of organic fertilizer increase by inoculation with biofertilizer. In this way, availability of nutrients can be increased to plant and maximum yield can be achieved (El-Shanshorey, 1995).

This study showed that all of the AMF treatments were contained higher leaf concentrations of N, P, K, Zn, and Fe compared to non-mycorrhizal plants. Increased P absorption is one of the best known responses of host plants to AMF inoculation because the absorbing surface of plant root systems goes on to be well extended in Table (4.19). Furthermore, reported that AMF may dissolve insoluble inorganic forms of P via the production of organic or inorganic acids. Generally, elements with immobility in the soil, such as P, Zn, and Fe can be absorbed

in higher amounts by mycorrhizal plants. It has been proved that mycorrhizal symbiosis can improve Zn acquisition as a secondary consequence of P uptake, It is considered that mycorrhizal fungi increase nutrient uptake and transport by producing a variety of siderophores and chelating agents, higher nutrient uptake by plants inoculated by AMF could also be ascribed to the fact that fungal hyphae penetrate into the root and soil, thereby increasing the surface areas of roots and thus acquiring more elements beyond the depletion zone the increased leaf concentration of Fe and Zn in gerbera plants through symbiosis with AMF is of paramount importance (Hosseini and Gharaghani, 2015) this study could also lead to reduced fertilizer applications in the soil, which is important from the standpoint of economy and environmental concern.

Foliar spray with carbolizer were found beneficial as compared to control, on the other hand this increase in characters of vegetative and flowering growth of gerbera plants in this study may be mainly due to the additional availability of macro and micro nutrients, which promoted till later growth stages, the role of macro and micronutrients is crucial in crop nutrition and thus important for achieving higher yields.

4.2 Effect of Biofertilizers and Carbolizer on the Flowers Quality Characteristics of *Gerbera Jamesonii* Cv. Stanza.

4.2.1 Flower dry matter (%)

The results in Table (4.10) explained that the effect of biofertolizers on percentage of flower dry matter of *Gerbera jamesonii* cv. Stanza was significant. The highest value (17.58%) was observed from dual inoculation ($A_{3)}$, while the lowest value (12.42 %) was recorded in control (A_0). The data in the same table demonstrated that foliar application of carbolizer with concentration of (B_2) levels gave the highest value of flower's dray matter content (16.06%) which differed significantly than control (B_0).

However the interactions among biofertilizers and different levels of carbolizer were found significant. The highest percentage of flower dry matter (18.42%) was obtained from (A_3xB_2), and it was not differed significantly with (A_3xB_1). Both concentrations were significantly different with control A_0B_0 (10.58%).

Increasing flower dry matter with biofertilizers inoculation may be due to that using microorganisms with *Gerbera jamasonii* L. synthesize and secrete many amino acids, which influence on plant growth that ultimately affects various parameters, such as flower character (Bellubbi *et al*., 2015).

Phosphate solubilizing bacteria (PSB) may be enhance mineral nutrients uptake by plants through solubilizing insoluble P from silicate in soil and fertilized with N-fixing bacteria in combination with it and with VAM. Spray with carbolizer was found beneficial as compared to control. This increase in characters of vegetative and flowering of gerbera plants in this study may be mainly due to the additional availability of macro and micro nutrients, which promote till later growth stages. The role of macro and micronutrients is crucial in crop nutrition and thus important for achieving higher yields. Nitrogen (N), phosphorus (P) and potassium (K), being primary essential nutrient, have prime importance in crop nutrition. Nitrogen is a primary constituent of proteins and thus all enzymes (Raun and Johnson, 1999). Phosphorous is involved in almost all biochemical pathways as a component part of energy carrier compounds, ATP and ADP (Khalil and Jan, 2003). Six micronutrients i.e., Mn, Fe, Cu, Zn, B and Mo are known to be required for all higher plants (Welch, 1995). These have been well documented to be involved in photosynthesis, N-fixation, respiration and other biochemical pathways (Marschner, 1986; Romheld, 1987 and Warman and Sampson, 1992). The exact function of potassium in plant growth has not been clearly defined. Potassium is associated with movement of water, nutrients and carbohydrates in plant tissue. If potassium is deficient or not supplied in adequate amounts, growth is stunted and yields are reduced. It is involved in the adjustment of plant cellular osmotic pressure and the transportation of compounds in plants. Potassium helps in the building of protein, photosynthesis, promotes the activation of enzymes (Bahadur *et al.*, 2014).

Table 4.10 Effect of biofertilizers, carbolizer and their interactions on the percentage of flower dry matter (%) of *Gerbera jamesonii* cv. Stanza.

Concentration of carbolizer (B)	**Biofertilizers (A)**				**Effect of carbolizer (B)**
	A_0 Control	**A_1** Bacteria	**A_2** Mycorrhiza	**A_3** (Bacteria*Mycorrhiza)	
B_0 0.0 ml.L^{-1}	10.58 h*	13.17 gh	14.99 d	16.10 c	13.70
B_1 1.5 ml.L^{-1}	12.80 g	14.05 e	16.20 c	18.21 a	15.31 b
B_2 2.5 ml.L^{-1}	13.91 ef	14.59 de	17.33 b	18.42 a	16.06 a
Effect of (A)	12.42 d	13.93 c	16.17 b	17.58 a	
L.S.D 0.05	**A**	0.46			
	B	0.40			
	AB	0.80			

*The values in each column, row and their interactions followed by the same letters are not significantly different from each other according to Least Significant Difference Test ($P \leq 0.05$).

4.2.2 Length of flower stalk (cm)

The data in Table (4.11) explained that the biofertilizers had a significant effect on length of flower stalk of *Gerbera jamesonii* cv. Stanza. The longest flower stalk (52.35 cm) was obtained from dual combination of *Glomus mosseae* and Bacteria followed by *Glomus mosseae* inoculated alone A_2 (45.76 cm), while the shortest flower stalk of gerbera (39.90 cm) was for non-inoculated treatment.

However, the effect of carbolizer with different levels on the length of flower stalk of gerbera was significant, the longest flower stalk (48.83 cm) was obtained from level (B_2) and the shortest flower stalk (41.58 cm) resulted from control (B_0).

Table 4.11 Effect of biofertilizers, carbolizer and their interactions on the length of flower stalk (cm) of *Gerbera jamesonii* cv. Stanza.

Concentration of carbolizer (B)	Biofertilizers (A)				Effect of Carbolizer (B)
	A_0 Control	A_1 Bacteria	A_2 Mycorrhiza	A_3 (Bacteria*Mycorrhiza)	
B_0 0.0 ml.L^{-1}	36.14 i*	39.67 h	42.54 fgh	47.99 cd	41.58 c
B_1 1.5 ml.L^{-1}	40.50 gh	42.75 fgh	45.17 def	52.72 b	45.29 b
B_2 2.5 ml.L^{-1}	43.34 efg	46.07 de	49.56 bc	56.34 a	48.83 a
Effect of (A)	39.90 d	42.83 c	45.76 b	52.35 a	
L.S.D 0.05	**A**	1.87			
	B	1.62			
	AB	3.24			

*The values in each column, row and their interactions followed by the same letters are not significantly different from each other according to Least Significant Difference Test ($P \leq 0.05$).

The significant effect of interaction treatments on length of gerbera flower stalk shown in the same Table, the tallest flower stalk (56.34 cm) were obtained from dual interaction between combination (Fungi x Bacteria) and carbolizer (A_3xB_2), while the shortest flower stalk (36.14 cm) was obtained from control.

The biofertilizers, carbolizer and organic manures used in conjugation with not only enhancement of the efficiency of fertilizers but also partly supply nutrients, at the same time improve the soil physical, chemical and biological properties. Atmospheric N in a free living state, like *Azotobacter*, these bacteria secrete some growth promoting factors, e.g. gibberellin, cytokinin-like substances, auxins and some vitamins such as thiamine, riboflavin, pyridoxine, nicotinic and pantothenic acids. This increase in plant height was due to the presence of readily available form of nitrogen. *Azotobacter* improved plant macro and micro nutrient

absorption and synthesize antifungal antibiotics, which gave it additional advantage for the field of production, this reason also may be due to that both biofertilizers and carbolizer had effected on floral characteristics. Bohra and Kumar (2014) studied the effect of organic matter and bio-inoculants on vegetative and floral attributes of *Chrysanthemum* cv. Little Darling. Show that stem length of *chrysanthemum* cut flower increased significantly with application of VAM and organic matter.

4.2.3 Diameter of flower stalks (mm)

The data presented in Table (4.12) indicated that the diameter of gerbera flower stalk significantly affected by biofertilizers, different levels of carbolizer and their interactions. The maximum diameter of gerbera flower stalk (9.53 mm) was observed with the combination of (*Glomus mosseae* and Bacteria) followed by A_2 and A_1 (8.75 mm and 8.16 mm) respectively, whereas it was minimum (7.29 mm) with non-inoculation (A_0).

Table 4.12 Effect of biofertilizers, carbolizer and their interactions on the diameter of flower stalk (mm) of *Gerbera jamesonii*.

Concentration of carbolizer (B)	**Biofertilizers (A)**				**Effect of carbolizer (B)**
	A_0 Control	**A_1 Bacteria**	**A_2 Mycorrhiza**	**A_3 (Bacteria*Mycorrhiza)**	
B_0 $^{-1}$ 0.0 ml.L	6.28 g*	7.69 f	7.98 f	8.64 de	7.64 c
B_1 $^{-1}$ 1.5 ml.L	7.60 f	8.11 ef	8.91 cd	9.63 b	8.56 b
B_2 $^{-1}$ 2.5 ml.L	8.00 f	8.68 b	9.37 bc	10.33 a	9.10 a
Effect of (A)	7.29 d	8.16 c	8.75 b	9.53 a	
L.S.D 0.05	**A**	0.33			
	B	0.29			
	AB	0.58			

*The values in each column, row and their interactions followed by the same letters are not significantly different from each other according to Least Significant Difference Test ($P \leq 0.05$).

The data also reveals that carbolizer application significantly influenced on the flower stalk diameters. The maximum diameter (9.10 mm) was recorded with the highest level of carbolizer (2.5 $ml.L^{-1}$), while it was minimum (7.64 mm) in control treatment.

The interaction between biofertilizers and different levels of carbolizer was found to be significant. The maximum diameter of flower stalk of gerbera (10.33 mm) was recorded with biofertilizers (fungi and bacteria) inoculated with the highest level of carbolizer (2.5 $ml.L^{-1}$), while the minimum diameter of flower stalk (6.28 mm) was obtained from (A_0xB_0).

4.2.4 Capitulum diameter (cm)

Table (4.13) shows that the effect of biofertilizers significantly increased capitulum diameter of gerbera. The highest capitulum diameter (17.34 cm) was obtained with dual inoculation (A_3) followed by A_2 (15.60 cm) as compared with the lowest value (11.62 cm) which was obtained from non-inoculated plants (A_0).

Table 4.13 Effect of biofertilizers, carbolizer and their interactions on the capitulum diameter (cm) of *Gerbera jamesonii* cv. Stanza.

Concentration of carbolizer (B)	Biofertilizers (A)				Effect of carbolizer (B)
	A_0 Control	A_1 Bacteria	A_2 Mycorrhiza	A_3 (Bacteria*Mycorrhiza)	
B_0 0.0 ml.L^{-1}	10.31 h*	11.71 g	13.95 de	15.82 c	12.95 c
B_1 1.5 ml.L^{-1}	11.63 g	12.58 fg	15.42 c	17.61 ab	14.31 b
B_2 2.5 ml.L^{-1}	12.93 ef	14.26 d	17.43 b	18.60 a	15.80 a
Effect of (A)	11.62 d	12.85 c	15.60 b	17.34 a	
L.S.D 0.05	**A**	0.59			
	B	0.51			
	AB	1.02			

*The values in each column, row and their interactions followed by the same letters are not significantly different from each other according to Least Significant Difference Test ($P \leq 0.05$).

Spray plants with carbolizer had a significant effect on capitulum diameter especially at concentration B_2 (2.5 ml.L^{-1}) which gave the highest value (15.80 cm) and significantly differed from the other concentrations which gave the lowest value (12.95 cm) at control.

It's clear that the interaction between biofertilizers and different levels of Carbolizer significantly increased capitulum diameters compared to control. The highest value (18.60 cm) was obtained from (A_3xB_2), whereas the lowest capitulum diameter (10.31 cm) was obtained in control treatment.

This may be due to the effect of biofertilizers on gerbera floral attributes the increases in diameter of flower stalks and capitulum diameter due to the inoculation might be attributed to the biological fixation of nitrogen and solubilization of phosphorus in root parts of plants resulting in absorption of more nutrients and its utilization. Moreover, *Azotobacter* had a role in nitrogen fixation and also involved in the production of indole-3-acetic acid (IAA), gibberellic acid (GA) and cytokinin like substances which enhanced the growth of plants, phosphorous solubilizing bacteria helped in solubilization and mobilization of phosphorous in

soil. This is in agreement with the results of (Selosse *et al*., 2004). Influence of biofertilizers (Azospirillum, phosphate solubilizing microorganisms) and vermicompost on leaf nutrient status and flower quality of *Carnation* cv. Sunrise plant, and biofertilizers enhance nutrient uptake and produce growth promoting substances like IAA and GA_3 resulting in better flower quality (Bhatia *et al*., 2016).

4.2.5 Anthocyanin concentration in ray florets (mg.100g^{-1})

It is clear in Table (4.14) that the inoculation of biofertilizers significantly increased anthocyanin concentration in Gerbera ray flowers, inoculation with A_3 (*Glomus mossea* and Bacteria) gave the maximum values of anthocyanin (32.39 mg.100g^{-1}) compared to the control treatment which gave the lowest value (22.45 mg.100g^{-1}).

Foliar application of carbolizer caused a significant increase in anthocyanin concentration especially (B_2) treatment which gave the highest value (30.11 mg.100g^{-1}), when compared to the lowest value (24.57 mg.100g^{-1}) was for control treatment.

The interaction between biofertilizers and foliar applications of carbolizer affected significantly on anthocyanin concentrations. The maximum anthocyanin concentration (34.69 mg.100g^{-1}), was obtained as a result of the interaction between (A_3xB_2) whereas the minimum value (20.12 mg.100g^{-1}) obtained in control treatment.

Table 4.14 Effect of biofertilizers, carbolizer and their interactions on the anthocyanin concentration in ray florets (mg.100g^{-1}) of *Gerbera jamesonii* cv. Stanza.

Concentration of carbolizer (B)	Biofertilizes (A)				Effect of carbolizer (B)
	A_0 Control	A_1 Bacteria	A_2 Mycorrhiza	A_3 (Bacteria*Mycorrhiza)	
B_0 0.0 ml.L^{-1}	20.12 i*	23.31 h	25.16 fg	29.71 de	24.57 c
B_1 1.5 ml.L^{-1}	23.02 h	26.02 f	28.63 e	32.76 b	27.62 b
B_2 2.5 ml.L^{-1}	24.22 gh	30.52 cd	31.00 c	34.69 a	30.11 a
Effect of (A)	22.45 d	26.62 c	28.28 b	32.39 a	
L.S.D 0.05	**A**	0.71			
	B	0.61			
	AB	1.23			

*The values in each column, row and their interactions followed by the same letters are not significantly different from each other according to Least Significant Difference Test ($P \leq 0.05$).

These results may be caused by the effect of biofertilizers and organic liquid fertilizer (carbolizer) on some plant pigments. Gendy *et al*.bio-inoculant (2012) showed that the

interaction of cattle manure and bio-fertilizer significantly increased anthocyanin content in Roselle plant compared with control treatment. The beneficial effect of nitrogen on photosynthetic pigments as observed in this study might be due to its role in increasing the rates of photochemical reduction and Anthocyanin accumulation can be induced by sugars in many plant species (Teng *et al*., 2005).

4.2.6 Number of flowers during the study period

As shown in Table (4.15), it is clear that the bio-inoculants (*Glomus mosseae* and bacteria) and different levels of carbolizer significantly increased the number of flowers during the study period in all treated plants as compared to control plants. However, the highest number of flowers (46.45) was obtained in A_3 (*Glomus mosseae* and bacteria) followed by A_2 containing *Glomus mosseae* alone (40.56) and it was not differed significantly with (A_1), while Plants grown in control treatment (A_0) gave the lowest number of flowers (36.55).

Different levels of carbolizer significantly increased number of flowers during the study period. The highest number of flowers (42.25) was obtained when spray (2.5 $ml.L^{-1}$), while the lowest value (39.41) was obtained from (B_0) control plants.

As for interaction, it was found that the maximum number of flowers (55.00) was found in the highest concentration of carbolizer (B_2) and *Glomus mosseae* and bacteria (A_3), while the lowest values (32.33) was obtained from control (A_0xB_0).

Table 4.15 Effect of biofertilizers, carbolizer and their interactions on the number of flowers during the study period of *Gerbera jamesonii* cv. Stanza.

Concentration of carbolizer (B)	Biofertilizers (A)				Effect of carbolizer (B)
	A_0 Control	A_1 Bacteria	A_2 Mycorrhiza	A_3 (Bacteria*Mycorrhiza)	
B_0 0.0 $ml.L^{-1}$	32.33 e*	36.67 d	38.00 cd	40.33 bcd	39.41 b
B_1 1.5 $ml.L^{-1}$	38.00 cd	40.33 bc	43.00 bc	44.00 b	40.92 ab
B_2 2.5 $ml.L^{-1}$	39.33 cd	41.33 bc	42.00 bc	55.00 a	42.25 a
Effect of (A)	36.55 c	39.89 b	40.56 b	46.45 a	
L.S.D 0.05	**A**	3.15			
	B	2.73			
	AB	5.25			

*The values in each column, row and their interactions followed by the same letters are not significantly different from each other according to Least Significant Difference Test ($P \leq 0.05$).

It may be related to the effect of biofertilizers and carbolizer on the availability and concentration of plant nutrients which cause increasing of root and vegetative growth. Treatments with bacterial inoculation provided balance nutrients for gerbera plants, uptake of nitrogen and phosphorus through roots are due to interaction between nitrogen fixing and phosphate solubilizing bacteria. Therefore inoculation with the bio-fertilizers *Azotobacter*, *Bacillus* bacteria, arbuscular mycorrhiza and farmyard manure application enhanced vegetative and floral qualities of gerbera compared with control treatment. This results agreement with (Bhalla *et al*., 2006) on *Gladiolus* and (Bohra and Kumar, 2014) on *Chrysansemum*. The increase in number of flowers might be due to elevated levels of macro-nutrients which have a positive effect on floral characteristics. It is dependent on food material prepared as a result of photosynthesis in leaves. On the other hand, may be due to induced cytokinin synthesis and rapid assimilation of photosynthesis resulting in early transformation in the axillary bud from vegetative to reproductive phase and carbohydrates are the major nutrient taking part in the development of flowers and may cause an increase in number of flowers.

4.2.7 Vase life of flowers (Days)

As shown in Table (4.16) about the vase life parameters of (*Gerbera jamesonii*) cv. Stanza according to the role of biofertilizers. The result of vase life was significantly affected by inoculation of biofertilizers. The highest vase life of gerbera (28.52 days) was obtained from inoculation of plants by (A_3), while the lowest vase life (19.37 days) was obtained from non-inoculated treatments. The foliar application of carbolizer affected significantly in vase life of gerbera flowers, the maximum vase life (26.72 days) was obtained from (B_2) and the lowest vase life (22.16 days) was recorded for control treatment.

The results of the interaction between biofertilizers and carbolizer on vase life of *Gerbera jamesonii* cv. Stanza were also significant. The significant variation was observed due to the interaction effect of biofertilizers and carbolizer in terms of vase life. The highest vase life (29.66 days) was observed from (A_3xB_2), and it was not differed significantly with A_3xB_1 (29.44). Both concentrations were significantly different than control A_0B_0 (15.77 days).
The increase of vase life of the flower may be due to an increase in biofertilizers. Ali *et al*. (2014) revealed the preservative role of biofertilizers in gladiolus flower longevity, when corms were treated with this supplement. Increment in vase life might be due to reduction in ethylene synthesis which has a harmful effect on flower life. Biofertilizers regulate nutrient uptake process and prolonged vase phenomenon. Bekheta and Mahgoub (2005) concluded

that the increase in nitrogen level lead to change in amino acids quantity and specific proteins in carnation plants. Plants treated with microbial inoculations showed more sugar contents (stored carbohydrates) through effective contents and protein contents showed a positive correlation, were protein contents increased the level of total soluble sugars

Table 4.16 Effect of biofertilizers, carbolizer and their interactions on the vase life (Days) of *Gerbera jamesonii* cv. Stanza.

Concentration of carbolizer (B)	Biofertilizers (A)				Effect of carbolizer (B)
	A_0 Control	A_1 Bacteria	A_2 Mycorrhiza	A_3 (Bacteria*Mycorrhiza)	
B_0 0.0 ml.L^{-1}	15.77 g*	21.67 ef	24.78 cd	26.44 bc	22.16 c
B_1 1.5 ml.L^{-1}	19.67 f	24.55 cde	26.33 bc	29.44 a	25.05 b
B_2 2.5 ml.L^{-1}	22.67 de	26.89 abc	27.89 ab	29.66 a	26.72 a
Effect of (A)	19.37 d	24.37 c	26.33 b	28.52 a	
L.S.D 0.05	**A**	1.68			
	B	1.46			
	AB	2.92			

*The values in each column, row and their interactions followed by the same letters are not significantly different from each other according to Least Significant Difference Test ($P \leq 0.05$).

4.3 Effect of Biofertilizers and Carbolizer on the Root Growth Characteristics of *Gerbera jamesonii* Cv. Stanza

4.3.1 Length of main root (cm)

Table (4.17) shows the effect of biofertilizers (fungi and bacteria) on main root length of *Gerbera jamesonii* cv. Stanza. It is clear that there was significant effect of bioinoculation on main root length. The longest main root (43.28 cm) was obtained from (A_3), while the shortest main root (30.82 cm) was obtained from control (A_0). Also, the same table shows that main root length was affected by carbolizer with different concentrations. The longest main root (39.27 cm) was observed from (B_2) which was significantly different with (B_0), and control gave the shortest main root (35.71 cm).

The interaction data in this table pointed out that the interaction of biofertilizers and different levels of carbolizer affected significantly on main root length, the longest main root (44.89 cm) was obtained from the interaction of (A_3xB_2) which was superior to the shortest main root (27.61 cm) for control.

Table 4.17 Effect of biofertilizers, carbolizer and their interactions on the main root length (cm) of *Gerbera jamesonii* cv. Stanza.

Concentration of carbolizer (B)	Biofertilizers (B)				Effect of carbolizer (B)
	A_0 Control	A_1 Bacteria	A_2 Mycorrhiza	A_3 (Bacteria*Mycorrhiza)	
B_0 0.0 ml.L^{-1}	27.61 f*	33.55 de	39.89 c	41.79 bc	35.71 c
B_1 1.5 ml.L^{-1}	30.71 e	35.55 d	40.55 bc	43.16 ab	37.49 b
B_2 2.5 ml.L^{-1}	34.15 d	35.70 d	42.35 abc	44.89 a	39.27 a
Effect of (A)	30.82 d	34.93 c	40.94 b	43.28 a	
L.S.D 0.05	**A**	1.71			
	B	1.48			
	AB	2.97			

*The values in each column, row and their interactions followed by the same letters are not significantly different from each other according to Least Significant Difference Test ($P \leq 0.05$).

This increase may be resulted from application of biofertilizers because biofertilizers cause increase in root depletion zone and nutrient availability to the plant. Arbuscular mycorrhiza fungi effects on root development might be the result of better P uptake in colonized gerbera seedlings which increases the length of primary and secondary roots (Pedreza-Santos *et al*., 2001). Inoculation with AMF (*Glomus mosseae*) improved root colonization of *Gerbera jamesonii* cv. stanza (Table 3.3). The treatments with *Azotobacter chroococcum* alone or in combination with *Glomus mosseae*, improved the VAM infected root length. This effect was not only caused by an improved total root length but also by a significantly higher VAM infection. Zare Hoseini *et al*. (2015) also showed that root length of *Stevia rebaudiana* was affected by the inoculation with fungus alone and the longest roots were recorded for inoculations of *Glomus mosseae* and *Pseudomonas indica* respectively in comparison to non-inoculated plants. Glick *et al*. (1998) put forward a theory that the mode of action of some PGPR was the production of the enzyme (ACC) deaminase which its activity would decrease ethylene production in the roots of host plants and result in root lengthening. Karishma *et al*. (2013) declared that the uttermost increase in root length of gerbera was observed in low concentration of superphosphate with arbuscular mycorrhizal fungi (*Glomus mosseae, Acaulospora laevis*) and phosphate solubilizing bacteria (*Pseudomonas fluorescens*) treatment.

4.3.2 Diameter of main root (mm)

As shown in Table (4.18) that diameter of main root of *Gerbera jamesonii* cv. Stanza was significantly affected by bioinoculation. According to the result, the maximum diameter of main root (3.24 mm) was observed from (A_3), while the minimum diameter of main root (2.39 mm) was found from control.

Diameter of main root differed significantly due to the effect of different levels of carbolizer as shown in the same table. The maximum diameter of main root (2.98 mm) was observed from spray (2.5 mlL^{-1}) while the minimum value (2.49 mm) was shown by at the control treatment.

Table 4.18 Effect of biofertilizers, carbolizer and their interactions on the main root diameter (mm) of *Gerbera jamesonii* cv. Stanza.

Concentration of carbolizer (B)	Biofertilizers (A)				Effect of carbolizer (B)
	A_0 Control	A_1 Bacteria	A_2 Mycorrhiza	A_3 (Bacteria*Mycorrhiza)	
B_0 0.0 $ml.L^{-1}$	2.24 f*	2.37 ef	2.64 dc	2.72 dc	2.49 c
B_1 1.5 $ml.L^{-1}$	2.37 ef	2.52 de	2.75 dc	3.12 b	2.69 b
B_2 2.5 $ml.L^{-1}$	2.56 de	2.67 dc	2.83 c	3.88 a	2.98 a
Effect of (A)	2.39 a	2.52 c	2.74 b	3.24 a	
L.S.D 0.05	**A**	0.12			
	B	0.13			
	AB	0.26			

*The values in each column, row and their interactions followed by the same letters are not significantly different from each other according to Least Significant Difference Test ($P \leq 0.05$).

Concerning the interaction of biofertilizers and foliar application of carbolizer, significant effect on the diameter of main root was observed, the highest value (3.88 mm) was obtained from the interaction of (A_3xB_2), while the lowest value (2.24 mm) was obtained from control (A_0xB_0).

This result may be due to application of biofertilizers which was affected on some functions in the plant cells. Biofertilizers involve in production of phytohormones that induce root growth, indole-3-acetic acid is a phytohormone which is known to be involved in root initiation, cell division, and cell enlargement (Salisbury, 1994), and this hormone is very commonly produced by plant growth promoting rhizobacteria (Barazani and Friedman, 1999).

4.3.3 Root surface area (cm^2)

As shown in Table (4.19), inoculation of biofertilizers affected significantly on root surface area of *Gerbera jamesonii* cv. Stanza. The highest value (86.05 cm^2) was recorded from dual combination A_3 (*Glomus mosseae* and Bacteria), followed by A_2 (83.33 cm^2), while the lowest value (73.24 cm^2) was obtained from non-inoculated plants (A_0).

Table 4.19 Effect of biofertilizers, carbolizer and their interactions on the root surface area (cm^2) of *Gerbera jamesonii* cv. Stanza.

Concentration of carbolizer (B)	Biofertilizers (A)				Effect of carbolizer (B)
	A_0 Control	A_1 Bacteria	A_2 Mycorrhiza	A_3 (Bacteria*Mycorrhiza)	
B_0 0.0 $ml.L^{-1}$	71.14 g*	74.57 ef	78.72 cd	80.73 c	76.29 b
B_1 1.5 $ml.L^{-1}$	73.59 fg	76.71 def	84.92 b	87.21 ab	80.61 a
B_2 2.5 $ml.L^{-1}$	74.99 ef	77.01 de	86.34 b	90.22 a	82.14 a
Effect of (A)	73.24 d	76.09 c	83.33 b	86.05 a	
L.S.D 0.05	**A**	1.80			
	B	1.56			
	AB	3.12			

*The values in each column, row and their interactions followed by the same letters are not significantly different from each other according to Least Significant Difference Test ($P \leq 0.05$).

Root surface area of gerbera significantly affected by application of carbolizer, which gave the highest value (82.14 cm^2) at concentration (2.5 $ml.L^{-1}$) and it was not differed significantly with concentration (1.5 $ml.L^{-1}$). Both concentrations were significantly different with control B_0 (76.29 cm^2).

The same table also indicated to significant interactions between the two studied factors in their effect on root surface area. The interaction (A_3 x B_2) gave the highest root surface area (90.22 cm^2), while the lowest root surface area (71.14 cm^2) was recorded from control treatment.

The number of VAM spores, after the inoculation, was also increased with these two groups of bacteria (Singh and Kapoor, 1998). This result may be due to increase in nutrient uptake and root zone activation as a result of application of biofertilizers. The fungus obtains photosynthesis and other growth factors from the host and in turn increases the functional root surface area through hyphal extension improving absorption of nutrients and water from soil (Edriss *et al*., 1984). Many researches revealed which biofertilizers promote root growth in

some ways. In this case the researchers found that biofertilizers increase surface area of the roots, Vessey (2003) indicated that biofertilizing-PGPR affect root morphology and more specifically increase root surface area. Additionally, increasing of nutrient absorption in mycorrhizal plants is related with the increasing of root surface area by the mycorrhizae, the physical extension of the hyphae system, hyphae absorptive power and exploration of sites rich in nutrients (Bolan, 1991). Mycorrhizal colonization of roots caused in an increase in root surface area for nutrient acquisition. The extrametrical fungal hyphae can extend several centimeters into the soil and absorb large amounts of nutrients for the host root (Wua *et al.*, 2004).

4.3.4 Root dry matter (%)

Table (4.20) shows the effect of biofertilizers on root dry matter of *Gerbera jamesonii* cv. Stanza was significant, the maximum values (18.41%) was recorded in (A_3) as compared to the non-inoculated treatments which gave the minimum value (12.96%).

The foliar application of carbolizer had a significant effected on root dry matter, the highest value (16.72%) was recorded from spraying with (2.5 $ml.L^{-1}$), while the lowest value (14.18%) was achieved from control.

Table 4.20 Effect of biofertilizers, carbolizer and their interactions on the percentage of root dry matter (%) of *Gerbera jamesonii* cv. Stanza.

Concentration of carbolizer (B)	Biofertilizers(A)				Effect of carbolizer (B)
	A_0 Control	A_1 Bacteria	A_2 Mycorrhiza	A_3 (Bacteria*Mycorrhiza)	
B_0 0.0 $ml.L^{-1}$	11.63 i*	13.63 hi	14.63 fg	16.85 c	14.18 c
B_1 1.5 $ml.L^{-1}$	13.13 i	15.03 ef	15.85 d	18.19 b	15.55 b
B_2 2.5 $ml.L^{-1}$	14.14 gh	15.47 de	17.05 c	20.21 a	16.72 a
Effect of (A)	12.96 d	14.71 c	15.84 b	18.41 a	
L.S.D 0.05	**A**	0.43			
	B	0.37			
	AB	0.75			

*The values in each column, row and their interactions followed by the same letters are not significantly different from each other according to Least Significant Difference Test ($P \leq 0.05$).

The interaction between biofertilizers and different levels of carbolizer revealed that there were significant effects on root dry matter. The highest value (20.21%) was obtained from

(A_3xB_2), as compared with the control (11.63%). Increasing root dry matter with an increase in mycorrhiza may be due to increase in depletion zone for plant nutrient absorption which causes increase nutrient concentration in the plant and result in root dry matter. The root growth of *gerbera* and *Nephrolepis* plant were influenced by mycorrhizae inoculation. VAM-inoculated plantlets had higher root dry weights than control plants (Wang *et al*., 1993). Apart from, carbolizer enhances some physiological functions, such as photosynthesis metabolism, nutrient uptake and provides the source of energy for plants, ultimately improve vegetative and root growth.

4.3.5 Nitrogen concentration in root (%)

The results have explained that there was significant effect of biofertolizers on nitrogen concentration in root of *Gerbera jamesonii* cv. Stanza as shown in Table (4.21). Concentration of nitrogen was increased in all treated plants as compared to control and maximum nitrogen content was observed in dual inoculation of (*Glomus mosseae* and bacteria) A_3 (4.51%), followed by bacterial inoculation alone A_1 (3.83%) compared to control which showed least N% (2.85).

Table 4.21 Effect of biofertilizers, carbolizer and their interactions on the nitrogen concentration (%) in root of *Gerbera jamesonii* cv. Stanza.

Concentration of carbolizer (B)	**Biofertilizers (A)**				**Effect of carbolizer (B)**
	A_0 **Control**	**A_1** **Bacteria**	**A_2** **Mycorrhiza**	**A_3** **(Bacteria*Mycorrhiza)**	
B_0 **0.0 ml.L^{-1}**	2.04 g*	2.90 f	2.58 fg	3.83 abcde	2.82 b
B_1 **1.5 ml.L^{-1}**	2.71 efg	3.99 abcd	3.55 cdef	4.77 ab	3.76 a
B_2 **2.5 ml.L^{-1}**	3.81 abcde	4.58 abc	3.63 bcdef	4.91 a	4.23 a
Effect of (A)	2.85 c	3.83 bc	3.25 b	4.51 a	
L.S.D 0.05	**A**	0.67			
	B	0.58			
	AB	1.17			

*The values in each column, row and their interactions followed by the same letters are not significantly different from each other according to Least Significant Difference Test ($P \leq 0.05$).

However, effects of carbolizer with different levels on nitrogen concentrations in gerbera roots were significant. The highest N% (4.23) was obtained from (B_2) and it was not differed significantly with (B_1). Both concentrations were significantly different with control B_0 (2.82%).

The interaction between biofertilizers and different levels of carbolizer was found significant. The highest concentration of nitrogen in gerbera roots (4.91%) was recorded with (A_3xB_2), while the lowest N% (2.04) was obtained from ($A_0xB_{0)}$.

The treatments of microbial inoculations significantly increased nitrogen content as compared with the control treatment. This could be attributed to the rapid absorption of this element (N) by the plant surface and their translocation in the plant (Mengel and Kirkby, 1987) and due to the application of biofertilizers that contain *Azotobacter* and Arbuscular mycorrhiza.

4.3.6 Concentration of phosphorus in root (%)

Results in Table (4.22) clearly show significant effect of different bioinoculants on percentage of phosphorus in roots of *Gerbera jamesonii* cv. Stanza. Concentration of phosphorus was increased in all treated plants as compared to control and maximum P% was observed in dual inoculation of (*Glomus mosseae* and bacteria) A_3 (0.60), as compared to control which gave least P% (0.46). The effect of carbolizer was significant on phosphorus concentrations in gerbera roots, the highest value (0.59%) was obtained with (B_2) compared to control (0.51).

The interaction between biofertilizers and different levels of carbolizer was found significant. The highest concentration of phosphorus in gerbera roots (0.63%) was recorded with (A_3xB_2), while the lowest P% (0.40) was obtained from (A_0xB_0).

Table 4.22 Effect of biofertilizers, carbolizer and their interactions on the concentration of phosphorus (%) in root of *Gerbera jamesonii* cv. Stanza.

Concentration of carbolizer (B)	Biofertilizers (A)				Effect of Carbolizer (B)
	A_0 Control	A_1 Bacteria	A_2 Mycorrhiza	A_3 (Bacteria*Mycorrhiza)	
B_0 0.0 ml.L^{-1}	0.40 c*	0.51 bc	0.55 ab	0.58 ab	0.51 b
B_1 1.5 ml.L^{-1}	0.43 c	0.53 abc	0.56 ab	0.59 ab	0.53 b
B_2 2.5 ml.L^{-1}	0.54 ab	0.58 ab	0.61 ab	0.63 a	0.59 a
Effect of (A)	0.46 b	0.54 a	0.58 a	0.60 a	
L.S.D 0.05	**A**	0.06			
	B	0.05			
	AB	0.10			

*The values in each column, row and their interactions followed by the same letters are not significantly different from each other according to Least Significant Difference Test ($P \leq 0.05$).

Increase in absorptive surface area of the roots due to VAM might have led to enhanced uptake and transportation of available water and nutrients like P, Zn, Fe, Mg and Cl ultimately

resulting in better sink for faster mobilization of photosynthates and early transformation of gerbera parts from vegetative to reproductive phase. These findings are also in confirmation with the findings of (Pathak and Kumar, 2009) in gladiolus.

The effect of phosphate solubilizing bacteria in phosphorus availability in soil via secreting phosphatase enzyme which promoted to change unavailable phosphorus to it is available forms (El-Ghandour *et al*., 2009). Therefore, it increases phosphorus absorption and more phosphorus accumulates in plant tissues. The significant effect of microbial inoculants was observed which may be due to the effect of different strain groups and nutrients mobilizing microorganisms which help in nutrient availability and increased levels of extracted minerals.

4.3.7 Concentration of potassium in root (%)

Table (4.23) shows that the potassium content in roots of *Gerbera jamesonii* cv. Stanza significantly affected by inoculated plants with biofertilizers compared to control treatment. The highest K% (4.64) was obtained from dual inoculated plants (A_3), while the lowest K% (3.09) was achieved from non-inoculated treatment.

The concentration of potassium in gerbera roots was significantly affected by different levels of carbolizer. The highest K% (4.84) was obtained from (2.5 $ml.L^{-1}$), while the lowest K% (3.28) was obtained from control.

Table 4.23 Effect of biofertilizers, carbolizer and their interactions on the concentration of potassium (%) in root of *Gerbera jamesonii* cv. Stanza.

Concentration of carbolizer (B)	Biofertilizers (A)				Effect of carbolizer (B)
	A_0 Control	A_1 Bacteria	A_2 Mycorrhiza	A_3 (Bacteria*Mycorrhiza)	
B_0 0.0 $ml.L^{-1}$	1.66 c*	3.42 ab	3.75 ab	4.29 ab	3.28 c
B_1 1.5 $ml.L^{-1}$	2.85 bc	4.29 ab	4.49 ab	4.74 a	4.09 b
B_2 2.5 $ml.L^{-1}$	4.75 a	4.83 a	4.86 a	4.90 a	4.84 a
Effect of (A)	3.09 b	4.18 a	4.36 a	4.64 a	
L.S.D 0.05	**A**	0.44			
	B	0.38			
	AB	0.76			

*The values in each column, row and their interactions followed by the same letters are not significantly different from each other according to Least Significant Difference Test ($P \leq 0.05$).

The interaction between (biofertilizers x carbolizer) had a significant effect on concentration of potassium in gerbera roots. The highest values (4.90%) was obtained from (A3 x B_2), while the lowest value (1.66%) was obtained from (A_0xB_0).

This increase may be resulted from biofertilizers inoculation (bacteria and fungi) which caused increase of availability of nutrients to the plant. Wu *et al*. (2005) explained dual inoculation with arbuscular mycorrhizal fungi (AMF) and rhizobacteria seemed to be the most effective combination treatment to improve maize plant nutrient uptake, the maximum P and K assimilation were obtained with the dual inoculation of *Glomus mosseae* and rhizobacteria (*Azotobacter chroococcum and Bacillus spp.*).

4.4 The Effect of Biofertilizers, Carbolizer, Aluminum Sulfate and Their Interactions on the Vase Life of *Gerbera jamesonii* Cv. Stanza

4.4.1 Storage (10 Days)

The results in Table (4.24) explained that the influence of biofertilizers and carbolizer in the plastic house and concentrations of aluminum sulfate on vase life of gerbera flowers during the storage duration (10 days) at 8 ± 2℃. There were significant differences of biofertilizers, the treatment of inoculation using both bacteria and mycorrhiza showed significantly increasing vase life of the flowers, it reached to (22.32 days) comparing to the control (noninoculated plants), the vase life was (14.26 days). Foliar spray with carbolizer significantly influenced especially the level 2 (B_2) which increased the vase life to (20.93 days) comparing with control which reached to (15.13 days). Treated with $Al_2 (SO_4)_3$ especially the treatment C_2 (150 $mg.L^{-1}$) showed significantly increased vase life after storage to (20.96 days) where the treatment with distilled water have (16.72 days). The interaction between biofertilizers and carbolizer especially (A_3B_2) significantly enhanced the vase life to (25.06 days) were the treatment (A_0B_0) had (11.89 days).

The interaction between biofertilizers and concentrations of $Al_2 (SO_4)_3$ especially the treatment (A_3C_2) showed significantly increased vase life (24.53) days where the vase life of the treatment (A_0C_0) had only (12.37 days). The interaction between concentrations of carbolizer and aluminum sulfate significantly influenced the vase life especially (B_2C_2) which increased to (23.54 days) where the treatment (B_0C_0) had only (13.47 days).

The interaction among study factors significantly enhanced the vase life after storage duration (10 days) especially ($A_3B_2C_2$) and ($A_3B_2C_3$) it reached (28.23 and 27.00 days), respectively, significantly increased over all treatments, the lowest number of days in vase life (9.77 days) after storage were observed from control ($A_0B_0C_0$).

Table 4.24 effects of biofertilizers, carbolizer, aluminum sulfate and their interactions on the vase life (Days) of *Gerbera jamesonii* cv. Stanza after 10 days storage.

A	B	C_0	C_1	C_2	C_3	A x B	Average (A)
A_0	B_0	9.77 w*	11.69 vw	13.10 tuv	13.00 tuv	11.89 i	14.26 d
	B_1	13.25 tuv	13.90 stu	17.45 m-p	13.55 stu	14.53 h	
	B_2	14.10 rst	16.59 n-q	19.07 ijk	15.67 qrs	16.36 g	
A_1	B_0	12.11 vw	13.00 tuv	18.03 mno	13.11 tuv	14.06 h	17.44 c
	B_1	16.43 n-q	18.28 k-n	21.77 d-g	15.94 opq	18.11 ef	
	B_2	19.43 h-k	19.92 f-i	22.83 b-e	18.44 j-n	20.16 d	
A_2	B_0	15.02 qrs	20.88 e-h	19.33 kjw	17.89 kmn	17.34 fg	20.55 b
	B_1	19.78 g-j	22.25 b-e	22.29 b-e	20.79 e-h	20.93 cd	
	B_2	21.59 d-g	19.87 g-j	24.03 bc	22.94 b-e	22.70 b	
A_3	B_0	17.00 m-p	19.88 g-j	20.93 e-h	19.33 i-l	19.28 de	22.32 a
	B_1	20.61 e-h	22.20 c-f	24.43 b	23.23 bcd	22.62 bc	
	B_2	21.55 d-g	23.43 bcd	28.23 a	27.00 a	25.06 a	
LSD (ABC)				2.21		**LSD (AB)** 1.74	**LSD (A)** 0.63
A x C							
A_0		12.37 h	14.06 gh	16.54 efg	14.07 gh	**LSD (CA)** 2.55	
A_1		15.99 fg	17.06 de	20.88 bcd	15.83 fg		
A_2		18.80 ef	21.00 cd	21.88 bc	20.54 cd		
A_3		19.72 cd	21.83 bc	24.53 a	23.19 ab		
B x C						**Average (B)**	
B_0		13.47 h	13.36 gh	17.85 efg	15.83 gh	15.13 c	
B_1		17.52 efg	19.16 cde	21.48 ab	18.38 cde	19.14 b	
B_2		19.17 cd	19.95 bcd	23.54 a	21.07 abc	20.93 a	
LSD (CB)		2.82				**LSD (B)**	0.55
Average (C)		16.72 c	17.49 b	20.96 a	18.43 b		
LSD (C)			0.63				

*The values in each column, row and their interactions followed by the same letters are not significantly different from each other according to Least Significant Difference Test ($P \leq 0.05$).

4.4.2 Storage (20 days)

The results in Table (4.25) have explained that the influence of biofertilizers and carbolizer in the plastic house and concentrations of $Al_2 (SO_4)_3$ in vase life of gerbera flowers during the storage duration (20 days) at 8±2℃. There were significant differences treatments of biofertilizer especially (A_3), it showed the elongated vase life after storage for amount of 20 days had (10.19 days) were the treatment (A_0) had (6.14 days).

Foliar spray with different levels of carbolizer significantly influenced, especially the concentration of (2.5 $ml.L^{-1}$) which increased the vase life to (9.73 days), while the treatment (B_0) had (6.79 days). Treated with $Al_2 (SO_4)_3$ especially the concentration of (C_2) showed significantly increased vase life after storage for amount of (20 days) to (9.46 days), where treatment with distilled water (C_0) had (7.22 days).

Table 4.25 Effects of biofertilizers, carbolizer, aluminum sulfate and their interactions on the vase life (Days) of *Gerbera jamesonii* cv. Stanza after 20 days storage.

A	B	C_0	C_1	C_2	C_3	A x B	Average (A)
A_0	B_0	3.23 z*	5.00 w-z	4.50 yz	4.66 z	4.47 f	6.14 d
	B_1	6.50 r-u	6.27 s-v	5.57 u-y	5.54 z	5.77 e	
	B_2	8.00 j-m	8.27 h-k	8.50 h-k	7.68 n-q	7.94 cd	
A_1	B_0	5.91 v-y	6.27 s-v	6.13 t-w	5.43 wty	5.93 e	7.73 c
	B_1	7.57 m-p	8.43 k-m	8.50 k-n	6.40 r-u	7.72 d	
	B_2	10.00 cd-f	8.67 h-k	11.40 abc	8.10 m-p	9.54 b	
A_2	B_0	6.93 r-u	6.60 r-u	10.00 c-g	7.00 o-s	7.63 d	9.19 b
	B_1	10.17 c-f	7.66 o-r	10.90 bcd	7.50 m-p	9.06 bc	
	B_2	11.01 abc	7.93 k-n	12.27 a	9.07 g-j	10.07 ab	
A_3	B_0	7.97 k-n	9.50 e-h	11.67 ab	7.83 k-o	9.24 b	10.19 a
	B_1	10.03 c-f	9.00 fgh	11.83 ab	9.43 e-h	10.07 ab	
	B_2	10.67 b-e	9.83 d-g	12.20 a	12.20 a	10.68 a	
LSD (ABC)		1.48				**LSD (AB)** 1.12	**LSD (A)** 0.42

A x C				
A_0	5.91 fg	6.51 efg	6.19 fg	5.96 g
A_1	7.83 cde	7.79 cde	8.68 bcd	6.64 efg
A_2	9.37 b	7.39 def	11.06 a	8.92 cde
A_3	9.55 b	9.44 b	11.90 a	9.85 bc

LSD (CA) 1.45

B x C					Average (B)
B_0	6.01 f	6.84 ef	8.08 cde	6.23 f	6.79 c
B_1	8.57 bcd	7.84 cde	9.20 bc	7.21def	8.20 b
B_2	9.92 bc	8.68 cd	11.09 a	9.22 bc	9.73 a
LSD (CB)	1.52				**LSD (B)** 0.37
Average (C)	7.22 d	7.78 b	9.46 a	7.55 c	
LSD (C)	0.42				

*The values in each column, row and their interactions followed by the same letters are not significantly different from each other according to Least Significant Difference Test ($P \leq 0.05$).

The interaction between biofertilizers and concentrations of carbolizer significantly increased the vase life of cut flowers especially (A_3B_2) which enhanced to (10.68 days) with no differences with treatments (A_2B_2 and A_3B_1) which had (10.07 days), whereas the treatment (A_0B_0) had (4.47 days) only. The interaction between biofertilizers and concentrations of $Al_2(SO_4)_3$ significantly influenced the vase life especially (A_3C_2 and A_2C_2) they had (11.90 and 11.06 days), respectively compared with the treatment (A_0C_0) which had only (5.91 days). Foliar spray with concentrations of aluminum sulfate especially (B_2C_2) showed significantly increased vase life to (11.09 days), while the treatment (B_0C_0) had (6.01 days).

The interaction among the experimental factors significantly enhanced the vase life after storage duration (20 days) especially ($A_3B_2C_2$ and $A_3B_2C_3$) in which the vase life reached to (12.20 days), compared with the treatment ($A_0B_0C_0$) that had only (3.23 days).

4.4.3 Comparison between 10 and 20 days of storage

It is clear from the results in Table (4.26) that the storage period (18.59 days) which was done (tested) by (T) test, significantly outperformed (dominated) on (20 days), which recorded (8.17 days) only. This superiority may be due to that Gerbera flowers did not resist relatively with low storage temperature for a long time (20 days) because low temperature affects on cell metabolism and cold damage which in turn affects on the operations of physiological and performance of the cell, as a result, shortens the age of the flower after storage. This may be due to poor performance of xylem and phloem thus reduce transportation of the solution which causes of a blockage of these cells and reduce the rise of the solution as a result of plant senescence, which lead to the end of vase life (Salunkhe *et al*., 1990).

Table 4.26 Shows comparison among 10 and 20 days of storage of cut *Gerbera jamesonii* cv. Stanza, was donning using T test.

Storage duration (Day)	Vase life (Day)
10	18.59
20	8.17
LSD (0.05)	0.80

The present results suggest the absence of deleterious effects of wet storage at 8±2 temperatures. Thermal or chemical regulation of senescence in enhancing vase life and improving postharvest performance has assumed considerable significance in ornamental horticulture. Low temperature is recognized as the most important factor for the successful storage of cut flowers by reducing both plant metabolic processes and microbial growth rate; besides delaying the symptoms of senescence (chilling injury, spike bending, petal curling and color change) through regulation at biochemical level (Gul and Tahir, 2012). The effect of this temperature can be attributed to the increase in carbohydrate content in tepals, thus enhancing the influx of water and osmolyte into tepal cells and higher protein content in wet storage, high protein content of petal tissues probably caused by inhibiting specific proteases responsible for protein degradation (Gul and Tahir, 2009). But in long vase life, higher phenol content was observed in wet stored, these results corroborate with the observations on rose (Mwangi *et al.*, 2003).

Storage of flowers for 10 and 20 days with aluminum sulfate extended the vase life of gerbera cut flowers compared to control (Tables 24 and 25). This may be due to aluminum sulfate application which acidifies the solution and diminishes bacterial growth (Hassanpour *et al*., 2004). This compound acts as a bacterial filter by forming Al $(OH)_3$ sediments on the cut surface of the stem, sugars accelerate the bacterial growth in the vase solution, and the proliferation of microbial population in the vase, results in vascular plugging. Flow rate of

sucrose solution in the vessels becomes slower and water uptake decreases (Särkkä, 2005). A decline in water uptake rate in sucrose contained treatments compared with pure aluminum sulfate solutions may be caused slow solution uptake rate and higher bacterial population. Probably applied concentrations of aluminum sulfate were not enough to neutralize the effect of sucrose on bacterial nutrition and proliferation. Aluminum sulfate application enhanced water uptake significantly compared to control in *Eustoma* cut flowers (Liao *et al*., 2001). Effectiveness of aluminum sulfate application has been proved in cut *Rosa hybrida* cv. Boeing) flowers (Seyf *et al.*, 2012). Aluminum sulfate (150 and 100 $mg.L^{-1}$) application improved all measured traits and extended the vase life storage of flowers beyond the optimum period leads to a considerable loss of vase life and flower quality. It is immensely important to determine the optimum duration for storage of cut flowers that keeps the quality and potential vase life at its best. This explains that flowers storage for longer duration cannot be scored well with respect to freshness and color as compared to short term stored flowers. The results also get the support from the findings of (Singh and Kumar, 2007) in gladiolus cut spikes. Vase life is an important criterion to assess the postharvest quality of cut flowers, the results are agreement with results of an experiment that in which aluminum sulfate application caused continuous water uptake in various temperatures between 20-30 ºC in cut rose flowers (Ichimura and Ueyama, 1998).

Conclusions and Recommendations

1. Conclusions

According to the results obtained from this study, it may be concluded that:

1. The results show that the inoculation of *Gerbera jamesonii* cv. Stanza with arbuscular mycorrhizal fungi (AMF) generally enhanced the plant growth.
2. It was observed that the combined inoculation of arbuscular mycorrhizal fungi (AMF) and bacteria had a positive effect on plant growth and nutrient uptake.
3. The foliar spray of carbolizer improved plant growth and nutrient uptake under plastic house conditions.
4. Inoculation of *Gerbera* with mycorrhizae (*Glomus mosseae*) increased vase life without storage or after storage.
5. The wet storage of gerbera cut flowers for 10 days with aluminum sulfate (150 $mg.L^{-1}$) significantly influenced the vase life.

2. Recommendations

1. Using suitable strains of other biofertilizers to increase vegetative and floral growth of other ornamental plants.
2. It is recommended to treat seeds and cuttings of ornamental plants with biofertilizers before planting.
3. Investigation of other biofertilizers with other organic matters (such as composting cows and poultry manure), are extensively as an eco-friendly approach to minimize the use of chemical fertilizers, improve soil fertility status and for enhancement of crop production.
4. Post-harvest treatment facilities such as irradiation, electronic beam processing, fumigation, water drip treatment, x-ray and waxing etc. to enhance shelf life.
5. Dry storage of *Gerbera jamesonii* and using different pulsing solutions before storage.

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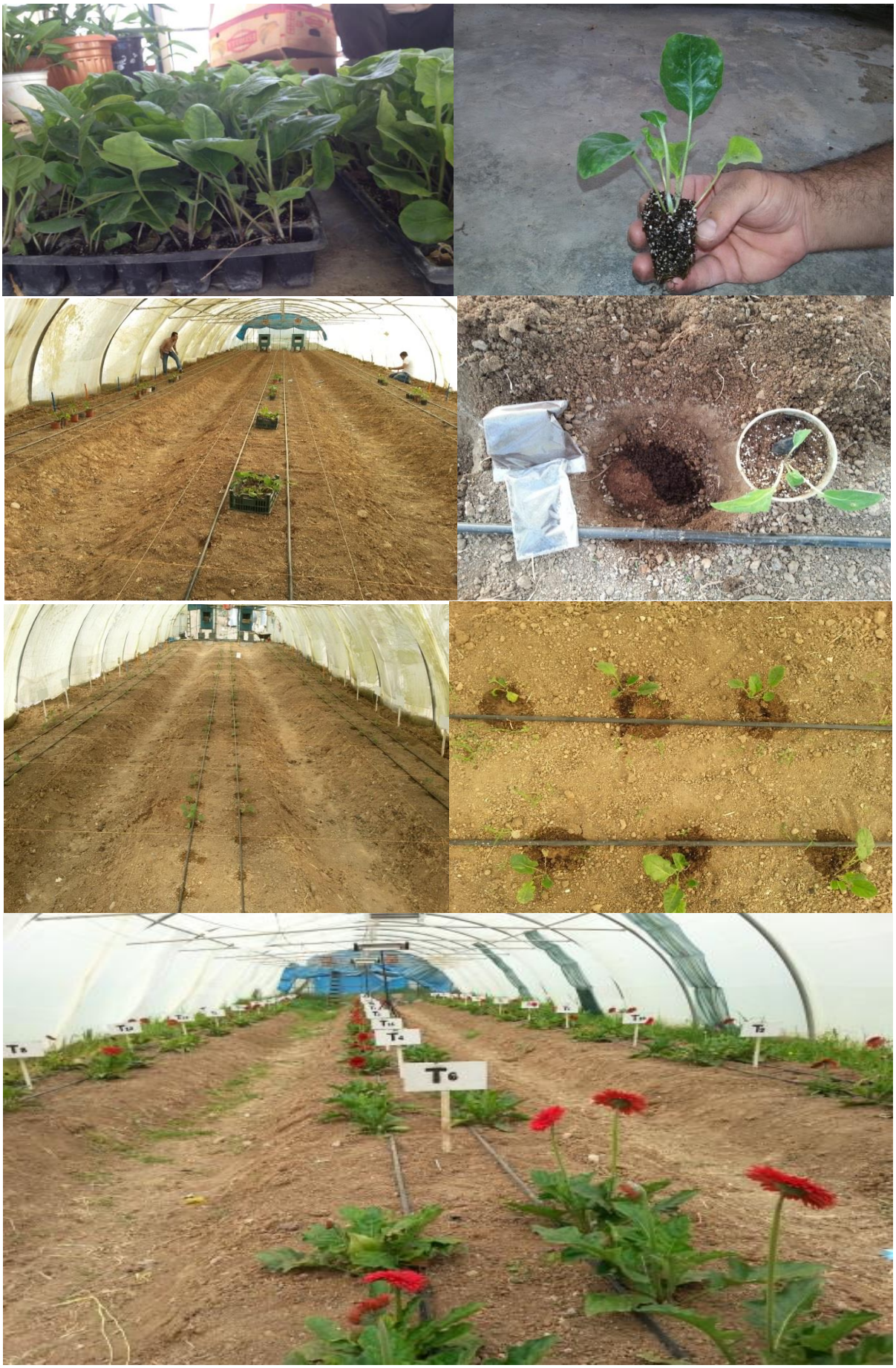
Appendices

Appendix 1. The preparation of greenhouse soil.

Appendix 2. Seedlings planting of *Gerbera jamesonii* cv. Stanza.



Appendix 3. Preparation of bacterial inoculant and seedlings inoculation.

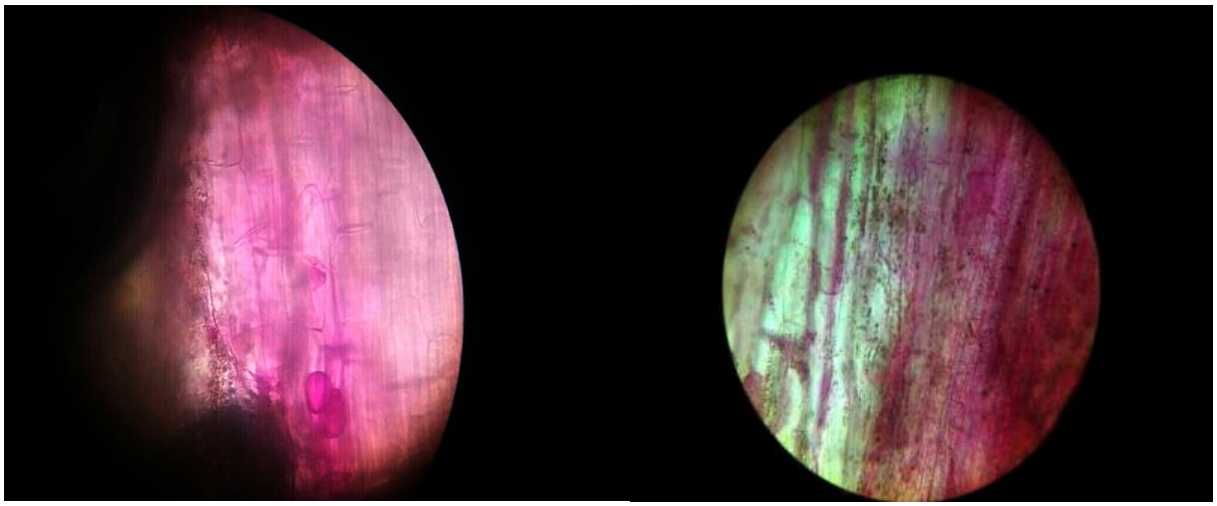
Appendix 4. Flowering stages.

Appendix 5. Wet storage and vase life of cut flowers.

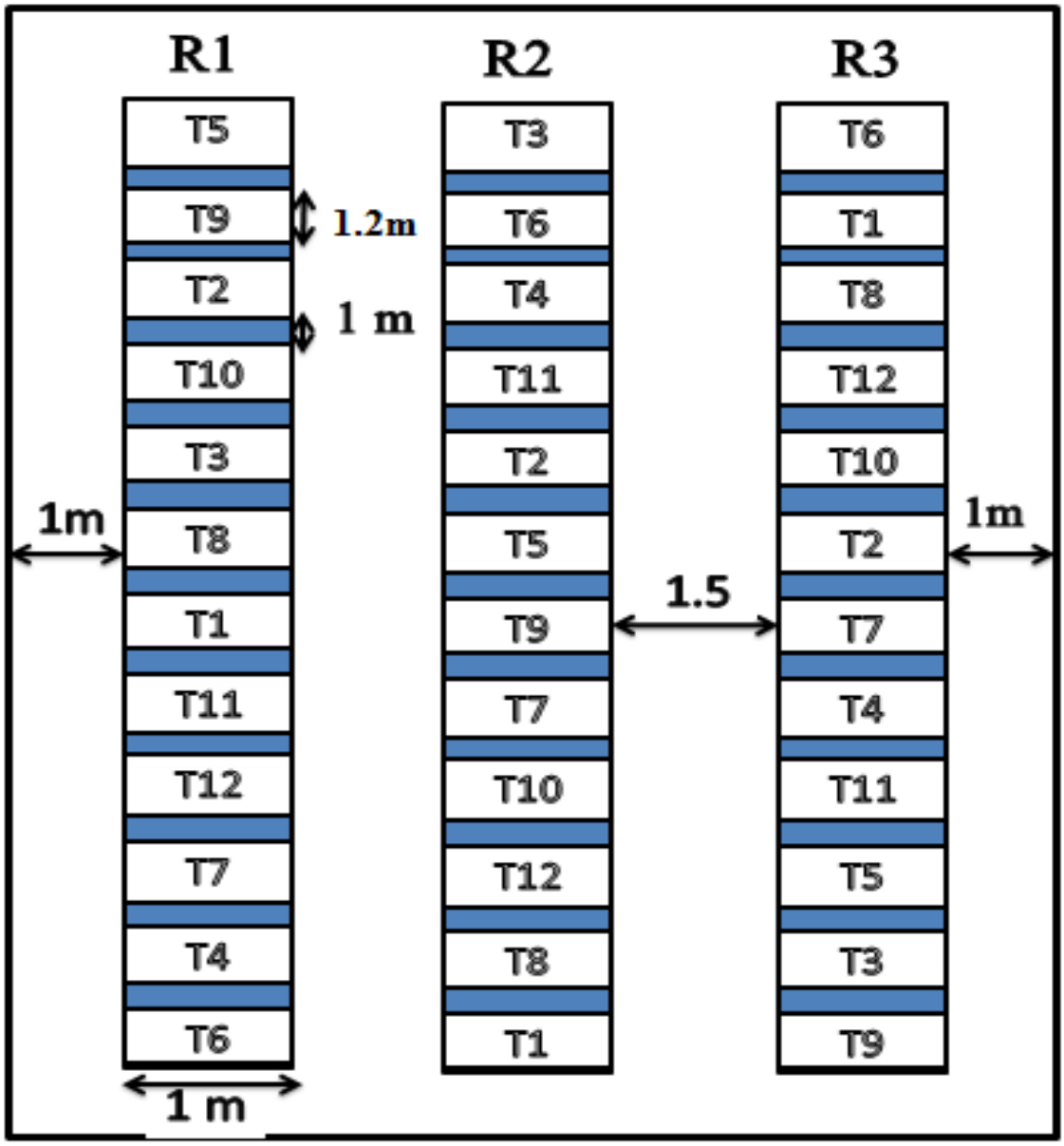
Appendix 6. Root of *Gerbera jamesonii* cv. Stanza.

Control **Biofertilizers and Carbolizer**

Appendix 7. Root infection by Mycorrhizae.



Appendix 8. Field layout.



T_1 = Control
T_2 = Carbolizer (1.5 $ml.L^{-1}$)
T_3 = Carbolizer (2.5 $ml.L^{-1}$)
T_4 = Bacteria
T_5 = Bacteria + Carbolizer (1.5 $ml.L^{-1}$)
T_6 = Bacteria + Carbolizer (2.5 $ml.L^{-1}$)
T_7 = Mycorrhiza
T_8 = Mycorrhiza+ Carbolizer (1.5 $ml.L^{-1}$)
T_9 = Mycorrhiza+ Carbolizer (2.5 $ml.L^{-1}$)
T_{10} = Bacteria + Mycorrhiza
T_{11} = Bacteria + Mycorrhiza+ Carbolizer (1.5 $ml.L^{-1}$)
T_{12} = Bacteria + Mycorrhiza + Carbolizer (2.5 $ml.L^{-1}$)

R= Replication

Appendix 9. Organic liquid fertilizer (Carbolizer).

تأثير السماد الحيوي و الكاربوليزر فى نمو و عمر المزهرى لنبات الجربيرا [*Gerbera jamesonii* cv. Stanza]

رسالة

مقدمة الى مجلس كلية العلوم الزراعية في جامعة السليمانية

كجزء من متطلبات نيل شهادة الماجستير في البستنة

نباتات الزينة

من قبل

هيمن عبدالله مصطفى

بكالوريوس بستنة (2011)، جامعة السليمانية

باشراف

الدكتور سوسن عبدالله عبداللطيف

استاذ مساعد

ربيع الثاني 1438 هـ

كانون الثاني 2017 م

الخلاصة

أجريت هذه البحث في البيت البلاستيكي التابع لقسم البستنة/ كلية العلوم الزراعية/ جامعة السليمانية خلال موسم النمو 2015-2016 لدراسة تأثير اللقاح الحيوي و كاربوليزر في النمو و مدة الخزن لنبات الجربيرا (*Gerbera jamesonii* cv. Stanza)، نفذت تجربة عاملية وفق تصميم القطاعات العشوائية الكاملة (RCBD) و بثلاثة مكررات وتم تحليل النتائج بإستخدام نظام (SAS) و قورنت المتوسطات باستخدام مقارنة اختبار اقل فرق معنوي (L.S.D) تحت مستوى المعنوية ($P\leq0.05$). تشمل التجربة عاملين:

العامل الأول: اللقاح الحيوي وهو بأربعة مستويات بدون تلقيح (A_0)، التلقيح ببكتريا *Azotobacter chroococcum* و *Bacillus subtilus* (A_1)، التلقيح الفطري بمايكوريزا *Glomus mosseae* (A_2) و التلقيح بخليط البكتريا والمايكوريزا (A_3).

العامل الثاني: السماد العضوي السائل (الكاربوليزر) وبثلاث مستويات control (B_0) ، 1.5 (B_1) و 2.5 (B_2) مل. لتر$^{-1}$.

أظهرت نتائج هذه التجربة ما يلي :

تفوقت معاملة التلقيح الحيوي بخليط البكتريا والمايكورايزا A_3 معنوياً في جميع صفات النمو الخضري ، فأدت الى زيادة شدة صبغة الكلوروفيل فى الاوراق(44.99 spad unit)، المساحة الورقية للنبات (1305.00 ds^2) ، عدد الخلفات (6.52)، النسبة المئوية للمادة الجافة فى الاوراق (28.59%) و النسبة المئوية لكل من النتروجين (4.95%)، الفسفور (0.45%)، البوتاسيوم (4.39%)، الحديد (141.70 ملغم.كغم$^{-1}$) و الزنك (35.29ملغم.كغم$^{-1}$) وكذلك تفوقت معنوياً في صفات النمو الزهري اذ تفوقت في زيادة طول الحامل الزهري (48.83 سم)، قطر الحامل الزهري (9.10 ملم)، قطر الزهرة (15.80 سم)، النسبة المئوية للمادة الجافة للازهار (16.06%)، تركيز صبغة الانثوسيانين في بتلات الازهار (30.11 ملغم.100غم$^{-1}$)، عدد الازهار خلال موسم التجربة (46.45) و العمر المزهري (26.72 يوم)، و اثرت معنوياً في صفات الجذور اذ تفوقت فى زيادة طول الجذر الرئيسي (43.28 سم)، قطر الجذر الرئيسي (3.24 ملم)، المساحة السطحية للجذر الرئيسى

(86.05 سم^2)، النسبة المئوية لتركيز النايترؤجين (4.51%) ، فسفور (0.60%) ، بوتاسيوم فى الجذر (4.64%)و النسبة المئوية للمادة الجافة للجذر (18.41%).

اثر الرش الورقي بالكاربوليز معنوياً في صفات النمو الخضري اذ تفوقت المعاملة (2.5 مل.لتر$^{-1}$) زيادة معنوية في صفات شدة صبغة الكلوروفيل فى الاوراق (44.72)، المساحة الورقية للنبات (1302.60 ds^2) ، عدد الخلفات (6.06)، النسبة المئوية للمادة الجافة فى الاوراق (26.92%) والنسبة المئوية لكل من النتروجين (4.31%)، الفسفور (0.38)، البوتاسيوم (4.05%)، الحديد (136.26 ملغم.كغم$^{-1}$) و الزنك (29.45 ملغم.كغم$^{-1}$).

تفوقت معاملة السماد العضوي السائل (الكاربوليزر) بالمستوى B_2 معنوياً في زيادة صفات النمو الزهري فأدت الى زيادة طول الحامل الزهري (48.83 سم)، قطر الحامل الزهري (9.10 ملم)، قطر الزهرة (15.80 سم)، النسبة المئوية للمادة الجافة للازهار 16.06تركيز صبغة الانثوسيانين في بتلات الازهار30.11 ملغم.100غم^1)، عدد الازهار خلال موسم التجربة (42.25) و العمر المزهري (26.72 يوم)

أدى الرش الورقي الى زيادة معنوية في صفات الجذور فتفوقت المعاملة (2.5 مل.لتر$^{-1}$) في زيادة طول الجذر الرئيسي (39.27 سم)، قطر الجذر الرئيسي (2.98 ملم)، المساحة السطحية للجذر الرئيسى (82.14 سم^2)، النسبة المئوية للتركيز النايترؤجين (4.23%)، الفسفور (0.59%)، البوتاسيوم (4.84%) فى الجذر و النسبة المئوية للمادة الجافة للجذر (16.72%).

تفوقت التداخل الثنائى بين العاملى التجربة الحقلية، الرش باالكاربوليزر (B_2) مع التلقيح الحيوى بفطريات المايكورايزا و البكتيريا (A_3) في جميع صفات النمو الخضري و الزهرى وكذالك صفات الجذور.

أدى الخزن الرطب لازهار الجربيرا المقطوفة مع تراكيز كبريتات الالمنيوم (0 ، 100 ، 150 ، 200 ملغم.لتر$^{-1}$) في درجة حرارة 8 ± 2 م ولمدتي الخزن 10 و 20 يوم الى زيادة العمر المزهري اذ تفوق لتركيز 150 *ملغم.لتر*$^{-1}$ كبريتات الالمنيوم والخزن لمدة عشرة أيام.

کاریگەری پەینە زیندەییەکان و کاربۆلایزەر لەسەر گەشە و تەمەنی گوڵی ڕووەکی جێربێرا [*Gerbera jamesonii* cv. Stanza]

نامەیەکە

پێشکەش کراوە بە ئەنجومەنی کۆلێژی زانستە کشتوکاڵییەکان لە زانکۆی سلێمانی وەک بەشێک لە پێداویستیەکانی بڕوانامەی ماستەر لە باخداری

ڕووەکەجوانەکان

لە لایەن

هێمن عبدالله مصطفی

بەکالۆریۆسی باخداری (2011)، زانکۆی سلێمانی

بە سەرپەرشتی

دکتۆر سوسن عبدالله عبداللطیف

پرۆفیسۆری یاریدەدەر

گەلاڵ ڕێزان 2016 **ك** **کانونی دووەم** 2017 **ز**

پوختە

ئەم توێژینەوەیە ئەنجام درا، لە ناو خانوی پلاستیکی، بەشی باخداری/ کۆلێژی زانستە کشتوکاڵییەکان/ زانکۆی سلێمانی لەماوەی ساڵی 2015- 2016، بە مەبەستی لێکۆڵینەوە لە کاریگەری پەینە زیندەییەکان و کاربۆلایزەر لەسەر گەشە و ماوەی هەڵگرتنی گوڵی ڕووەکی جێربێرا (*Gerbera jamesonii* cav. Stanza). ئەم توێژینەوەیە نەخشە کێشرا بە بەکارهێنانی (RCBD) دوو هۆکاری بە سێ جار دووبارە کردنەوە، وە بۆ بەراوردکردن لەگەڵ تێکرای ئەنجامەکان بە بەرنامەی کۆمپیوتەری (SAS) بە تاقیکردنەوەی کەمترین جیاوازی مەعنەوی (L.S.D) ئاستی ($P\leq0.05$) بەکارهێنرا.لێکۆڵینەوەکە دوو هۆکارە:

هۆکاری یەکەم: بەکارهێنانی پەینە زیندەییەکان بە چوار ئاست کۆنترۆڵ (A_0)، بەکتریای *Azotobacter chroococcum* و *Bacillus suptilus* (A_1)، کەڕووی *Glomus mosseae* (A_2) و بەکتریا و کەڕوو پێکەوە (A_3).

هۆکاری دووەم: بەکارهێنانی پەینی ئەندامی شل (کاربۆلایزەر) بە سێ ئاست کۆنترۆڵ (B_0)، 1.5 (B_1)،2.5 (B_2) مل.لیتر$^{-1}$.

ئەنجامەکانی لێکۆڵینەوەکە دەریانخست کە کاریگەری پەینە زیندەییەکان (بەکتریا و کەڕوو) و تێکەڵکردنیان سەرکەوتوو بووە لە هەموو خەسڵەتەکانی سەوزە گەشە دا، بووەتە هۆی زیادکردنی بۆیەی کلۆرۆفیل (44.99 spad unit)، ڕوبەری ڕووی گەڵا ($1305.00 ds^2$) ، ژمارەی بڕالە (6.52)، ڕێژەی سەدی ماددەی ووشک لە گەڵادا (28.59%)، ڕێژەی سەدی هەریەک لە نایترۆجین (4.95%)، فسفۆر (0.45%)، پۆتاسیۆم (4.39%)، ئاسن (141.70 ملگم.کگم$^{-1}$) و زینک (35.29 ملگم.کگم$^{-1}$).

هەروەها سەرکەوتوو بوو لە خەسڵەتەکانی گەشەی گوڵ و بووە هۆی زیادکردنی درێژی هەڵگری گوڵ (48.83 سم) ، تیرەی هەڵگری گوڵ (9.10 ملم)، تیرەی گوڵ (15.80 سم)، ڕێژەی سەدی ماددەی ووشک لەگوڵدا (16.06%)، چڕی بۆیەی ئەنسۆسیانین لە پەرەکانی گوڵدا (30.11 ملگم.100گم$^{-1}$)، ژمارەی گوڵ لەماوەی لێکۆڵینەوەکەدا (46.45) و تەمەنی گوڵ (26.72 ڕۆژ). وە سەرکەوتوو بوو لە گەشەی ڕەگ و بووە هۆی زیادکردنی سیفاتەکانی درێژی ڕەگی سەرەکی (43.28 سم)، تیرەی ڕەگی سەرەکی (3.24 ملم)،

ڕووبەری ڕووی ڕەگی سەرەکی (86.05 سم^2)، ڕێژەی سەدی نایترۆجین (4.51%)و فسفۆر (4.64%) و پۆتاسیۆم (0.60%) لە ڕەگدا و ڕێژەی سەدی ماددەی وشك لە ڕەگدا (18.41).

ڕشاندنی گەڵا بە کاربۆلایزەر بەتایبەتی ئاستی (2.5 مل.لیتر$^{-1}$) سەرکەوتوو بوو لە خەسڵتەکانی سەوزە گەشە, بووە هۆی زیادکردنی چڕی بۆیەی کلۆڕفیل لە گەڵادا (44.72 spad unit)، ڕووبەری ڕووی گەڵا (1302.60 ds^2)، ژمارەی براڵە (6.06)، ڕێژەی سەدی ماددەی وشك لە گەڵادا (26.92%) ڕێژەی سەدی هەریەك لە نایترۆجین (4.3%)، فسفۆڕ (0.38%)، پۆتاسیۆم (4.05%)، ئاسن (136.26 ملگم.کگم$^{-1}$) و زینك (29.45 ملگم.کگم$^{-1}$).

هەروەها پەینی ئەندامی شل (کاربۆلایزەر) سەرکەوتوو بوو بەتایبەتی لە ئاستی (B_2) لە باش کردنی درێژی هەڵگری گوڵ (48.83 سم)، تیرەی هەڵگری گوڵ (9.10 ملم)، تیرەی گوڵ (15.80 سم)، ڕێژەی سەدی ماددەی وشك لە گوڵدا (16.06)، چڕی بۆیەی ئەنسۆسیانین لە پەڕەکانی گوڵدا (30.11 ملگم.100گم$^{-1}$)، ژمارەی گوڵ لەماوەی لێکۆڵینەوەکەدا (42.25) و تەمەنی گوڵ (26.72 ڕۆژ).

لە لایەکی ترەوە ڕشاندنی گەڵا بە (کاربۆلایزەر) سەرکەوتوو بوو بە تایبەتی خەستی (2.5 مل.لیتر$^{-1}$) لە زیادکردنی درێژی ڕەگی سەرەکی (39.27 سم)، تیرەی ڕەگی سەرەکی (2.98 ملم)، ڕووبەری ڕووی ڕەگی سەرەکی(82.14 سم^2)، ڕێژەی سەدی نایترۆجین (4.23%) و فسفۆر (0.59%) و پۆتاسیۆم (4.84%) لە ڕەگدا و ڕێژەی سەدی ماددەی وشك لە ڕەگدا (16.72%).

بەکارهێنانی پەینی ئەندامی (کاربۆلایزەر) و پەینە زیندەییەکان (بەکتریا و کەڕوو) پێکەوە سەرکەوتوو بوون لە خەسڵەتەکانی سەوزە گەشە، گەشەی گوڵ و گەشەی ڕەگ بە تایبەتی تێکەڵەی مایکۆڕایزا و بەکتریا (A_3) لەگەڵ کاربۆلایزەر ئاستی (B_2).

هەڵگرتنی تەڕ ی گوڵی جێربێرا لەگەڵ ئاستەکانی خەستی کبریتات ئەلەمنیۆم (0، 100، 150، 200 ملگم.لیتر$^{-1}$) لە پلەی گەرمی 8±2 م^0 بۆ ماوەی (10 ڕۆژ و 20 ڕۆژ) بۆ زیادکردنی تەمەنی مانەوەی گوڵ لەناو گوڵداندا سەرکەوتوو بوو بە تایبەتی ئاستی 150ملغم.لیتر$^{-1}$ کبریتاتی ئەلەمنیۆم وە هەڵگرتنی بۆماوەی 10 ڕۆژ.