Influence of Bio Fertilizers and Foliar Spray of Spermine and Vermiwash on Growth, Yield and Postharvest Quality of Gerbera (Gerbera jamesonii Hook.) Under Naturally Ventilated Polyhouse

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A B S T R A C T

An experiment was conducted during 2013-2015, with factorial concept to study the influence of soil inoculation of bio fertilizers (Azotobacter @ 1l/ha and VAM @ 2 g/plant) and foliar application of chemicals (spermine and salicylic acid @ 25 and 50 ppm each) and organic growth enhancers (banana pseudo stem sap @ 0.5% and 1% and vermiwash @ 4%) on gerbera. Pooled data of two years indicated that the treatment combination of bio fertilizers along with the foliar spray of spermine @ 25 ppm showed maximum plant growth parameters viz., plant height (42.87 cm), leaf area index (4.72), suckers per plant (8.42), flower parameters viz., yield per plant (57.17), diameter (11.41 cm) and fresh weight (25.11 g) of the flower and physiological parameters like membrane stability index (75.50 %), protein content (30.73 mg/g) and peroxidase activity (48.19 mM/min/g protein) in the petal tissue and postharvest life (9.29 days) of gerbera which was at par with or followed by the treatment combination of bio fertilizers along with the foliar spray of vermiwash @ 4%. Thus, these treatment combinations significantly influenced the growth, yield as well as postharvest quality and life of gerbera.

Keywords
Azotobacter, Mycorrhiza, Spermine, Protein, Peroxidase activity, Vase life.

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Introduction

Gerbera (Gerbera jamesonii Hook) popularly known as Transvaal daisy, belongs to the family Asteraceae. It is highly popular in the category of cut flowers and ranks fifth amongst the elite group of top ten cut flowers of the international flower markets (Zheng et al., 2016). Inoculation with bio fertilizers and foliar spray of chemical and organic growth substances can significantly influence the plant growth, yield and quality of cut flowers. Bio fertilizers viz., Azotobacteris free living bacteria, utilize atmospheric nitrogen gas for their cell protein synthesis. This cell protein is then mineralized in soil after the death of Azotobacter cells thereby contributing towards the nitrogen availability of the crop plants (Tchan and New, 1989). Azotobacter has beneficial effects on crop growth and yield through, biosynthesis of biologically active substances and stimulation of rhizospheric microbes (Chen, 2006; Lenart, 2012). Mycorrhiza aid in nutritional management by solubilizing and mobilizing the major and minor plant nutrients and some
trace elements (Kraepiel et al., 2009) and secretes organic acids, vitamins and growth promoting substances which helps in better plant growth and development (Prasad et al., 2014). Spermine comes under the class of aliphatic polyamines that are ubiquitous in plants and have been associated in wide range of biological processes, including cell division, protein synthesis, DNA replication, differentiation and rhizogenesis (Van den Broek et al., 1994). Vermiwash contains nitrogenous excretory product and growth promoting hormones and essential enzymes for plant growth and also infuses resistance in plants (Kaur et al., 2015). Role of different bio fertilizers, chemicals and natural growth substances as a pre harvest spray in improving the growth, flowering and quality of gerbera has not been explored so far. Hence, this investigation was planned to study the individual and interaction effect of bio fertilizers, chemicals and organic growth substances on growth, yield and postharvest quality of gerbera under naturally ventilated polyhouse.

Materials and Methods

Present experiment was conducted during 2013-2015, under naturally ventilated polyhouse located at greenhouse complex, Dept. of Floriculture and Landscape Architecture, ACHF, NAU, Navsari. Experiment was laid out in completely randomised design with factorial concept. There were two factors, factor one consisted of two levels as B_0– without bio fertilizers and B_1- with bio fertilizers (Azotobacter @ 1 l/ha + VAM @ 2 g/plant) and factor two consisted of 7 levels of foliar sprays viz., spermine @ 25 ppm (C_1), spermine @ 50 ppm (C_2), salicylic acid @ 25 ppm (C_3), salicylic acid @ 50 ppm (C_4), banana pseudo stem sap @ 0.5 % (C_5), banana pseudo stem sap @ 1.0 % (C_6) and vermiwash @ 4% (C_7). Thus, there were 14 treatment combinations and were repeated three times. Bio fertilizers viz., Azotobacter was given in the form of drenching and VAM was inoculated in the soil during planting of gerbera. Foliar spray of respective treatments was given one month after transplanting and repeated at six months interval. All the three parameters viz., vegetative like plant height (cm), leaf area index, suckers per plant, yield per plant and flowering parameters i.e., diameter of the flower (cm) and fresh weight of the flower (g) and physiological parameters like membrane stability index (%), protein (mg/g), peroxidase activity (mM/min/g protein) in the petal tissue and vase life (days) of gerbera were recorded in both the years and data was pooled. Protein and peroxidase activity in the petal tissue were estimated by the methods described by Lowry et al., (1951) and Costa et al., (2002) respectively. The experimental data pertaining to the characters studied were subjected to statistical analysis of variance technique as described by Panse and Sukhatme (1967).

Results and Discussion

Data depicted in the tabular form revealed that the individual effects of bio fertilizers, foliar spray as well as their interaction showed significant effect on vegetative growth, flower yield and postharvest life of gerbera in both the years as well as pooled data.

Growth and yield

Growth of the plant in terms of maximum plant height (44.40, 41.33, 42.87 cm), leaf area index (4.81, 4.62 and 4.72), number of suckers per plant (6.23, 10.60 and 8.42) and flower yield per plant (52.00, 62.33 and 57.17) were recorded in the treatment combination of Azotobacter @ 1 l/ha + VAM @ 2 g/plant as soil application and spermine @ 25 ppm as foliar spray (B_1C_7), which was at par or followed by the treatment combination
of *Azo* @ 1 l/ha + VAM @ 2g/plant + vermiwash @ 4% (B$_7$C$_7$) in first year, second year and pooled data respectively. *Azotobacter* being a diazotroph, the beneficial response on crops is known due to its atmospheric nitrogen fixing ability and its subsequent mineralization by conversion of elemental form of nitrogen to ammonia as it contains catechol siderophores which have significant percentage of nitrogen and also enhances the uptake of metal ions from the rhizosphere (Yoneyama et al., 2009) (Table 1 and 2).

Further, the ability of *Azotobacter* to produce B group vitamins (Revillas et al., 2000), indole acetic acid and other plant growth regulators (Lenart, 2012) enhance the root growth and thereby helps in better nutrient absorption (Chen, 2006).

Further, symbiotic relationship of the mycorrhiza with host plants helps in absorption of phosphorus (Miller, 2000), mobilization of organically bound nitrogen (Hodge et al., 2001) and micro and trace elements (Smith and Read, 2008) from soil which are relatively unavailable to the plants and thereby enhance the growth of the plants. Improved growth and flower yield with inoculation of *Azotobacter* and mycorrhiza were earlier reported in gladiolus (Meenakshi et al., 2015) and in chrysanthemum (Neelima et al., 2015).

Further, spermine is low molecular weight organic polyamine that comes under new class growth regulator (Morgan 1999). Uptake and accumulation of N (Rangan et al., 2014), P (Hewitt, 1963) and K (Hanafy – Ahmad et al., 2002) with spermine application has been well documented and also reported in rose (Farahi et al., 2012). In addition to this, stimulated effect of spermine treatment on plant growth and yield was due to their effect on many metabolic and physiological processes viz., enhanced root growth and floral initiation as per earlier reports (Sood and Nagar, 2003). Vermiwash being mixture of nutrients, vitamins and enzymes (Zambare et al., 2008) have also been reported to facilitate improved growth and yield in orchid (Karuppaiah and Sendilnathan, 2011) and in rose (Himanshu and Ajit, 2015).

**Flower quality**

Gerbera plants inoculated with bio fertilizers (*Azo* and VAM) and sprayed with spermine @ 25 ppm (B$_7$C$_7$) recorded maximum diameter (12.26 10.54, and 11.41 cm) and fresh weight of flower (27.04, 23.21 and 25.11 g) which was on par with or followed by treatment combination of *Azo* @ 1 l/ha + VAM @ 2g/plant + vermiwash @ 4% (B$_7$C$_7$) in both the years and pooled data respectively. Improved flower quality parameters can be ascribed to enhanced vegetative growth parameters by inoculation of *Azotobacter* and VAM and foliar spray of spermine @ 25 ppm and vermiwash @ 4%. Improved quality parameters have been disclosed earlier with bio fertilizers in chrysanthemum (Neelima et al., 2015) and China aster (Prabhat et al., 2003) and with spermine in rose (Sumathi 2013) (Table 3).

**Postharvest physiology and vase life**

Among the interaction of bio fertilizer and foliar spray treatments, significantly maximum protein content (32.34, 29.12 and 30.73 mg/g), peroxidase activity (48.21, 46.38 and 47.30 mM/min/g protein) and membrane stability index (79.00, 71.99 and 75.50 %) in the petal tissue and vase life (10.25, 8.33 and 9.29 days) were recorded in the treatment combination of bio fertilizers + spermine @ 25 ppm (B$_7$C$_7$) which was at par with *Azo* @ 1 l/ha + VAM @ 2g/plant + vermiwash @ 4% (B$_7$C$_7$) in both the years and pooled data respectively (Tables 4 and 5).
Table 1. Effect of bio fertilizers, chemicals and organic growth substances on plant height and Leaf Area Index of gerbera var. Alcatraz

|        | 2013-14 | 2014-15 | Pooled | 2013-14 | 2014-15 | Pooled |
|--------|---------|---------|--------|---------|---------|--------|
|        | B₀      | B₁      | C Mean | B₀      | B₁      | C Mean |
| C₁     | 40.46   | 44.40   | 42.43  | 39.16   | 41.33   | 40.25  | 39.82   | 42.87   | 41.34  | 3.87   | 4.81   | 4.34  | 3.66   | 4.62   | 4.14  | 3.77   | 4.72   | 4.24  |
| C₂     | 39.93   | 40.06   | 39.76  | 39.00   | 39.80   | 39.40  | 39.47   | 39.70   | 39.58  | 3.60   | 4.19   | 3.89  | 3.55   | 4.02   | 3.79  | 3.58   | 4.11   | 3.84  |
| C₃     | 39.73   | 39.60   | 39.90  | 36.03   | 39.53   | 37.78  | 37.88   | 39.80   | 38.84  | 3.74   | 4.07   | 3.90  | 3.58   | 4.01   | 3.79  | 3.66   | 4.04   | 3.85  |
| C₄     | 39.60   | 40.00   | 39.80  | 38.63   | 39.86   | 39.25  | 39.12   | 39.93   | 39.53  | 3.76   | 3.84   | 3.80  | 3.61   | 3.61   | 3.61  | 3.69   | 3.73   | 3.71  |
| C₅     | 40.46   | 41.80   | 41.13  | 34.46   | 39.53   | 37.00  | 37.47   | 40.67   | 39.07  | 3.66   | 4.28   | 3.97  | 3.48   | 4.01   | 3.74  | 3.57   | 4.15   | 3.86  |
| C₆     | 39.46   | 41.60   | 40.53  | 38.26   | 40.13   | 39.19  | 38.87   | 40.98   | 39.93  | 3.91   | 4.32   | 4.11  | 3.65   | 4.17   | 3.91  | 3.78   | 4.25   | 4.01  |
| C₇     | 39.60   | 43.20   | 41.40  | 39.13   | 40.33   | 39.73  | 38.27   | 41.67   | 39.97  | 3.98   | 4.43   | 4.20  | 3.61   | 4.22   | 3.92  | 3.8    | 4.33   | 4.06  |
| B Mean | 39.89   | 41.52   | 41.40  | 37.50   | 40.08   | -     | 38.70   | 40.80   | -     | 3.79   | 4.28   | -    | 3.59   | 4.09   | -    | 3.69   | 4.19   | -    |
| B C BC | B C BC  | B C BC  | B C BC | B C BC  | B C BC  | B C BC |
| C D.5% | 0.78    | 1.46    | 2.06   | 0.46    | 0.81    | 1.02  | 0.44    | 0.82    | 1.17  | 0.25   | 0.45   | 0.67 | 0.30   | 0.54   | 0.72 | 0.20   | 0.32   | 0.68 |

Table 2. Effect of bio fertilizers, chemicals and organic growth substances on suckers/plant and yield/plant of gerbera var. Alcatraz

|        | 2013-14 | 2014-15 | Pooled | 2013-14 | 2014-15 | Pooled |
|--------|---------|---------|--------|---------|---------|--------|
|        | B₀      | B₁      | C Mean | B₀      | B₁      | C Mean |
| C₁     | 3.36    | 6.23    | 4.80   | 5.36    | 10.60   | 7.98   | 4.37    | 8.42    | 6.39   | 42.00  | 52.00  | 47.00  | 53.00  | 62.33  | 57.67  | 47.50  | 57.17  | 52.33  |
| C₂     | 3.00    | 4.73    | 3.86   | 5.60    | 7.66    | 6.63   | 4.30    | 6.20    | 5.25   | 40.67  | 49.33  | 45.00  | 52.33  | 60.33  | 56.33  | 46.50  | 54.83  | 50.67  |
| C₃     | 2.70    | 4.86    | 3.78   | 4.20    | 6.60    | 5.40   | 3.45    | 5.73    | 4.59   | 38.33  | 46.67  | 42.50  | 52.00  | 58.67  | 55.33  | 45.17  | 52.67  | 48.92  |
| C₄     | 2.56    | 5.43    | 4.00   | 4.20    | 6.03    | 5.11   | 3.38    | 5.73    | 4.56   | 39.67  | 48.67  | 44.17  | 51.67  | 58.33  | 55.00  | 45.67  | 53.50  | 49.58  |
| C₅     | 3.50    | 5.20    | 4.35   | 5.91    | 7.43    | 6.66   | 4.70    | 6.32    | 5.51   | 40.00  | 47.67  | 43.83  | 51.00  | 59.00  | 55.00  | 45.50  | 53.33  | 49.42  |
| C₆     | 3.66    | 5.81    | 4.73   | 5.43    | 7.70    | 6.56   | 4.55    | 6.75    | 5.65   | 41.00  | 48.33  | 44.67  | 52.00  | 59.67  | 55.83  | 46.50  | 54.00  | 50.25  |
| C₇     | 4.06    | 6.06    | 5.06   | 6.30    | 8.10    | 7.20   | 5.18    | 7.08    | 6.13   | 41.33  | 51.33  | 46.33  | 52.33  | 61.00  | 56.67  | 46.83  | 56.17  | 51.50  |
| B Mean | 3.26    | 5.47    | -      | 5.28    | 7.73    | -      | 4.28    | 6.60    | -      | 4.04   | 49.14  | -      | 52.05  | 59.90  | -      | 46.24  | 54.52  | -      |
| B C BC | B C BC  | B C BC  | B C BC | B C BC  | B C BC  | B C BC |
| C D.5% | 0.15    | 0.28    | 0.39   | 0.18    | 0.35    | 0.49   | 0.18    | 0.35    | 0.49   | 0.97   | 1.87   | 2.61   | 1.22   | 2.37   | 3.59   | 0.70   | 1.31   | 1.86   |
Table 3: Effect of bio fertilizers, chemicals and organic growth substances on diameter and fresh weight of flower of gerbera var. Alcatraz

|          | Diameter of flower (cm) |          | Fresh weight of flower (g) |          |
|----------|-------------------------|----------|----------------------------|----------|
|          | 2013-14 | 2014-15 | Pooled                    | 2013-14 | 2014-15 | Pooled          |
|          | B₀ | B₁ | C | Mean | B₀ | B₁ | C | Mean | B₀ | B₁ | C | Mean | B₀ | B₁ | C | Mean |
| C₁  | 11.28 | 12.26 | 11.77 | 9.07 | 10.54 | 9.80 | 10.18 | 11.41 | 10.79 | 21.51 | 27.04 | 24.27 | 21.69 | 23.21 | 22.45 | 21.60 | 25.11 | 23.36 |
| C₂  | 11.20 | 11.82 | 11.51 | 8.82 | 9.52 | 9.17 | 10.01 | 10.67 | 10.34 | 21.06 | 24.34 | 22.70 | 17.82 | 20.97 | 19.40 | 19.44 | 22.65 | 21.05 |
| C₃  | 11.07 | 11.63 | 11.35 | 8.85 | 9.62 | 9.23 | 9.97 | 10.63 | 10.30 | 21.27 | 23.89 | 22.58 | 17.35 | 20.07 | 18.71 | 19.31 | 21.98 | 20.65 |
| C₄  | 11.01 | 11.71 | 11.36 | 8.75 | 9.74 | 9.24 | 9.89 | 10.73 | 10.31 | 20.41 | 24.36 | 22.38 | 16.93 | 21.87 | 19.40 | 18.67 | 23.11 | 20.89 |
| C₅  | 11.23 | 11.59 | 11.41 | 8.65 | 9.76 | 9.21 | 9.95 | 10.68 | 10.31 | 20.65 | 23.95 | 22.30 | 17.84 | 21.21 | 19.52 | 19.25 | 22.58 | 20.91 |
| C₆  | 11.19 | 11.43 | 11.31 | 8.49 | 9.99 | 9.24 | 9.84 | 10.71 | 10.28 | 20.58 | 25.35 | 22.96 | 18.12 | 21.96 | 20.04 | 19.35 | 23.66 | 21.50 |
| C₇  | 11.02 | 12.20 | 11.61 | 8.21 | 10.32 | 9.26 | 9.62 | 11.27 | 10.44 | 21.44 | 26.49 | 23.96 | 20.28 | 23.20 | 21.74 | 20.86 | 24.85 | 22.85 |
| B Mean | 11.14 | 11.80 | - | 8.69 | 9.93 | - | 9.92 | 10.87 | - | 20.99 | 25.06 | - | 18.43 | 21.78 | - | 19.59 | 23.42 | - |
| C, D.5% | 0.037 | 0.067 | 0.098 | 0.030 | 0.056 | 0.079 | 0.019 | 0.035 | 0.50 | 0.46 | 0.86 | 1.22 | 0.36 | 0.67 | 0.95 | 0.28 | 0.53 | 0.75 |

Table 4: Effect of bio fertilizers, chemicals and organic growth substances on membrane stability index and protein of gerbera var. Alcatraz

|          | Protein (mg/g) |          | Peroxidase activity (mM/min/g protein) |          |
|----------|----------------|----------|----------------------------------------|----------|
|          | 2013-14 | 2014-15 | Pooled                        | 2013-14 | 2014-15 | Pooled           |
|          | B₀ | B₁ | C | Mean | B₀ | B₁ | C | Mean | B₀ | B₁ | C | Mean | B₀ | B₁ | C | Mean |
| C₁  | 27.57 | 32.34 | 29.96 | 24.32 | 29.12 | 26.72 | 25.95 | 30.73 | 28.34 | 47.29 | 49.13 | 48.21 | 45.52 | 47.24 | 46.38 | 46.40 | 48.19 | 47.30 |
| C₂  | 25.67 | 30.26 | 27.96 | 22.34 | 27.03 | 24.69 | 24.00 | 28.65 | 26.32 | 46.77 | 47.29 | 47.03 | 44.50 | 45.62 | 45.06 | 45.63 | 46.45 | 46.04 |
| C₃  | 24.37 | 31.46 | 27.92 | 21.12 | 28.23 | 24.68 | 22.75 | 29.85 | 26.30 | 46.25 | 48.31 | 47.28 | 44.46 | 46.13 | 45.29 | 45.35 | 47.22 | 46.29 |
| C₄  | 24.54 | 30.90 | 27.72 | 21.59 | 27.87 | 24.73 | 23.07 | 29.39 | 26.23 | 46.67 | 47.91 | 47.29 | 44.85 | 45.71 | 45.28 | 45.76 | 46.81 | 46.28 |
| C₅  | 25.06 | 29.64 | 27.35 | 21.68 | 26.41 | 24.05 | 23.37 | 28.03 | 25.70 | 46.67 | 47.06 | 46.87 | 43.81 | 45.41 | 44.61 | 45.24 | 46.24 | 45.74 |
| C₆  | 25.37 | 28.97 | 27.17 | 22.14 | 26.35 | 24.25 | 23.76 | 27.66 | 25.71 | 46.74 | 47.63 | 47.19 | 44.86 | 45.15 | 45.01 | 45.80 | 46.39 | 46.10 |
| C₇  | 26.36 | 32.25 | 29.31 | 23.24 | 28.32 | 25.78 | 24.80 | 30.28 | 27.54 | 46.87 | 48.54 | 47.71 | 45.32 | 46.31 | 45.82 | 46.10 | 47.43 | 46.76 |
| B Mean | 25.56 | 30.83 | - | 22.35 | 27.62 | - | 23.96 | 29.22 | - | 46.75 | 47.98 | - | 44.76 | 45.94 | - | 45.76 | 46.96 | - |
| C, D.5% | 0.67 | 1.26 | 1.78 | 0.76 | 1.42 | 2.00 | 0.64 | 1.20 | 1.69 | 0.31 | 0.58 | 0.83 | 0.25 | 0.45 | 0.66 | 0.17 | 0.32 | 0.46 |
Table 5 Effect of bio fertilizers, chemicals and organic growth substances on anthocyanin and vase life of gerbera var. Alcatraz

| Membrane Stability Index (%) | Vase life (days) |
|------------------------------|------------------|
| 2013-14                      | 2014-15          | Pooled          | 2013-14 | 2014-15 | Pooled |
| B0  | B1  | C  | Mean | B0  | B1  | C  | Mean | B0  | B1  | C  | Mean | B0  | B1  | C  | Mean |
|-----|-----|----|------|-----|-----|----|------|-----|-----|----|------|-----|-----|----|------|
| C1  | 72.01 | 79.00 | 75.51 | 69.32 | 71.99 | 70.66 | 70.67 | 75.50 | 73.08 | 8.30 | 10.25 | 9.27 | 7.08 | 8.33 | 7.70 |
| C2  | 70.14 | 72.34 | 71.24 | 68.01 | 70.00 | 69.01 | 69.07 | 71.17 | 70.12 | 7.63 | 9.15 | 8.39 | 6.34 | 7.96 | 7.15 |
| C3  | 69.59 | 71.39 | 70.49 | 68.41 | 70.31 | 69.36 | 69.00 | 70.85 | 69.93 | 7.73 | 8.55 | 8.14 | 6.26 | 7.65 | 6.96 |
| C4  | 69.11 | 72.10 | 70.61 | 67.87 | 70.34 | 69.11 | 68.49 | 71.22 | 69.86 | 7.93 | 8.64 | 8.28 | 6.17 | 7.68 | 6.93 |
| C5  | 70.12 | 72.87 | 71.50 | 68.73 | 69.99 | 69.36 | 69.43 | 71.43 | 70.43 | 7.53 | 8.68 | 8.10 | 5.57 | 6.64 | 6.10 |
| C6  | 69.77 | 73.55 | 71.66 | 67.81 | 71.21 | 69.51 | 68.79 | 72.38 | 70.59 | 7.63 | 8.84 | 8.23 | 5.92 | 7.01 | 6.46 |
| C7  | 73.81 | 73.72 | 73.76 | 69.28 | 71.41 | 70.35 | 71.54 | 72.57 | 72.05 | 8.26 | 9.58 | 8.95 | 6.44 | 7.96 | 7.20 |
| B Mean | 70.65 | 73.57 | - | 68.49 | 70.75 | - | 69.57 | 72.16 | - | 7.86 | 9.10 | - | 6.25 | 7.60 | - |

C. D.5% 0.89 1.66 2.53 0.31 0.58 0.82 0.44 0.82 1.77 0.10 0.20 0.28 0.05 0.10 0.14 0.06 0.12 0.14
Improved postharvest parameters might be due to enhanced overall food and nutrient status of the flowers and greater development of conducting tissues which facilitated higher flower fresh weight in inoculated plants. Further, application of spermine have been known to prevent senescence through inhibition of protein degradation (Baraniak and Kostecka, 1999), by maintaining the membrane stability (Apelbaum et al., 1981) through binding with membrane phospholipids and other anion component of the membranes (Katarzyna et al., 2012). Thus, retained flower fresh weight, higher protein content, peroxidase activity and membrane stability in the petal tissue with Azotobacter and VAM inoculation and foliar spray of spermine @ 25 ppm and vermiwash @ 4% treatments ultimately resulted in to enhanced vase life of gerbera. Similar results of enhanced vase life were earlier reported with bio fertilizers in gerbera (Barreto and Jagtap, 2002) and with spermine in gladiolus (Nahed et al., 2009) and rose (Sumathi, 2013) and with vermiwash in gladiolus (Samir, 2016).

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