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EFFECT OF BIOFERTILIZERS AND CARBOLIZER ON GROWTH OF GERBERA PLANT (GERBERA JAMESONII)

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Abstract

This Study was during the growing seasons 2015 to 2016 to study the effect of biofertilizer and carbolizer on the growth 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=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}). 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 spade 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 (141.70mg.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%), anthocyanins 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 (136.26mg.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%), anthocyanins 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 (2.98mm), 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 (biofertilizer and carbolizer) significantly enhanced vegetative, root and floral growth characteristics, especially ($A_3 \times B_2$).

Key words: Biofertilizer, Crbolizer, Gerbera Plant

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). 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

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widespread ones in markets by consumers (Sirin, 2011) .To improve the growth and production of the cut flowers, different types of chemicals, organic and biofertilizer were used. Biofertilizer 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). 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). 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. This study was done to investigate different biofertilizers (*Glomus mosseae, Azotobacter chroococcum* and *Bacillus subtillus*) and Organic liquid fertilizer (Carbolizer) on the growth and cut flower storage of *Gerbera jamesonii* cv. Stanza.

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. 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. Bohra and Kumar (2014) refers in their study on the effect of organic manures (poultry manure, vermicompost) and bio-inoculants (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.

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. 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*. Bohra and Kumar (2014) carried out an experiment to study the effect of organic manures (poultry manure, vermicompost) and bio-inoculants (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).

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.

Dufault *et al.,* (1990) reported that the mycorrhizal inoculation improves the phosphorus and potassium uptake which results in improved flower quality in gerbera. Selvaraj *et al.,* (2008) showed that the leaf content of phosphorus, potassium, zinc, copper andiron 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 ìg.plant^{-1}, 89.2 ìg.g^{-1}, and 94.2 ìg.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. 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 tripleinteraction 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 (1706.47dcm^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).

Materials & Methods

A field experiment was conducted to investigate the effects of biofertilizers and Carbolizer on growth and vase life of *Gerbera jamesonii* cv. Stanza, 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: aluminium sulfate [$Al_2(SO_4)_3$] (0, 100, 150 and 200 mg.L^{-1}).

Soil Characteristics of the Experiment Site

Some physical and chemical properties of the soil under the experimental plots after applied 8m^3 of manure and 3 m^3 of sandy loam during the study period were shown in table 1.

Table 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.

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 2.

The factorial experiment included two factors: Biofertilizers including two types of bacteria (*Azotobacter chroococcum* and *Bacillus subtilus*) and arbuscular mycorrhizal fungi (*Glomus mosseae*). And three levels of organic liquid fertilizer (Carbolizer), (0, 1.5, 2.5mg.L^{-1}).

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.

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°C) for 15 minutes before adding bacteria.

Table 2: Some meteorological data inside greenhouse during the study period (2015-2016).

Month	Max. Temp. (°C)	Min. Temp. (°C)	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

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 (28^0C) for 72 hours.
4. After inoculation period (3g) 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: 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.

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 4.

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=0.05) which was claimed by (SAS, 2001).

Vegetative growth Parameters.

Leaf chlorophyll intensity (Spad unit) : Was measured as SPAD units using digital monitor chlorophyll meter (SPAD 502 PLUS).

Leaf area (ds^2) : Measured by Leaf area meter (ADC-Area Meter AM300).

Number of offsets.$plant^{-1}$: Counted of offsets for each plant.

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:

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

Concentration of nitrogen in leaves (%): Samples were taken from leaves and determined by Micro-Kjeldahl (Page *et al.,* 1982)

Concentration of phosphorus in leaves (%): Samples were taken from leaves and determined by Spectrophotometer (Page *et al.,* 1982).

Concentration of potassium in leaves (%): Samples were taken from leaves and determined by Flame photo meter (Erwin and Houba, 2004).

Concentration of iron in leaves (mg.kg^{-1}): Samples were taken from leaves and determined by (Atomic Absorption Spectrophotometer).

Concentration of zinc in leaves (mg.kg^{-1}): Samples were taken from leaves and determined by (Atomic Absorption Spectrophotometer)

Floral growth - Flower dry matter (%): The same method indicated in 3.10.1.4 was applied

Length of flower stalk (cm): Measured 2 *cm* above soil surface to the neck of the capitulum by using measuring tape.

Diameter of flower stalk (mm): Measured at (1-2 cm) above the cut site by using electronic caliper.

Capitulum diameter (cm) : Measured during full open of inflorescences, and then calculated the farthest distance between the points by using electronic caliper.

Anthocyanin concentration in ray florets (mg.$100g^{-1}$) : Samples were taken from ray florets and determined by Spectrophotometer (Ranganna, 1977), method II.

Numbers of flowers during the study period

Root growth

Length of main roots (cm): Measured by measuring tape.

Diameter of main roots (mm): Measured by electronic caliper.

Root surface area (cm^2) : Measured by measuring digimizer software version 4.5.

Root dry matter (%): The same method indicated in 3.10.1.4 was applied

Concentration of nitrogen in root (%): Samples were taken from root and determined by Micro-Kjeldahl (Page *et al.,* 1982).

Concentration of phosphorus in root

Table 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.

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

Concentration of potassium in root (%): Samples were taken from root and determined by Flame photometer (Erwin and Houba, 2004).

Results & Discussion

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

Leaf chlorophyll intensity (spad unit) :

The effect of biofertilizers on leaf chlorophyll intensity of *Gerbera jamesonii* cv. Stanza is shown in table 5 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). 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 (48.98spad unit) was recorded with ($A_3 \times B_2$), 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 5 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).

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 6 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 (1305.00ds^2) and it was not differed significantly with *Glomus mosseae* alone (A_2). Both concentrations were significantly different with non-inoculated treatments A_0 (692.30ds^2). The different levels of carbolizer significantly increased leaf area. The highest leaf area of gerbera

Table 5: 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 = 0.05).

Table 6: Effect of biofertilizers, carbolizer andtheir 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 $ml.L^{-1}$	645.10cd	1068.80abc	1166.20abc	1417.40 a	1074.40 a
B_2 2.5 $ml.L^{-1}$	1078.60abc	1270.50ab	1337.10ab	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 = 0.05).

(1302.60ds^2) was obtained from (B_2), while the lowest value (680.40ds^2) was obtained from (B_0). The interaction treatments affected significantly on leaf area of gerbera. The highest leaf area (1524.00ds^2) was observed from (A_3×B_2). While, the lowest value (353.30ds^2) was obtained from control treatments (A_0×B_0). 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).

Number of offsets.plant^{-1}

The results in Table 7, 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 (2.5ml.L^{-1}), while the lowest value (4.06) was obtained from (B_0) control plants. 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_0×B_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

Table 7: 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 = 0.05).

Table 8: 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 = 0.05).

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).

Leaf dry matter (%)

The results in Table 8 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 ($A_3 \times B_1$) and ($A_0 \times B_0$), respectively. 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).

Concentration of nitrogen in leaves (%)

The data in Table 9 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. 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 ($A_3 \times B_2$), while the lowest N% (1.93) was obtained from ($A_0 \times B_0$). 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

Table 9: 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 = 0.05).

Table 10: 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 = 0.05).

and Higazy, 2009).

Concentration of phosphorus in leaves (%)

Results depicted in Table 10 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%). 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 ($A_3 \times B_2$) and it was not differed significantly with ($A_3 \times B_1$), while the lowest P% (0.10) was obtained from ($A_0 \times B_0$). 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.

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 11, 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

Table 11: 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 = 0.05).

Table 12: 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 = 0.05).

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 $A_3 \times B_1$ (4.68), while the lowest value (1.81%) was obtained from ($A_0 \times B_0$). 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.

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

The results in Table 12 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 (116.68mg.kg^{-1}). 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 (A3×B2), 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, gave the highest value of the most of study parameters for leaves content from N, P, K and Fe.

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

It is clear from data in table 13 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

Table 13: 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 = 0.05).

Table 14: 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 = 0.05).

concentration in leaves (21.21mg.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). 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 ($A_3 \times B_2$), while the lowest value (19.92 mg.kg^{-1}) were obtained from ($A_0 \times B_0$). 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 13. 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.

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

Flower dry matter (%)

The results in table 14 explained that the effect of biofertolizers on percentage of flower dry matter of *Gerbera jamesonii* cv. Stanzawas 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 ($A_3 \times B_2$), and it was not differed significantly with ($A_3 \times B_1$). 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 plantcellular 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 15: 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 = 0.05).

Table 16: 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 0.0 ml.L^{-1}	6.28 g*	7.69 f	7.98 f	8.64 de	7.64 c
B_1 1.5 ml.L^{-1}	7.60 f	8.11 ef	8.91 cd	9.63 b	8.56 b
B_2 2.5 ml.L^{-1}	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 = 0.05).

Length of flower stalk (cm)

The data in table 15 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). 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 × Bacteria) and carbolizer ($A_3 \times B_2$), 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.

Diameter of flower stalks (mm)

The data presented in table 16 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).

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 (6.28mm) was obtained from ($A_0 \times B_0$).

Capitulum diameter (cm)

Table 17 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). 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 (15.80cm) 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 ($A_3 \times B_2$), whereas

Table 17: 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 = 0.05).

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).

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

It is clear in table 18 that the inoculation of biofertilizers significantly increased anthocyanin concentration in Gerberaray 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 ($A_3 \times B_2$) whereas the minimum value (20.12 mg.100g^{-1}) obtained in control treatment. 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).

Number of flowers during the study period

As shown in table 19, 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 periodin 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 (2.5ml.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 ($A_0 \times B_0$).

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

Table 18: 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)	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}	20.12 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 = 0.05).

Table 19: 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 = 0.05).

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.

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

Table 20: Effect of biofertilizers, carbolizer and their interactions on the main root length (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}	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 = 0.05).

Length of main root (cm)

Table 20 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 (39.27cm) 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 ($A_3 \times B_2$) which was superior to the shortest main root (27.61cm) for control. 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.

Diameter of main root (mm)

As shown in table 21 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.

Concerning the interaction of biofertilizers and foliar application of carbolizer, significant effect on the diameter of main root was observed, the highest value (3.88mm) was obtained from the interaction of ($A_3 \times B_2$), while the lowest value (2.24mm) was obtained from control ($A_0 \times B_0$). 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).

Root surface area (cm^2)

As shown in table 22, 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).

Root surface area of gerbera significantly affected by application of carbolizer, which gave the highest value (82.14cm^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

Table 21: 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 = 0.05).

Table 22: 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 = 0.05).

in their effect on root surface area. The interaction (A_3 xB_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).

Root dry matter (%)

Table 23 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.

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 ($A_3 \times B_2$), 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.

Table 23: 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 $^{-1}$ 0.0 ml.L	11.63 i*	13.63 hi	14.63 fg	16.85 c	14.18 c
B_1 $^{-1}$ 1.5 ml.L	13.13 i	15.03 ef	15.85 d	18.19 b	15.55 b
B_2 $^{-1}$ 2.5 ml.L	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 = 0.05).

Table 24: 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 $^{-1}$ 0.0 ml.L	2.04 g*	2.90 f	2.58 fg	3.83 abcde	2.82 b
B_1 $^{-1}$ 1.5 ml.L	2.71 efg	3.99 abcd	3.55 cdef	4.77 ab	3.76 a
B_2 $^{-1}$ 2.5 ml.L	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 = 0.05).

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 24. 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). 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 ($A_3 \times B_2$), while the lowest N% (2.04) was obtained from ($A_0 \times B_{0)}$. 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.

Concentration of phosphorus in root (%)

Results in table 25 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 ($A_3 \times B_2$), while the lowest P% (0.40) was obtained from ($A_0 \times B_0$). 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

Table 25: 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 = 0.05).

Table 26: 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 = 0.05).

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.

Concentration of potassium in root (%)

Table 26 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.

The interaction between (biofertilizers × carbolizer) had a significant effect on concentration of potassium in gerbera roots. The highest values (4.90%) was obtained from ($A3 \times B_2$), while the lowest value (1.66%) was obtained from ($A_0 \times B_0$). 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.).

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 aluminium 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 ($A_0B_0C_0$)..

Conclusions

According to the results obtained from this study, it may be concluded that: The results show that the inoculation of *Gerbera jamesonii* cv. Stanza with arbuscular mycorrhizal fungi (AMF) generally enhanced the plant growth. It was observed that the combined inoculation of arbuscular mycorrhizal fungi (AMF) and bacteria had a positive effect on plant growth and nutrient uptake. The foliar spray of carbolizer improved plant growth and nutrient uptake under plastic house conditions

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