Original Research Article

EFFECT OF BIOFERTILIZERS ON SOIL QUALITY UNDER GERBERA *(Gerbera jamesonii* Bolus) CULTIVATION

Abstract:*An field experiment was carried out at the Experimental Farm, Department of Horticulture, Assam Agricultural University, Jorhat during the period of 2015-2016 and 2016-2017. The experiment was set in Randomized Block Design(RBD) consisting of three replications and eight treatments.The Treatments comprised of T_0 (Control), T_1 {Bacillus subtilis (4% solution)}, T_2 {Microbacterium laevaniformans (4% solution)}, T_3 NPK (@15:10:20 g m-2), T_4 Vermicompost (5 kg per plot), T_5 (½ NPK + ½ Vermicompost + Bacillus subtilis), T_6 (½ NPK + ½ Vermicompost + Microbacterium laevaniformans), T_7 (½ NPK + ½ Vermicompost + Consortium) and T8 (Consortium). The results revealed that the soil parameters were significantly influenced by the treatments. Studies revealed that soil pH (5.26), Organic Carbon (0.86%), N (276.9 kg ha^{-1}), K (135.1kg ha^{-1}), MBC (379.23µg g^{-1}soil 24 hour^{-1}) were found highest in T_4. For P (44.6kg ha^{-1}) and Electrical Conductivity(0.19 dS/m) was recorded highest in treatment T_7.*

Keywords: Influence, biofertilizer, organic, floriculture, fertility and sustainability.

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Comment [GN2]: Small letter for treatment

Comment [GN3]: Give space between unit and numericals

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1. INTRODUCTION

In recent years, floriculture is fast emerging as highly competitive, commercial and economic activity with potential for earning valuable foreign exchange. The flower markets both at national and international levels are very much quality oriented. The overall quality of the cut flowers is governed by the cultivars grown, growing conditions and pre and post harvest management practices. Performance of each gerbera cultivar varies with region, season and other growing conditions.

Today, agrochemicals are being used excessively in crop production due to high trend in industrialization and population explosion in the world. Their continuous application has introduced major challenges for farmers in the form of soil infertility, nutrient imbalance, accumulation of toxic chemicals in the soil which have an adverse effect on the soil productivity, ecosystem destruction, environmental degradation and also affecting the yield and quality of the product. (Eman *et al*, 2008).Steady decline in soil organic matter levels due to continuous cropping with injudicious applications of chemical fertilizers has lead to negative nutrient balances in Indian agriculture, impaired soil health and weaken factor productivity (Rao, 2007).

Soil quality and its degradation depend on a large number of physical, chemical, biological, microbiological and biochemical properties, the last two being the most sensitive since, they respond rapidly to changes. The microbiological activity of a soil directly influences ecosystem stability and fertility and it is widely accepted that a good level of microbiological activity is essential for maintaining soil quality. The microbiological activity *viz*., the enzymatic activities play a key role in soil nutrient cycling, its activity is essential in both the mineralisation and transformation of organic matters and plant nutrients in soil ecosystem (Dick and Tabatabai, 1993). Soil enzyme activities are very sensitive to both natural and anthropogenic disturbances and show a quick response to induced changes (Dick, 1997).

To cope with all these problems a cheaper, better and safer way is necessary in order to improve the soil fertility status, maximize the agricultural productivity with minimum Eco hazards. All these criteria can be achieved through application of bio-fertilizers which is known as "microbial inoculants", these are the products containing the living cells (Mainly bacteria & fungi) that naturally activate the

microorganisms found in the soil, restoring the soil fertility and improve physico-chemical and biological properties of soil.

2. MATERIALS AND METHODS

The experiment was undertaken in the Experimental Farm of Department of Horticulture, Assam Agricultural University, Jorhat-785013 during the year 2015-17. The experimental soil was sandy loam in texture, well drained and having pH 5.1. The experiment was set out in a Randomized Block Design (RBD) which was replicated thrice. Cultivar Indukumari having uniform vigour and age were selected and planted on 15th of October in both the years of the study at a spacing of 30 cm x 30 cm. The area of the experimental plot was 134.25 sq.m. and that of the individual bed was 1.5m x 1.5m (2.25 sq.m.) were raised to 25 cm from the ground level to avoid water stagnation. The crops were raised by following nine tratments in both the years.

` The Treatments were T_0 (Control), T_1 {Bacillus subtilis (4% solution)}, T_2 {Microbacterium laevaniformans (4% solution)}, T_3 NPK (@15:10:20 g m-2), T_4 Vermicompost (5 kg per plot), T_5 (½ NPK + ½ Vermicompost + Bacillus subtilis), T_6 (½ NPK + ½ Vermicompost + Microbacterium laevaniformans), T_7 (½ NPK + ½ Vermicompost + Consortium) and T_8 (Consortium). Where, as per recommendation package and practices fertilizers was applied at the time of field preparation. N, P_2O_5 and K_20 respectively which were applied NPK @15:10:20g m^{-2}. All the fertilizers were applied four days ahead of planting. Half of urea, full dose of SSP, MOP was applied at the time of basal dose. The second dose of N was applied at 30 days after planting.

Observations on soil parameters

Soil samples collected from each plot after the harvest of the crop were air dried, ground and sieved through 2mm diameter and stored in butter paper bags with proper tagging and used for various analysis.

2.1 Soil pH

Soil pH was determined before and at harvest by glass electrode method (Jackson, 1973). For the purpose, soil water suspension was prepared at the ratio of 1:2.5 and the pH of the suspension was determined with pH meters with glass electrode.

2.2 Organic carbon(OC) by Wet Digestion (%)

Organic Carbon in the soil (0.2g) was oxidized with a mixture of 1N K_2Cr_2O7 (potassium dichromate), conc. H_2SO_4 (sulphuric acid) and conc. H_3PO_4 (ortho phosphoric acid) for reduction of $K_2Cr_2O_7$ by organic compounds as per the method described by Walkley, (1934). The unused $K_2Cr_2O_7$ was back titrated with ferrous ammonium sulphate (FAS) $[(NH_4)_2\ SO_4\ FeSO_4\ 6H_2O]$ (0.5M) using diphenylamine indicator till the colour changed from violet blue to green. Blank contained no soil but all reagents treated similarly for calculation. Oxidizeable organic carbon (%) and total organic carbon (TOC %) were calculated using the following formula

$$\% \text{ Oxidizeable OC (w/w)} = \frac{(Vb\ \ Vs) \times 0.3 \times M}{Wt}$$

$$\% \text{ TOC (w/w)} = 1.334 \times \% \text{ Oxidizeable OC}$$

Where, M = Molarity of ferrus ammonium sulphate (0.5M)

Vb = Volume of FAS for blank (ml)

Vs = Volume of FAS for sample (ml)

Wt = weight of soil (g)

$0.3 = 3 \times 10^{-3} \times 100$ where 3 is equivalent weight of C.

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2.3 Soil Electrical Conductivity(dS/m)

The electrical conductivity (EC) indicates the amount of soluble (salt) ions in soil. The determination of electrical conductivity (EC) is made with a conductivity cell by measuring the electrical resistance of a 1:5 soil:water suspension. We use KCl solution as a reference solution of 0.01M concentration. This reference solution has an electrical conductivity of 1.413 ds/m at 25˚C (Rayment and Higginson, 1992). If the meter is not equipped for automatic temperature compensation, we use following formulas:

If the meter reads directly in conductivity values , then calculate EC_{25}

EC_{25} (ds/m)= S x 1.413 / K

Where, S= Measured EC of suspensuion

K= Measured EC of KCl solution

If the meter reads resistance value, then calculate EC_{25}

EC_{25} (ds/m)= K / S x 0.708

Where, S= Measured EC of suspensuion

K= Measured EC of KCl solution

2.4 Available nitrogen (kg ha^{-1})

Available N of the soil sample was estimated by modified Kjeldalh's method as described by Jackson (1973) and expressed as kg ha^{-1}.

2.5 Available phosphorous (kg ha^{-1})

Available P in soil sample was extracted by Bray's method as outlined by Jackson (1973) and expressed as available P_2O_5 (kg ha^{-1}).

2.6 Available potassium (kg ha^{-1})

Available K content of the soil sample was extracted with neutral normal ammonium acetate as outlined by Jackson (1973). The potassium content was determined with the help of Flame Photometer and expressed as available K_2O (kg ha^{-1}).

2.7 Soil microbial biomass carbon (µg g^{-1})

Microbial biomass carbon was determined by chloroform fumigation- extraction technique following the method of Vance *et al*. (1987). Moist samples (5g soil) in 50ml glass beakers were placed in a desiccator and a vial of soda lime. A beaker containing 50ml ethanol free $CHCl_3$ (chloroform) and the desiccators evacuated until the $CHCl_3$ has boiled vigorously for 2min. The desiccator was then incubated in dark at 25°C for 24h. After fumigation, $CHCl_3$ was removed by repeated evacuation, the soil were then extracted with 25ml 0.5M K_2SO_4 (5:1) for 30 min by oscillating shaking at 200 rpm and then filtered through a Whatman No. 42 filter paper. Controls were prepared by extracting soils without fumigation. Organic carbon content in the extracts was measured with dichromate (66.7mM) and 15ml of the digestion mixture (2:1 conc. H_2SO_4: H_3PO_4 (v/v)) was added. The mixture was gently refluxed for 30 min, allowed to cool and diluted with 20ml distilled water. The excess $K_2Cr_2O_7$ (Potassium dichromate) was measured by back titration with FAS (40.0mM) using 1.10-phenanthroline-ferrous sulphate complex (25mM) solution as an indicator. MBC was calculated from the differences in extractable OC between the fumigated and non fumigated soil and expressed as µg g^{-1} on dry weight basis as-

$$\text{MBC } (\mu g\ g^{-1}) = \frac{Ec}{kEC}$$

Where, Ec = [(OC extracted from fumigated soil) – (OC extracted from non fumigated soil)] and kEC = 0.38 (Vance *et al*., 1987)

Comment [GN4]: Follow uniform method of indication for all units

Comment [GN5]: Check the unit

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3. RESULT AND DISCUSSION

Influence of biofertilizers on soil parametrers:

3.1 Soil pH

Data recorded on soil pH initially was 5.1. There was a significant increase in soil pH (5.26) in treatment T_4(Table.1). Higher pH in the organic treatments might be due to the deactivation of Al^{3+} and concomitant release of basic cations due to addition of organic matter (Gogoi, 2015). However, application of different organic sources did not effect the soil pH much perhaps due to great buffering action of organic matter present in the organic manures (Rajkonwar, 2012). Similar results were reported by Prakash *et al.* (2002) and Sushma *et al*. (2007). Also, higher pH might be due to the increase in microbial activities in the root zone which decomposes organic manures and also fix unavailable form of mineral nutrient into available forms in soil thereby substantiates crop requirement and improve organic carbon level and stabilize soil pH. Similar result was also reported by Tekasangla *et al.*(2015) in cauliflower.

Comment [GN6]: Gogoi et al.,

3.2 Organic carbon(OC) by Wet Digestion (%)

The initial organic carbon was to be recorded as 0.58% which was significantly influenced by different treatments. There was a significant increase in organic carbon (0.86%) in treatment T_4(Table.1). It might be due to relatively higher carbon content in the organic manure compared to other organic and inorganic treatments. Similar findings were reported by various workers (Gupta *et al.*, 2000;Bullock, 2002;Garcia-Ruiz, 2008and Chanu, 2015). Organic carbon of soil acts as a sink and source of nutrients for microbial population, which regulates the availability of different nutrients through microbial transformation. The net increase in organic carbon was much higher with organic manures with microbial consortium. It is probably due to application of organic inputs and their releasing behaviour of different acids.

3.3 Electrical conductivity

The initial soil EC was to be recorded as 0.13 dS/m. Nutrient integrations (both with organic and inorganic sources) showed an increase in EC of soil(Table.1) and data ranged between 0.13 and 0.19 dS m^{-1}. The highest Electrical conductivity of 0.19 dS m^{-1} was recorded in T_7. More availability of soluble forms of K, Ca, Mg and Na those lead to formation of some salts due to addition of organics, which might be responsible for the higher EC of the soil (Gogoi et al,2015).

3.4 Available nitrogen (kg ha^{-1})

The initial available N in the soil was 250.7 kg ha^{-1}. The highest available nitrogenof276.94 kg ha^{-1} was recorded under treatment T_4 (Table.2).Such a build up of available N to fix atmospheric N in the rhizosphere throughout the cropping periodmight be due to the fact that pH value rises as a result of organic sources and thus lowered the oxidation-reduction process. Organic acid and microbial product of decomposition from organic sources solubilises the insoluble compounds by interacting with their specific binding cations and clay minerals. Therefore, it was seen that application of organic sources was found to be good in enhancing the nitrogen availability in soil(Workneh *et al.* (1993).Organically managed soil exhibited great of biological activity of inoculated microorganisms as well as their potential nitrogen fixation (Merelo *et al*., 2006).

3.5 Available phosphorous (kg ha^{-1})

The initial availablephosphorus content of soil was recorded as 41.1 kg ha^{-1}. The highest available soil phosphorus of 67.84 kg $ha^{-1}$was recordedunder treatment T_7(Table.2). Increase in available phosphorus might be due to the application of vermicompost and phosphate solubilising and mineralizing ability of the microorganisms from the soluble from of phosphorus sources (Tao et al., 2008). It is established that application of PSB along the rock phosphate significantly increased the available

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phosphorus status in soil which could be attributed to the production of organic acids which acts as chelating agent from stable complexes with Fe and Al which are available in acid soil and thereby release phosphorus from clutches of Fe and Al to the soil solution (Biswas 2008 andUmlong 2010).Reports are also available on the role of biofertilizers in improving the availability of nutrients (Mishra et al., 1999). Similar results of better availability of Nitrogen and Phosphorus due to biofertilizers and vermicompost were reported in crossandra Cv. Dindigul local (Narasimaharaju and Haripriya, 2001),in marigold (Mashaldi, 2000)and in carnation (Gangadharswamy,2010).

3.6 Available potassium (kg ha^{-1})

Initially 121.8 kg ha^{-1} of potassium was recorded in the soil. In case of residual potassium(Table.2), treatment T_4 showed higher potassium content of 135.11kg ha^{-1}. This might be due to release of potassium from these organic amendments and also due to solubilisation of mineral based potassium or native potassium. The positive influence of organic manure on the available potassium was earlier reported by Srikanth *et al*. (2000). Besides, it could be also due to prevention of leaching loss due to retention of more potassium by organic components while inorganic fertilizers could have released potassium at a faster rate. These results were similar to the findings by Bahadur et al.,2006; Biswas(2008)and Umlong(2010).The positive influence of organic manure on the available potassium in soil might be due to the effect of organic manures on the reduction of potassium fixation; added organic matter interacted with potassium clay to release potassium from the non-exchangeable fraction to the available pool (Reddy, 1998).

3.7 Soil microbial biomass carbon (µg g^{-1})

The initial soil microbial biomass carbon content of soil was recorded as 228.76 µg g^{-1} soil 24 hour^{-1}. Significant variation in MBC(Table.3) was observed in the present study. In treatment T_4 resulted in the highest MBC (379.23 µg g^{-1} soil 24 hour^{-1}). This might be due to the application of organic source of nutrients which improves the microbial and enzymatic activities in soil (Rajkonwar, 2012). The biological properties were higher in the soil might be due to the increase in organic carbon, total N and P content in the soil with the application of organic inputs specially biofertilizers and vermicompost, which are directly related to the biological properties of the soil.

Table.1Soil pH and organic carbon (%) and electrical conductivity(dS/m):

Initial pH : 5.1**, organic carbon:** 0.58% **and EC:**0.13 dS/m

Treatment	Soil pH			Organic carbon			EC		
	2015-2016	2016-2017	Pooled	2015-2016	2016-2017	Pooled	2015-2016	2016-2017	Pooled
T_0	5.10	5.09	**5.09**	0.55	0.57	**0.56**	0.14	0.14	**0.14**
T_1	5.13	5.11	**5.12**	0.66	0.69	**0.68**	0.16	0.16	**0.16**
T_2	5.15	5.12	**5.14**	0.67	0.68	**0.67**	0.16	0.16	**0.16**
T_3	4.80	4.49	**4.65**	0.62	0.64	**0.63**	0.14	0.16	**0.15**
T_4	5.24	5.28	**5.26**	0.82	0.89	**0.86**	0.19	0.17	**0.18**
T_5	5.19	5.22	**5.21**	0.73	0.75	**0.74**	0.18	0.18	**0.18**
T_6	5.20	5.23	**5.22**	0.74	0.78	**0.76**	0.19	0.18	**0.18**
T_7	5.21	5.23	**5.22**	0.74	0.80	**0.77**	0.19	0.19	**0.19**

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T_8	5.11	5.11	**5.11**	0.67	0.70	**0.68**	0.16	0.16	**0.16**
S.Ed (±)	**0.07**	**0.06**	**0.04**	**0.02**	**0.04**	**0.02**	0.03	0.04	**0.03**
CD (5%)	**0.16**	**0.13**	**0.09**	**0.04**	**0.08**	**0.05**	**NS**	**NS**	**NS**

Table.2 Available soil N, P and K (kg ha^{-1}):

Initial N: 250.7 kg ha^{-1}, **P_2O_5 :**41.1kg ha^{-1}**and K_2O :** 121.8 kg ha^{-1}

Treatment	Available Nitrogen			Available Phosphorus			Available Potassium		
	2015-2016	**2016-2017**	**Pooled**	**2015-2016**	**2016-2017**	**Pooled**	**2015-2016**	**2016-2017**	**Pooled**
T_0	251.48	251.76	**251.62**	41.71	42.11	**41.91**	112.63	112.63	**113.59**
T_1	259.06	262.99	**261.03**	48.30	51.37	**49.84**	118.92	118.92	**120.57**
T_2	261.18	265.33	**263.26**	51.33	56.74	**54.03**	121.67	121.67	**123.62**
T_3	264.67	266.52	**265.59**	53.36	60.15	**56.76**	124.01	124.01	**126.66**
T_4	275.67	278.22	**276.94**	59.30	65.34	**62.32**	134.30	134.30	**135.11**
T_5	267.67	270.00	**268.83**	61.00	66.15	**63.58**	127.04	127.04	**127.90**
T_6	268.99	269.11	**269.05**	63.33	68.69	**66.01**	128.69	128.69	**128.34**
T_7	270.00	273.30	**271.65**	64.04	71.64	**67.84**	131.18	131.18	**131.74**
T_8	262.78	263.03	**262.91**	57.09	59.26	**58.18**	122.80	122.80	**123.55**
S.Ed (±)	**3.48**	**4.75**	**3.59**	**3.46**	**2.46**	**1.80**	**4.26**	**3.12**	**2.96**
CD (5%)	**7.37**	**10.06**	**7.61**	**7.33**	**5.22**	**3.82**	**9.04**	**6.62**	**6.28**

Table.3 Microbial Biomass Carbon (MBC)

Initial Microbial biomass carbon : 228.76 µg g^{-1}soil 24 $hour^{-1}$

Treatment	MBC		
	2015-2016	**2016-2017**	**Pooled**
T_0	228.48	229.11	**228.80**
T_1	230.25	235.32	**232.79**
T_2	233.59	239.33	**236.46**
T_3	253.33	264.51	**258.92**
T_4	377.00	381.47	**379.23**
T_5	321.93	324.92	**323.42**
T_6	325.33	328.30	**326.82**

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T_7	328.00	331.18	**329.59**
T_8	241.74	247.75	**244.74**
S.Ed (±)	**3.34**	**4.65**	**2.97**
CD (5%)	**7.07**	**9.85**	**6.30**

4. CONCLUSION

The investigation revealed that use of organic inputs had significant influence on soil properties at harvest. Highest value of soil pH, soil organic carbon,MBC , soil available N and K were recorded for the treatment T_7(½ NPK + ½ Vermicompost + Consortium) and T_4(Vermicompost 5 kg plot^{-1}), as regards to EC and P. In recent times government has identified whole N.E. region as organic zone where most of the cultivated areas have been identified as naturally organic. So, in this experiment Biofertilizer has been identified as an alternative to chemical fertilizer in order to increase soil fertility and crop production in sustainable farming.

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