

*Full Length Research Paper*

# Effect of different vermicomposts and bioslurry on growth, yield and postharvest quality of statice

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An experiment at Egerton University in Kenya studied effects of vermicomposts and bioslurry on growth, yield and postharvest quality in statice. Three vermicomposts prepared from Kitchen waste (V1), mowed lawn grass (V2) and Weed biomass (V3) were mixed at a rate of 40% by volume with garden soil and tested against the untreated control (V0). Bioslurry from a digester at Tatton Agricultural Park in the university was applied at 7.8 tons/ha (B1) alongside untreated control (B0). The results showed significant differences at  $P \leq 0.05$  between treatments, where vermicomposts and bioslurry were separately applied compared to the controls. V1 and B1 had the most stems per plant (22.9, 26.0) and (18.7, 19.8) compared to the control (15.2, 18.1) in season 1 and 2 respectively. The number of stems per plant increased to 26.3 in season 1 and 27 in season 2 in the plots treated with both Kitchen waste vermicompost and bioslurry (V1 × B1). The flower stem lengths were higher under V1 treatment (80.9 and 95.8) cm but similar to V3 which recorded 78.9 and 92.2 cm in season 1 and 2 respectively. In season 1 and 2 respectively, bioslurry treatment (B1) recorded flower stem length of 80.0 and 92.8 cm, compared to the control (53.4 and 64.7 cm). Combined treatment V1 × B1 increased flower stem lengths to 104.1 and 121.1 cm in season 1 and 2 respectively. In season 1 and 2 respectively, V3 × B1 had the longest vase life (22.2 and 22.9 days) when compared to V1 × B1, V2 × B1, V1, V2, V3 and B1 (15.4 to 20.1 days) but all exceeded the untreated plots (11.2 and 12.2 days).

**Key words:** Statice, bioslurry, vermicompost, growth, postharvest.

## INTRODUCTION

Kenya is among the leading centers of flower production in the world (Gursan and Erkal, 1998), accounting for 6% of the world's cut flower exports. The main export destinations are European countries that include Germany (18%), the United Kingdom (17%), and the United States

of America (16%) (Hornberger et al., 2007). There is an urgent need for diversification of products and markets to sustain competitiveness of the Kenyan flower industry (Rikken, 2011). This therefore calls for deliberate inclusion of Kenyan smallholders in Floriculture. Statice (*Limonium*

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*sinuatum* Mill: Plumbaginaceae) is among the most important cut flowers grown in Kenya. Its flowers are used both as a dried item and filler in flower arrangements. Well maintained static flowers can have a vase life of more than 10 days and keep their color even after drying. The crop is easily grown under outdoor production systems which are often affordable to a large number of smallholders in Kenya. However, the floriculture export value contribution from static drastically declined from 3.6% in 2016 to 0.4% in 2018. Static stood at position 11 behind roses, cuttings, mixed flowers, carnations, gypsophilla, alstroemeria, chrysanthemum, hypericum, pelargonium and hydrangea (Horticultural Crops Directorate, 2019).

The performance, yield and quality of static flowers is however often affected by the abiotic and biotic environments such as soil fertility and insect pests among other major factors (Kumar and Chaudhary, 2018). Production of good yields and high quality static flowers requires good soil fertility management practices. Adequate nitrogen (N) supply is critical for cut flower production and deficiency will result in poor plant growth and fewer low-quality flowers, while too much may result in too much vegetative growth, weak stems and delayed flowering. Phosphorus and potassium deficiencies on the other hand may result in smaller plants with shorter flowering stems and reduced overall yield.

The Kenya's flower industry which is among the largest in world (Leipold and Morgante, 2013) is often faced with volatile costs of chemical fertilizers and pesticides among other inputs. Expensive chemical fertilizers may therefore not be an appropriate solution to correct nutrient deficiencies and poor soil properties in low resource poor smallholder production systems. There is essential to evaluate affordable and locally available organic nutrient options that can enhance static production in Kenya. There is an urgent need for innovations and adoption of good agricultural practices to support profitability and environmental sustainability as well as bring more small-scale farmers into growing of summer flowers so as to realize growth in floriculture sub-sector.

Technologies such as composting, vermicomposting and bioslurry from biogas digesters provide plant nutrient sources alternative to chemical fertilizers with the additional benefit of organic waste management (Munnoli et al., 2010; YSDPL, 2006). Vermicomposts increase bioavailability of phosphorus in the soil, while enhancing soil nitrogen mineralization (Ansari, 2008). Bioslurry from biogas digesters on the other hand has an average plant nutrient content of about 0.75% nitrogen, 0.65% phosphorus and 1.05% potassium (Demont et al., 1991). These two organic fertilizers can therefore have a great potential to reduce fertilizer budgets among small-holder floriculture, while contributing to organic waste management and environmental sustainability. The main objective of this study was to establish the applicability, efficacy and benefits of different vermicomposts and

bioslurry combinations in the production of static.

## MATERIALS AND METHODS

### Experimental site

The study was carried out at Horticulture Research and Teaching Field, Egerton University-Njoro campus in Kenya. The site lies at a latitude of 0° 23' South and longitude of 35° 35' East in the Lower Highland III Agroecological Zone with an altitude of approximately 2,238 m above mean sea level. The temperature range of the area is 14.9-21.9°C with mean annual rainfall range of 850 to 1100 mm (Jaetzold and Schmidt, 1983). The soils are predominantly vitric mollic andosols (Kinyanjui, 1979).

### Soil media preparation

The garden soil used in potting media for this experiment was obtained from Egerton University's Horticulture Teaching and Research Farm, Field Three.

### Vermicompost preparation

The different vermicomposting substrates were collected within the campus. Food waste was collected from the various on campus kitchens at Egerton University including the student messes and the Agriculture Resource Centre Hotel. Bones and egg shells were removed. Mowed lawn grasses were gathered from the various on-campus lawns where machine mowing had taken place. The garden weed biomass was gathered from Egerton University's Horticulture Teaching and Research Farm in Njoro, Kenya. The various materials were put into their respective vermicomposting bins already stocked with the red wiggler earthworms (*Eisenia fetida*). Watering was done at three-day intervals to keep the substrate moderately moist and avoiding waterlogging. The worms fed on the substrates and their excrement known as worm casts was eventually harvested as vermicompost. Each of the different vermicompost was harvested from the respective bins after 30 days when all the substrate compost had been converted to worm casts.

### Bioslurry preparation

The bioslurry used in the experiment was obtained from the biogas digester at Egerton University's Tatton Agricultural Park in Njoro, Kenya.

### Plant materials

Seedlings of white static were obtained from Limuru Farm late in the evening to minimize withering. The nursery bed was thoroughly wetted and uniform size plants were lifted and placed in polythene bags containing moist soil. The seedlings were established by transplanting singly into uniform plastic potting bags measuring 30 cm diameter and 40 cm depth, filled to three quarters of depth, with appropriate potting media as per the randomly assigned treatments. The seedlings were transplanted at sufficient depth to cover all roots. All the experimental units received uniform cultural practices as described by HCDA and MOA (2003). The different vermicomposts were applied to assigned plots at a rate of 40% by volume (being a reduction of 100% under which Ali et al. (2007) reported poor performance in lettuce). Bioslurry (B<sub>1</sub>) was applied to the assigned plots as a drench at a rate of 7.8 t/ha (Jeptoo et al.,

2012) in 4 equal splits and at 15 days' interval from 35 DAT. The root media was kept moist by watering according to need during plant growth. Pest and disease scouting were done to inform decisions on control.

### Soil, vermicomposts and bioslurry analyses

Samples of the garden soil, the different vermicomposts and bioslurry used in growing media in the present study were analyzed at Kenya Agriculture and Livestock Research Organization's soil chemistry laboratories at Njoro, in Kenya, to establish their characteristics.

### Determination of pH

The pH was measured using pH-meter (digital ion analyzer). Air dried samples weighing 50 g for each of the different growing medium components were taken into separate 100-ml glass beakers. Into each beaker, 50 ml distilled water was added using a graduated cylinder and mixed thoroughly before being allowed to stand for 30 min. The resulting suspensions were stirred after every 10 min. The pH of the different suspensions was determined according to the procedure described by Okalebo et al. (2002).

### Determination of water holding capacity

The water holding capacity of the garden soil and the different vermicomposts was determined according to the procedure described by Okalebo et al. (2002).

### Determination of total organic carbon

For each of the growing medium components, one gram of air-dried growing medium was placed into separate 500-ml beakers. Ten milliliters of 1 N potassium dichromate solution and 20 ml concentrated sulphuric acid was added in each beaker and swirled to mix the suspension. 20 ml of distilled water was added along with 10 ml concentrated orthophosphoric acid into each beaker after 30 min and the mixtures were then allowed to cool. Ten drops of diphenylamine indicator were added. Each of the solutions was then titrated with 0.50 M ferrous ammonium sulphate solution and the reading was recorded upon colour change from violet blue to green. Organic carbon was determined by method of Walkley and Black (1934).

### Determination of nitrogen content (Kjeldahl method)

Nitrogen content was determined using Kjeldahl method (1883) as follows. A sample weighing 0.3 g was digested in a digestion tube using a digestion mixture comprising of HCl, HNO<sub>3</sub>, Se and CuSO<sub>4</sub>. The heating block temperature was maintained at 360°C for 2 h after which the sample were allowed to cool before transfer into a 50 ml volumetric flask and the volume made to the mark. It was then allowed to settle and 5 ml of the aliquot was put into the distillation bottle where 10ml of 40% NaOH was added. It was then steam distilled into 5ml 1% Boric acid containing 4 drops of mixed indicator for 2 min, from the time the indicator turned green. The distillate was titrated using HCl with the end point being reached when the indicator turned green through grey to definite pink. A blank experiment was prepared using the same procedure described by Kirk (1950).

### Determination of nitrate -N by calorimetric method

The nitrate content was determined by calorimetric method as described in Okalebo et al. (2020). A set of six clean well labeled 100 ml volumetric flasks was set up into which 0, 2.0, 4.0, 6.0, 8.0 and 10.0 ml of the standard solution (50 µg ml<sup>-1</sup>) were separately transferred. These were the working standards and contained 0, 2, 4, 6, 8, and 10 µg NO<sub>3</sub>-N ml<sup>-1</sup>. Each volumetric flask was filled to the 100 ml mark with 0.5 M potassium sulphate. 0.5 ml of the sample extract, blanks and the standard series K<sub>2</sub>SO<sub>4</sub> soil were transferred each into suitably marked test tube. 1.0 ml of salicylic acid was added to each test tube and mixed well and left to stand for 30 min. 10 ml 4M sodium hydroxide was added to each test tube, mixed well and left for 1 hour to allow development of full yellow colour. The colour was stable for the day. The absorbency was measured at wavelength 419 nm. A calibration curve was plotted and the absorbency calculated for each particular standard in the series, read off the value of the samples and the blanks. The concentration of nitrate N was calculated using the following formula.

$$\text{NO}_3 \text{ N } (\mu\text{g kg}^{-1}) = \frac{(a-b) \times v \times \text{MCF} \times 1000}{w}$$

where a = concentration of NO<sub>3</sub><sup>+</sup>-N in the solution, b = concentration of NO<sub>3</sub><sup>+</sup>-N the blank, v = volume of the extract; w = weight of the fresh soil; MCF = moisture correction factor.

The aliquot taken for both the standards and the unknown are the same therefore no multiplication factor is required within the calculations.

### Determination of total phosphorous

Total phosphorus in the substrate samples was determined by the method described by Juma et al. (2018). A sample of 0.3g for each of the growing medium components was separately digested in digestion tubes using a digestion mixture comprising of HCl, HNO<sub>3</sub>, Se and CuSO<sub>4</sub>. Temperatures in the heating block were kept at 360°C for 2 h and then left to cool before transfer into separate 50-ml volumetric flasks and volume made to the mark. Five ml of each of the aliquots was transferred into the sample bottles with 1 ml of developing colour solution (ammonium vanadate and ammonium molybdate in the ratio of 1:1). The samples were stood for 30 min after and then transferred to cuvettes. Readings of atomic absorbance were taken using a spectrophotometer at λ<sub>max</sub>= 430 nm. Calibration curve was done using laboratory certified standards containing 0, 0.2, 0.4, 0.6, 0.8 1.0 and 1.2 ppm P respectively

### Determination of potassium content

A sample weighing 0.3 g for each of the growing medium components was separately digested in digestion tubes using a mixture comprising HCl, HNO<sub>3</sub>, HF and H<sub>3</sub>BO<sub>3</sub>. The temperatures in the block was maintained at 360°C for 2 h, thereafter samples were cooled, transferred to 50-ml volumetric flasks and volume made to the mark. Calibration was done for potassium using certified standards. Samples were analyzed by atomic absorption spectrophotometer (AAS), Varian spectra AA10 AAS machine. The characteristics of the various growing medium components used in the present study are as presented below.

### Soil characteristics

The characteristics of the soil sample taken from the site for

**Table 1.** Characteristics of garden soil from experimental site.

Parameter	
Final pH	5.84
Water holding capacity	65.3%
Total organic carbon	1.72%
Total N	0.25%
Available P	0.18%
Exchangeable K (mg kg <sup>-1</sup> )	1.1

**Table 2.** Characteristics of the different vermicompost.

Parameter	Kitchen waste vermicompost (V <sub>1</sub> )		Mowed lawn grass vermicompost (V <sub>2</sub> )		Weed biomass vermicompost (V <sub>3</sub> )	
	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2
Final pH	6.9	7.2	6.8	6.9	7.2	7.4
Water holding capacity (%)	79.2	78.8	78.1	77.8	78.6	78.2
Total organic carbon (%)	13.1	13.3	15.7	16.5	12.8	13.2
Nitrate (mg/kg)	28.24	27.98	21.62	20.14	25.44	23.8
Phosphate (mg/kg)	33.42	33.28	39.42	39.14	26.42	25.74
Total potassium (mg/kg)	19.6	20.1	20.2	19.2	22.6	22.8

**Table 3.** Characteristics of the bioslurry.

Parameter	Season 1	Season 2
pH	7.86	7.94
Nitrogen (%)	0.25	0.18
Phosphorus (mg kg <sup>-1</sup> )	4.57	5.96
Potassium (mg kg <sup>-1</sup> )	78.50	72.43
Calcium (mg kg <sup>-1</sup> )	3.97	3.78
Magnesium (mg kg <sup>-1</sup> )	19.84	19.79
Density (g cm <sup>-3</sup> )	1.04	1.02

analysis were established as given in Table 1.

#### Characteristics of the different vermicomposts

The characteristics of the different vermicomposts after analysis of respective samples were established as given in Table 2.

#### Bioslurry characteristics

The characteristics of the bioslurry established after analysis of sample were as given in Table 3.

#### Experimental design and treatment application

Two different trials were conducted to determine the effects of treatment with different vermicomposts and bioslurry on growth and yield of static. The first trial was established in February 2013 and harvested in June 2013 and the second was planted in June 2013

and harvested in November 2013. The experiment was a 2 × 4 factorial in a randomized complete block design (RCBD) with four replications. The treatments applied included 100% garden soil (V<sub>0</sub>) as the control, 60% garden soil with 40% kitchen waste vermicompost (V<sub>1</sub>), 60% garden soil with 40% mowed lawn grass vermicompost and 60% garden soil with 40% garden weed biomass vermicompost (V<sub>3</sub>) with. The different vermicomposts were applied at 40% of the rate used by Ali et al. (2007) who reported poor growth performance in lettuce under 100% vermicompost. Bioslurry (B<sub>1</sub>) was applied at 7.8 t/ha (Jeptoo et al., 2012) as a drench in 4 equal splits untreated control (B<sub>0</sub>). The eight treatments applied in the experiment were V<sub>1</sub>, V<sub>2</sub>, V<sub>3</sub>, B<sub>1</sub>, (V<sub>1</sub> × B<sub>1</sub>), (V<sub>2</sub> × B<sub>1</sub>) and (V<sub>3</sub> × B<sub>1</sub>) with the control plot being the untreated (B<sub>0</sub> or V<sub>0</sub> or B<sub>0</sub> × V<sub>0</sub>).

#### Data collection

The seedling takeoff was observed by a stand count at 14 DAT and at 21 DAT and expressed as a percentage for each treatment. Gapping was done to replace any seedlings that did not survive initial transplanting. The number of days from the date of

**Table 4.** Effect of vermicompost on seedling take off, number of stems, days to flowering, and stem length.

Vermicompost type	Seedling take off (no./plot)		Stem number (no./plant)		Days to flowering		Flower stem length at 60 DAT (cm)	
	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2
V <sub>0</sub>	0.8 <sup>a</sup>	0.9 <sup>a</sup>	15.2 <sup>c</sup>	18.1 <sup>b</sup>	25.3 <sup>bc</sup>	24.2 <sup>c</sup>	53.4 <sup>c</sup>	64.7 <sup>c</sup>
V <sub>1</sub>	1.0 <sup>a</sup>	1.0 <sup>a</sup>	22.9 <sup>a</sup>	26.0 <sup>a</sup>	26.5 <sup>ab</sup>	25.9 <sup>bc</sup>	80.9 <sup>a</sup>	95.8 <sup>a</sup>
V <sub>2</sub>	1.0 <sup>a</sup>	1.0 <sup>a</sup>	16.5 <sup>c</sup>	18.0 <sup>bc</sup>	26.9 <sup>ab</sup>	26.6 <sup>ab</sup>	71.3 <sup>b</sup>	82.7 <sup>b</sup>
V <sub>3</sub>	1.0 <sup>a</sup>	1.0 <sup>a</sup>	17.0 <sup>bc</sup>	18.5 <sup>b</sup>	29.5 <sup>a</sup>	29.3 <sup>a</sup>	78.9 <sup>a</sup>	92.2 <sup>a</sup>

Means followed by the same letter within a parameter and a main effect are not significantly different according to Tukey's test at  $p \leq 0.05$ . Key: V<sub>0</sub> – Soil with no vermicompost, V<sub>1</sub>– Soil with 40% kitchen waste vermicompost, V<sub>2</sub>– Soil with 40% mowed lawn grass vermicompost, V<sub>3</sub>– Soil with 40% Garden weed biomass vermicompost.

**Table 5.** Effect of bioslurry on the number of stems, days to flowering, and stem length.

Bioslurry type	Stem number (no./plant)		Days to flowering (days)		Flower stem length at 60 DAT (cm)	
	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2
B <sub>0</sub>	15.2 <sup>b</sup>	18.1 <sup>b</sup>	25.3 <sup>b</sup>	24.2 <sup>b</sup>	53.4 <sup>b</sup>	64.7 <sup>b</sup>
B <sub>1</sub>	18.7 <sup>a</sup>	19.8 <sup>a</sup>	27.8 <sup>a</sup>	27.1 <sup>ab</sup>	80.0 <sup>a</sup>	92.8 <sup>a</sup>

Means followed by the same letter within a parameter and a main effect are not significantly different according to Tukey's test at  $p \leq 0.05$ . Key: B<sub>0</sub>- Soil with no bioslurry, B<sub>1</sub>- Soil with bioslurry at a rate of 7.8 t/ha.

transplanting to the 50% flower opening of the earliest flower stem for each treatment was recorded and used to calculate the average duration to flowering. The number of suckers produced by each plant was counted and the average for each treatment was calculated and recorded as a measure of growth and yield potential. The number of harvested flower stems of at least 30 cm length, from apex to point of cut, per plant by the end of data collection (10 weeks after first flowering) was recorded for each growing bag and used to calculate average yield for each treatment. The stem lengths of all the flower stems harvested from each growing bag, measured from the apex to the point of cut was recorded and used to calculate the mean response to the different treatment applications. The data obtained was subjected to analysis of variance (ANOVA) and significant means were separated by Tukey's test at 5% level of significance. Data analysis was done using JMP (ver. 10) by SAS Institute.

## RESULTS

### Effect of vermicompost and bioslurry on seedling take off, number of stems, days to flowering, and stem length

The results obtained show that the different vermicomposts had a significant effect on the number of stems, days to flowering, and stem length except seedling takeoff at  $p \leq 0.05$  (Table 4). Plots treated with 40% kitchen waste vermicompost (V<sub>1</sub>) resulted in a significantly higher number of flower stems (22.9 and 26.0) compared with the control (V<sub>0</sub>) which recorded 11.3 and 13.3 in season one and two respectively. This was followed by the plots treated with 40% garden weed biomass vermicompost (V<sub>3</sub>) with 17.0 in season 1 and

18.5 in season 2 and 40% mowed lawn grass vermicompost (V<sub>2</sub>) with 16.5 and 18.0 stems but was not significantly different from the control (15.2) in season one. Similarly, bioslurry treatment had significant effect on the number of stems produced per plant (Table 5). Application of bioslurry at 7.8 t/ha (B<sub>1</sub>) resulted in significantly higher number of stems (18.7 and 19.8) in seasons one and two respectively when compared with the control treatment (.15.2 and 18.1).

Application of the different vermicomposts significantly affected the days to flowering in static (Table 5). Vermicompost delayed flowering, ranging from 25.9 to 29.5 days across the treatments in both seasons compared to the controls (23.3 and 20.9) days in season one and two respectively. Similarly, application of (B<sub>1</sub>) bioslurry increased the number of days to flowering when compared to control (Table 5). Application of bioslurry resulted in significantly more days to flowering (27.8 and 27.1) days compared to the control plots (B<sub>0</sub>) with 25.3 days and 24.2 days in season one and two respectively, representing a delay of flowering by 2.5 to 2.9 days.

Flower stem length at 60 DAT was significantly affected by the application of vermicompost (Table 4). In both seasons, use of 40% kitchen waste vermicompost and 40% Garden weed biomass vermicompost resulted in significantly longer stems (ranging from 71.3 to 95.8 cm) compared to the control (35.8 and 44.3) cm in season one and two respectively. Similarly, application of bioslurry at 7.8 t/ha resulted in longer stems (80 and 92.8) cm in season one and two compared to the control (53.4 and 64.7) cm in season one and season two respectively.

**Table 6.** Effect of vermicompost and bioslurry on number of stems, days to first flowering and flower stem length at 60 DAT.

Treatment	Stem number		Days to first flowering		Flower stem length (cm)	
	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2
Untreated	15.2 <sup>c</sup>	18.1 <sup>c</sup>	25.3 <sup>c</sup>	24.2 <sup>c</sup>	53.4 <sup>d</sup>	64.7 <sup>d</sup>
V <sub>1</sub> × B <sub>1</sub>	26.3 <sup>a</sup>	27.5 <sup>a</sup>	28.3 <sup>bc</sup>	27.5 <sup>bc</sup>	104.1 <sup>a</sup>	121.1 <sup>a</sup>
V <sub>2</sub> × B <sub>1</sub>	18.8 <sup>b</sup>	19.0 <sup>b</sup>	28.5 <sup>bc</sup>	26.5 <sup>bc</sup>	83.4 <sup>c</sup>	94.3 <sup>c</sup>
V <sub>3</sub> × B <sub>1</sub>	18.8 <sup>b</sup>	19.0 <sup>b</sup>	31.3 <sup>ab</sup>	33.8 <sup>a</sup>	93.6 <sup>b</sup>	107.2 <sup>b</sup>

Means followed by the same letter within an evaluation period are not significantly different according to Tukey's test at  $p \leq 0.05$ . Key: Untreated – Soil with no vermicompost, V<sub>1</sub> × B<sub>1</sub> – Soil with 40% kitchen waste vermicompost and bioslurry at a rate of 7.8 t/ha, V<sub>2</sub> × B<sub>1</sub> – Soil with 40% mowed lawn grass vermicompost and bioslurry at a rate of 7.8 t/ha, V<sub>3</sub> × B<sub>1</sub> – Soil with 40% weed biomass vermicompost and bioslurry at a rate of 7.8 t/ha.

### Combined effect of vermicompost and bioslurry on number of stems, days to first flowering and flower stem length at 60 DAT

The applications of the different vermicompost types at a rate of 40% by volume in combination with bioslurry at a rate of 7.8 ton/ha on static significantly affected the number of stems produced per plant, the days to flowering and stem length at 60 DAT when compared to the untreated plots (Table 6). Respectively in season one and two, application of treatments combining any of the different vermicomposts with bioslurry (V<sub>1</sub> × B<sub>1</sub>, V<sub>2</sub> × B<sub>1</sub> and V<sub>3</sub> × B<sub>1</sub>) on static resulted in significant increase on the number of stems produced per plant (18.8 to 26.3 stems, and 19.0 to 27.5 stems) when compare with the control (15.2 and 18.1 stems). These responses were also significantly greater than the main effects of the different vermicomposts (16.5 to 22.9 stems in season one and 18.0 to 26.0 stems in season two) as well as from bioslurry 18.7 and 19.8 stems respectively in season one and two). The combination of kitchen waste vermicompost and bioslurry (V<sub>1</sub> × B<sub>1</sub>) produced significantly the greatest response (26.3 and 27.5 stems respectively in season one and two) compared to V<sub>2</sub> × B<sub>1</sub> and V<sub>3</sub> × B<sub>1</sub> (18.8 and 19.0 stems respectively in season one and two) and the untreated plots (15.2 and 18.1 stems respectively in season one and two).

The different vermicomposts and bioslurry had significant combined effect on the days to flowering in static (Table 6). The application of treatments combining any of the different vermicomposts with bioslurry (V<sub>1</sub> × B<sub>1</sub>, V<sub>2</sub> × B<sub>1</sub> and V<sub>3</sub> × B<sub>1</sub>) also significantly increased the days to flowering in static (28.3 to 31.3 days in season one and 26.5 to 33.8 days in season two) when compared with the control (25.3 and 24.2 days respectively in season one and two). These responses from combined treatments (28.3 to 31.3 days in season one and 26.5 to 33.8 days in season two) all significantly exceeded the main effect of the different individual vermicompost treatments (25.9 to 26.9 days, and 26.6 to 29.5 days respectively in season one and two) as well as bioslurry treatment (27.8 and 27.1 days respectively in season one and two). The greatest significant increase in days to

flowering resulted from the treatment combination of weed biomass vermicompost and bioslurry (V<sub>3</sub> × B<sub>1</sub>) which registered 31.3 to 33.8 days respectively in season one and two when compared with V<sub>1</sub> × B<sub>1</sub> and V<sub>2</sub> × B<sub>1</sub>, which registered 26.5 days to 28.5 during both seasons.

The applications of different vermicomposts when combined with bioslurry had significant combined effects on stem length of static at 60 DAT (Table 6). The three treatments combining the different vermicomposts with bioslurry (V<sub>1</sub> × B<sub>1</sub>, V<sub>2</sub> × B<sub>1</sub> and V<sub>3</sub> × B<sub>1</sub>) resulted in significantly increased stem lengths in static at 60 DAT (83.4 to 104.1 cm in season one and 94.3 to 121.1 cm in season two) when compared with the control (53.4 and 64.7 cm respectively in season one and two). These stem length responses from the combined treatments were significantly greater than for the main effect of the different individual vermicompost treatments (73.1 to 80.9 cm during season one and 82.7 to 95.8 cm during season two) as well as bioslurry treatment (80.0 and 92.8 cm respectively in season one and two). The greatest significant increase in stem length in static was observed under V<sub>1</sub> × B<sub>1</sub> (104.1 and 121.1 cm respectively in season one and two) when compared with both V<sub>2</sub> × B<sub>1</sub> and V<sub>3</sub> × B<sub>1</sub> (83.4 to 93.6 cm during season one and 94.3 to 107.2 cm during season two) as well as the control.

### Effect of vermicompost and bioslurry on fresh weight of flower stems

The fresh weight of static flower stems was significantly affected by the use of the different vermicomposts in the growth substrate (Table 7). Application of soil with 40% kitchen waste vermicompost resulted in the highest fresh weight (24.3 and 28.9) in season one and two respectively compared to the control. This was however not significant different with treatments with 40% mowed lawn grass vermicompost 23.6<sup>a</sup> and 40% garden weed biomass 23.4 in season one and 23.8 and 24.5 in season two.

The application of bioslurry at a rate of 7.8 t/ha (B<sub>1</sub>) significantly affected the fresh weight of flower stems in static (Table 8). The results of fresh weight of flower

**Table 7.** Effects of vermicompost on fresh weight of flower stems in statice.

Vermicompost type	Flower stem fresh weight (g)	
	Season 1	Season 2
V <sub>0</sub>	12.9 <sup>b</sup>	16.8 <sup>c</sup>
V <sub>1</sub>	24.3 <sup>a</sup>	28.9 <sup>a</sup>
V <sub>2</sub>	23.6 <sup>a</sup>	23.8 <sup>b</sup>
V <sub>3</sub>	23.4 <sup>a</sup>	24.5 <sup>b</sup>

Means followed by the same letter within an evaluation period are not significantly different according to Tukey's test at  $p \leq 0.05$ . Key: V<sub>0</sub> – Soil with no vermicompost, V<sub>1</sub>- Soil with 40% kitchen waste vermicompost, V<sub>2</sub>- Soil with 40% mowed lawn grass vermicompost, V<sub>3</sub>- Soil with 40% Garden weed biomass vermicompost.

**Table 8.** Effects of bioslurry on fresh weight of flower stems in statice.

Bioslurry type	Flower stem fresh Weight (g)	
	Season 1	Season 2
B <sub>0</sub>	12.9 <sup>b</sup>	16.8 <sup>b</sup>
B <sub>1</sub>	23.7 <sup>a</sup>	27.5 <sup>a</sup>

Means followed by the same letter within an evaluation period are not significantly different according to Tukey's test at  $p \leq 0.05$ . Key: B<sub>0</sub>- Soil with no bioslurry, B<sub>1</sub>- Soil with bioslurry at a rate of 7.8 t/ha.

**Table 9.** Combined effect of vermicompost and bioslurry on fresh weight of statice stems.

Treatment	Flower stem fresh weight (g)	
	Season 1	Season 2
Untreated (V <sub>0</sub> × B <sub>0</sub> )	12.9 <sup>d</sup>	16.8 <sup>d</sup>
V <sub>1</sub> × B <sub>1</sub>	27.2 <sup>ab</sup>	36.0 <sup>a</sup>
V <sub>2</sub> × B <sub>1</sub>	23.3 <sup>bc</sup>	28.3 <sup>b</sup>
V <sub>3</sub> × B <sub>1</sub>	23.0 <sup>c</sup>	27.9 <sup>bc</sup>

Means followed by the same letter within an evaluation period are not significantly different according to Tukey's test at  $p \leq 0.05$ . Key: Untreated –Soil with no vermicompost, V<sub>1</sub> × B<sub>1</sub>- Soil with 40% kitchen waste vermicompost and bioslurry at a rate of 7.8 t/ha, V<sub>2</sub> × B<sub>1</sub>- Soil with 40% mowed lawn grass vermicompost and bioslurry at a rate of 7.8 t/ha, V<sub>3</sub> × B<sub>1</sub>- Soil with 40% weed biomass vermicompost and bioslurry at a rate of 7.8 t/ha.

stems obtained from plots treated to bioslurry application (23.7 and 27.5) were significantly higher than observations from the control (12.9 and 16.8) g in season one and two, there was no differences between the observed effects of B<sub>1</sub> (23.7 g) and those of the different vermicomposts V<sub>1</sub>, V<sub>2</sub> and V<sub>3</sub> (23.4 to 24.3) g. However, in season two, the highest significant fresh weight of flower stems was observed under B<sub>1</sub> (27.5 g) and V<sub>1</sub> (28.9 g).

#### Combined effect of vermicompost and bioslurry on fresh weight of flower stems in statice

There was interaction on fresh weight between vermicompost and bioslurry (Table 9). The highest fresh weight (27.2g and 36.0 g respectively in season one and two) was observed from the combined treatment of 40%

kitchen waste vermicompost and 7.8 t/ha bioslurry (V<sub>1</sub> × B<sub>1</sub>) while the lowest fresh weight (12.9g and 16.8 g respectively in season one and two) was obtained from the untreated control plots (V<sub>0</sub> × B<sub>0</sub>). The combined effect on fresh weight of stems obtained from V<sub>1</sub> × B<sub>1</sub> was also significantly greater than the 23.4 to 24.3 g in season one and 23.8 to 28.9 g in season two, obtained from individual vermicompost treatments (V<sub>1</sub>, V<sub>2</sub> and V<sub>3</sub>) as well as 23.7 and 27.5 g respectively in season one and two from bioslurry treatment (B<sub>0</sub>).

#### Water uptake

Application of 40% by volume of the different vermicomposts significantly affected water uptake of statice in the vase when compared to the control treatment throughout the observation period (Table 10).

**Table 10.** Effect of vermicompost on water uptake of statice during days in the vase (DIV).

Vermicompost type	Water uptake during vase life (ml)									
	Day 3		Day 6		Day 9		Day 12		Day 15	
	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2
V <sub>0</sub>	46.5 <sup>c</sup>	49.7 <sup>c</sup>	35.8 <sup>b</sup>	38.8 <sup>b</sup>	28.3 <sup>c</sup>	32.8 <sup>c</sup>	25.2 <sup>d</sup>	25.0 <sup>d</sup>	22.5 <sup>d</sup>	22.2 <sup>d</sup>
V <sub>1</sub>	54.8 <sup>abc</sup>	61.2 <sup>a</sup>	55.2 <sup>a</sup>	54.8 <sup>a</sup>	46.3 <sup>b</sup>	47.7 <sup>b</sup>	40.0 <sup>c</sup>	42.5 <sup>bc</sup>	32.5 <sup>c</sup>	36.8 <sup>b</sup>
V <sub>2</sub>	58.3 <sup>ab</sup>	59.5 <sup>a</sup>	54.7 <sup>a</sup>	53.7 <sup>a</sup>	49.5 <sup>ab</sup>	49.8 <sup>ab</sup>	42.8 <sup>bc</sup>	42.5 <sup>bc</sup>	37.2 <sup>b</sup>	36.7 <sup>bc</sup>
V <sub>3</sub>	53.5 <sup>abc</sup>	58.2 <sup>ab</sup>	57.8 <sup>a</sup>	60.3 <sup>a</sup>	52.7 <sup>ab</sup>	56.8 <sup>a</sup>	46.8 <sup>ab</sup>	50.5 <sup>a</sup>	39.0 <sup>ab</sup>	43.0 <sup>a</sup>

Means followed by the same letter are not significantly different according to Tukey's test at  $p \leq 0.05$ . **Key:** V<sub>0</sub> – Soil with no vermicompost, V<sub>1</sub>- Soil with 40% kitchen waste vermicompost, V<sub>2</sub>- Soil with 40% mowed lawn grass vermicompost, V<sub>3</sub>- Soil with 40% weed biomass vermicompost.

**Table 11.** Effect of bioslurry on statice flower water uptake during days in the vase (DIV).

Treatment	Water uptake during DIV (ml)									
	Day 3		Day 6		Day 9		Day 12		Day 15	
	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2
B <sub>0</sub>	46.5 <sup>b</sup>	49.7 <sup>b</sup>	35.8 <sup>b</sup>	38.8 <sup>b</sup>	28.3 <sup>b</sup>	32.8 <sup>b</sup>	25.2 <sup>b</sup>	25.0 <sup>b</sup>	22.5 <sup>b</sup>	22.2 <sup>b</sup>
B <sub>1</sub>	50.4 <sup>a</sup>	55.2 <sup>ab</sup>	56.9 <sup>a</sup>	59.2 <sup>a</sup>	49.9 <sup>a</sup>	54.6 <sup>a</sup>	44.4 <sup>a</sup>	48.1 <sup>a</sup>	38.2 <sup>a</sup>	42.8 <sup>a</sup>

Means followed by the same letter are not significantly different according to Tukey's test at  $p \leq 0.05$ . **Key:** B<sub>0</sub>- Soil with no bioslurry, B<sub>1</sub>- Soil with bioslurry at a rate of 7.8 t/ha.

Treatments with vermicomposts, across the treatments, resulted in significantly higher water uptake (ranging from 53.5 to 58.2 ml at three days in the vase and 57.8 to 60.3 ml at six days in the vase during both seasons) when compared to the control (46.5 and 49.7 ml at three days in the vase and 35.8 ml and 38.8 ml at six days in the vase respectively in season one and two). However, there was no significant difference between the water uptakes of statice as a result of the different vermicompost treatments upto six days in the vase. On the ninth day in the vase, V<sub>2</sub> and V<sub>3</sub> resulted in the highest water uptake (ranging from 49.5 to 56.8 ml during both seasons). The water uptake observed under V<sub>1</sub> at nine days in the vase though significantly lower than results from V<sub>3</sub>, it was statistically similar to the results obtained from V<sub>2</sub>. At 12 days and 15 days in the vase, V<sub>3</sub> resulted in observations with significantly higher water uptake when compared to both V<sub>1</sub> and V<sub>2</sub>. At six days in the vase during both season one and two, a drastic reduction in water uptake was observed for the control treatment (V<sub>0</sub>) which was followed by a gradual reduction until the end of the observation period.

Bioslurry application also significantly affected water uptake of statice during vase life (Table 11). Bioslurry applied at 7.8 ton/ha (B<sub>1</sub>) resulted in significantly enhanced water uptake of statice in the vase consistently throughout the observation period when compared to the control treatment (B<sub>0</sub>). At three days in the vase (DIV), water uptake under B<sub>1</sub> (50.4 and 55.2 ml respectively in season one and two) was significantly higher than B<sub>0</sub> (46.5 and 49.7 ml respectively in season one and two).

Similarly, at six DIV, B<sub>1</sub> resulted in significantly higher water uptake (56.9 and 59.2 ml respectively in season one and two) was significantly more than B<sub>0</sub> (35.8 and 38.8 ml respectively in season one and two). The significantly superior water uptake was sustained in respective seasons throughout the observation period with results from B<sub>1</sub> at nine DIV (49.9 and 54.6 ml) higher than B<sub>0</sub> (28.3 and 32.8 ml), B<sub>1</sub> at 12 DIV (44.4 and 48.1 ml) higher than B<sub>0</sub> (25.2 and 25.0 ml) and B<sub>1</sub> at 15 DIV (38.2 and 42.8 ml) higher than B<sub>0</sub> (22.5 and 22.2 ml).

#### **Combined effect of vermicompost and bioslurry on statice water uptake during days in vase (DIV)**

The applications of different vermicomposts at a rate of 40% by volume in combination with bioslurry at a rate of 7.8 ton/ha significantly enhanced statice water uptake during vase life of statice in season one and two when compared with the control (Table 12). Respectively during season one and two, significantly higher water uptake results were obtained from combined treatments of the different vermicomposts with bioslurry (V<sub>1</sub>×B<sub>1</sub>, V<sub>2</sub>×B<sub>1</sub> and V<sub>3</sub>×B<sub>1</sub>) at three DIV (44.0 to 66.3 ml, and 43.7 to 75.3 ml) when compared with the control 46.5 and 49.7 ml); at six DIV (58.7 to 70.0 ml, and 56.3 to 73.0 ml) when compared with the control 35.8 and 38.8 ml); at nine DIV (51.7 to 62.7 ml, and 53.0 to 70.7 ml) when compared with the control (28.3 and 32.8 ml); at 12 DIV (46.3 to 57.3 ml, and 50.3 to 62.7 ml) when compared with the control (25.2 and 25.0 ml); and at 15 DIV (38.7 to 47.3 ml, and



**Table 12.** Combined effect of vermicompost and bioslurry on static water uptake during days in vase.

Treatment	Water uptake during DIV (ml)									
	Day 3		Day 6		Day 9		Day 12		Day 15	
	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2
Untreated	46.5 <sup>cd</sup>	49.7 <sup>cd</sup>	35.8 <sup>d</sup>	38.8 <sup>d</sup>	28.3 <sup>d</sup>	32.8 <sup>d</sup>	25.2 <sup>d</sup>	25.0 <sup>d</sup>	22.5 <sup>d</sup>	22.2 <sup>d</sup>
V <sub>1</sub> ×B <sub>1</sub>	56.0 <sup>bc</sup>	64.7 <sup>ab</sup>	61.7 <sup>bc</sup>	65.3 <sup>ab</sup>	51.7 <sup>bc</sup>	59.7 <sup>b</sup>	46.3 <sup>c</sup>	53.7 <sup>bc</sup>	38.7 <sup>c</sup>	48.7 <sup>ab</sup>
V <sub>2</sub> ×B <sub>1</sub>	44.0 <sup>d</sup>	43.7 <sup>d</sup>	58.7 <sup>bc</sup>	56.3 <sup>bc</sup>	54.0 <sup>b</sup>	53.0 <sup>bc</sup>	50.7 <sup>bc</sup>	50.3 <sup>c</sup>	44.7 <sup>ab</sup>	44.7 <sup>c</sup>
V <sub>3</sub> ×B <sub>1</sub>	66.3 <sup>a</sup>	75.3 <sup>a</sup>	70.0 <sup>ab</sup>	73.0 <sup>a</sup>	62.7 <sup>ab</sup>	70.7 <sup>a</sup>	57.3 <sup>ab</sup>	62.7 <sup>a</sup>	47.3 <sup>a</sup>	54.3 <sup>a</sup>

Means followed by the same letter within an evaluation period are not significantly different according to Tukey's test at  $p \leq 0.05$ . Key: Untreated – Soil with no vermicompost, V<sub>1</sub> × B<sub>1</sub>- Soil with 40% kitchen waste vermicompost and bioslurry at a rate of 7.8 t/ha, V<sub>2</sub> × B<sub>1</sub>- Soil with 40% mowed lawn grass vermicompost and bioslurry at a rate of 7.8 t/ha, V<sub>3</sub> × B<sub>1</sub>- Soil with 40% weed biomass vermicompost and bioslurry at a rate of 7.8 t/ha.

**Table 13.** Effect of vermicompost on static vase life.

Vermicompost type	Vase life (days)	
	Season 1	Season 2
V <sub>0</sub>	11.2 <sup>d</sup>	12.2 <sup>cd</sup>
V <sub>1</sub>	15.4 <sup>c</sup>	16.2 <sup>c</sup>
V <sub>2</sub>	17.3 <sup>bc</sup>	18.0 <sup>bc</sup>
V <sub>3</sub>	19.4 <sup>ab</sup>	20.0 <sup>a</sup>

Means followed by the same letter are not significantly different according to Tukey's test at  $p \leq 0.05$ . Key: V<sub>0</sub> – Soil with no vermicompost, V<sub>1</sub>- Soil with 40% kitchen waste vermicompost, V<sub>2</sub>- Soil with 40% mowed lawn grass vermicompost, V<sub>3</sub>- Soil with 40% weed biomass vermicompost.

44.7 to 54.3 ml) when compared with the control (22.5 and 22.2 ml). The observed water uptake responses under the different treatment combinations (V<sub>1</sub>×B<sub>1</sub>, V<sub>2</sub>×B<sub>1</sub> and V<sub>3</sub>×B<sub>1</sub>) were not significantly higher than the main effects observed under the different individual vermi-compost treatments (V<sub>1</sub>, V<sub>2</sub> and B<sub>1</sub>) as well as from bioslurry (B<sub>1</sub>). Respectively in season one and two, water uptake results from V<sub>3</sub>×B<sub>1</sub> represented significantly the highest response at three DIV (66.3 and 75.3 ml) when compared with V<sub>1</sub>×B<sub>1</sub> (56.0 and 64.7 ml) and V<sub>2</sub>×B<sub>1</sub> (44.0 and 43.7 ml)

and at 15 DIV (47.3 and 54.3 ml) when compared with V<sub>1</sub>×B<sub>1</sub> (38.7 and 48.7 ml) and V<sub>2</sub>×B<sub>1</sub> (44.7 and 44.7 ml) and generally tended to confer the highest water uptake in static throughout the observation period.

#### Vase life

The different vermicomposts had significant effect on vase life of static in both season one and two (Table 13). All the different vermicompost

treatments resulted in significantly longer vase life in season one compared to the control treatment (V<sub>0</sub>). Weed biomass vermicompost (V<sub>3</sub>) resulted in a significantly the longer vase life (19.4 and 20.0) days but was not significantly different from the mowed lawn grass vermicompost (V<sub>2</sub>) with 17.3 and 18.0 in season one. Kitchen waste vermicompost (V<sub>1</sub>) recorded a lower vase life of 15.4 in season one and 16.2 days in season two. Application of bioslurry at 7.8 ton/ha resulted in enhanced vase life (17.6 and 18.5 days) respectively in season one and two when

**Table 14.** Effect of bioslurry on static vase life.

Bioslurry type	Vase life (days)	
	Season 1	Season 2
B <sub>0</sub>	11.2 <sup>b</sup>	12.2 <sup>b</sup>
B <sub>1</sub>	17.6 <sup>a</sup>	18.5 <sup>a</sup>

Means followed by the same letter are not significantly different according to Tukey's test at  $p \leq 0.05$ . Key: B<sub>0</sub>- Soil with no bioslurry, B<sub>1</sub>- Soil with bioslurry at a rate of 7.8 t/ha.

**Table 15.** Combined effect of vermicompost and bioslurry on static vase life.

Treatment	Vase life (days)	
	Season 1	Season 2
Untreated	11.2 <sup>d</sup>	12.2 <sup>d</sup>
V <sub>1</sub> × B <sub>1</sub>	17.3 <sup>c</sup>	18.5 <sup>c</sup>
V <sub>2</sub> × B <sub>1</sub>	19.5 <sup>bc</sup>	20.1 <sup>bc</sup>
V <sub>3</sub> × B <sub>1</sub>	22.2 <sup>a</sup>	22.9 <sup>a</sup>

Means followed by the same letter within an evaluation period are not significantly different according to Tukey's test at  $p \leq 0.05$ . Key: Untreated –Soil with no vermicompost, V<sub>1</sub> × B<sub>1</sub>- Soil with 40% kitchen waste vermicompost and bioslurry at a rate of 7.8 t/ha, V<sub>2</sub> × B<sub>1</sub>- Soil with 40% mowed lawn grass vermicompost and bioslurry at a rate of 7.8 t/ha, V<sub>3</sub> × B<sub>1</sub>- Soil with 40% weed biomass vermicompost and bioslurry at a rate of 7.8 t/ha.

compared with the control (11.2 and 12.2 days) in season one and two respectively (Table 14).

#### Combined effect of vermicompost and bioslurry on static vase life

Applications of the different vermicomposts at a rate of 40% by volume in combination with bioslurry at a rate of 7.8 ton/ha significantly enhanced the vase life of static in season one and two (Table 15). Vase life results obtained from the combined treatment of kitchen waste vermicompost with bioslurry (17.3 and 18.5 days respectively in season one and two), mowed lawn grass vermicompost with bioslurry (19.5 and 20.1 days respectively in season one and two) as well as weed biomass vermicompost with bioslurry (22.2 and 22.9 days respectively in season one and two) all significantly exceeded results from untreated plots (11.2 and 12.2 days respectively in season one and two). The longest significant vase life response in static (22.2 and 22.9 days respectively in season one and two) was observed under the treatment combining weed biomass vermicompost and bioslurry (V<sub>3</sub> × B<sub>1</sub>) when compared with results under the other two treatment combinations (V<sub>1</sub> × B<sub>1</sub> and V<sub>2</sub> × B<sub>1</sub>) and the control (ranging from 11.2 to 20.1 days during both seasons).

## DISCUSSION

Vermicomposts and bioslurry applications significantly

affected the parameters of growth, yield, and postharvest quality in static when observed at  $P \leq 0.05$  except seedling take off. While, bioslurry could not affect seedling take off as its application commenced after seedling establishment, higher seedling takeoff tended to associate with the application of vermicompost. The higher seedling takeoff, though insignificant, was possibly due to suppression of soil plant pathogens while promoting growth of seedlings (Jack, 2011; Pathma and Sakthivel, 2012), improved soil health (Majumder et al., 2014) or due to improved soil physical, chemical and biological fertility including better soil porosity, structure, texture, bulk density, water tension capacity, and biological activities (Asciutto et al., 2006) which probably enhanced seedling take off over the control. According to Ahmad et al. (2013), humic acid present in the bio fertilizers promoted uniform sprouting, more foliage growth per plant, and greater leaf area as well as total leaf chlorophyll contents, and earlier spike emergence in gladiolus.

#### Effect on growth and yield

Application of vermicomposts and bioslurry on static had significant main and combined effects on the number of stems produced per plant, flower stem length attained at 60 days after transplanting, the number of days to flowering and the fresh weight of flower stems at harvest when compared with the control at  $P \leq 0.05$ . There was a significant increase in number of stems produced, days to first flowering, and flower stem length. The application of

kitchen waste vermicompost resulted in the highest number of flower stems per plant that were also significantly longer in both season one and two. Results obtained with vermicomposts from mowed lawn grass and garden weed biomass though significantly higher in these parameters than the control, they had no significant difference between them in both seasons. The combined effect of kitchen waste vermicompost and bioslurry significantly exceeded the main effects observed under the different vermicompost and bioslurry applications.

The observations of the present study suggesting promotive effect of vermicomposts on vegetative growth are consistent with the findings of Mahmud et al. (2020) who reported insignificant difference in plant height and foliage parameters between pineapple plants treated with vermicompost and chemical fertilizer. While working with strawberry cv. "Winter dawn", Sahana et al. (2020) reported the best response in vegetative growth, yield and yield attributes from treatment combination that included vermicompost. Similarly, Pansuriya et al. (2018) reported significantly enhanced growth and yield parameters in gladiolus from treatment combinations containing bio fertilizers. Sharma et al. (2017) also reported increased plant height, number of branches, plant spread, flowering duration and flower yield in African marigold under vermicompost treatments. Abubaker et al. (2015) attributed superior plant performance under application of bioslurry to the inhibition of ammonia oxidation and denitrification which potentially benefits crop growth due to reduced losses of soil nitrogen. Srivastava et al. (2014) reported enhanced vegetative growth and yield with use of vermicompost in tuberose var. Shringar. Geeta and Prabhat (2009) reported in gladiolus significant effect on both fresh and dry weight of spike, days taken to spike emergence, maximum diameter of first floret and number of florets opened from pre-harvest bio fertilizer treatments. Srivastava and Govil (2007) also reported improvement in the various characters of gladiolus resulting from the activity of rhizospheric bacteria attributable to bio fertilizer inoculation. Nikbakht et al. (2008) reported up to 52% increase in the number of harvested flowers per plant in Gerbera from humic acid treatments. Atiyeh et al. (2000) observed faster growth on tomatoes when vermicompost was applied compared to the control probably due to supply of phosphorus and calcium, important nutrients for cell growth and development. While working with basil (*Ocimum basilicum* L.) and tomato (*Solanum lycopersicum* L. 'Roma'), Huang et al. (2020) reported superior growth indexes from substrates mixes combining vermicompost and commercial peat-based substrate which they attributed to favourable substrate amendment including higher pH and better porosity. Furthermore, the reviews by Bhat et al. (2018) and Joshi et al. (2015) on effects of vermicomposts on growth, yield and quality of crops, assert that the enhanced observations on the studied parameters are due to positive effects of higher amounts of humic substances in the bio fertilizers on

growth of plants.

The meta-analysis by Blouin et al. (2019) also asserts that the presence of bio fertilizers promotes the increase in plant growth and yield due to effects of humic acids and growth promoting bacteria. Similarly, Kumar et al. (2018) in their review of the potential benefits of vermicomposts in crop production and soil fertility concluded that the bio fertilizer improves soil physical, chemical and biological properties sustainably supporting crop production.

### Effect on postharvest quality

Application of the different vermicomposts and bioslurry significantly enhanced postharvest quality of static when compared with the control at  $P \leq 0.05$ . Combined treatment applications of the different vermicomposts with bioslurry also had significant interaction effect on postharvest quality parameters in static when compared with the control at  $P \leq 0.05$  although they were not significantly different from the main effects of the vermicomposts and bioslurry. The different vermicomposts and bioslurry significantly enhanced water uptake during vase life in static and also resulted in a gradual decline in water uptake throughout the observation period. They also significantly extended vase life when compared to the plain garden soil. While no specific literature on static came up, findings similar to the present study have been reported from various studies involving treatments with organic manures on other crops. These findings are supported by Sharma et al. (2017) who when working with marigold (var. Pusa Narangi) reported maximum shelf life and flower vase life from treatments that included application of farm yard manure as organic manure alongside bio fertilizers and NPK in integrated plant nutrient management. Palagani and Alka (2017) observed significantly improved water uptake from treatments with bio-fertilizers inoculation alongside spermine foliar sprays. They also reported significantly improved flower quality parameters in Gerbera including improved postharvest physiology of flowers and higher retained flower fresh weight. Bohra and Kumar (2014) reported extended vase life in Chrysanthemum cv. Little Darling resulting from treatment that applied vermicompost at a rate of  $300\text{g/m}^2$ . Longchar and Keditsu (2013) reported significantly improved floral characteristics and flower vase life in Gerbera from treatments that included application of vermicompost as an organic nutrient source. Srivastava et al. (2007) reported maximum water uptake in tuberose under treatments incorporating vermicomposts. They also reported significantly longer vase life from treatments that had vermicompost while Ikram et al. (2012) reported enhanced shelf life and vase life from application of farm yard manure obtained from leaf compost. Geeta and Prabhat (2009) reported significantly extended vase life in gladiolus under treatments that combined vascular

arbuscular mycorrhiza with vermicompost and vermiwash suggesting a positive contributive effect of vermicompost. Tejada et al. (2008) reported improved vase life in Gerbera from treatments that incorporated phosphorous solubilizing bacteria found among the diverse nutrient solubilizing microbes (Ayyadurai et al., 2007) present in vermicomposts and other organic manures (Sinha et al., 2010).

## Conclusion

From the results of the present study, soil amendment with 7.8 t/ha bioslurry significantly enhances stem elongation and ultimate flower stem length, increases number of stems produced per plant and the duration to flowering, while also increasing the fresh weight of flower stems in potted statics when compared to plain soil. However, these effects were significantly lower than those produced by the different vermicompost used in the present study. On the other hand, when compared to plain garden soil and application of 7.8 t/ha of bioslurry, all the three vermicomposts used in the present study, regardless of type, significantly enhance stem elongation, flower stem length, number of stems produced per plant in potted statics. They also increase the duration to flowering, while also increasing the fresh weight of flower stems. Kitchen waste vermicompost consistently gives the highest significant responses for all the statics growth and yield parameters studied. Vermicomposts prepared from kitchen waste and mowed lawn grass had similar effect on statics stem length, with both producing the longest flower stems. Therefore, potting mixtures containing 40% vermicompost by volume for any of the types, and drenching with bioslurry at a rate of 7.8 t/ha significantly promote growth and yield responses in statics.

## Recommendation

Findings of the present research study recommend the use of 40% vermicompost obtained from the readily available kitchen waste, mowed lawn grass and garden weed biomass as well as the use of 7.8 t/ha of bioslurry improved growth and yield in statics. However, there is need for further work to test the use of vermicomposts at varied rates in order to establish the optimal rate of application in statics.

## CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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