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ORIGINAL RESEARCH

Agricultural waste as growing media component for the growth and flowering of *Gerbera jamesonii* cv. hybrid mix

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Abstract
Purpose This study was performed to investigate the impact of various agricultural wastes as potting media on growth, yield, and quality flower production of *Gerbera jamesonii* L. cv. hybrid mix, and to estimate hazardous impact of chemical fertilizers.
Method The effect of four agricultural substrates viz. farm yard manure, coconut coir dust, Lahore compost (local produce), and leaf compost combined with conventional media i.e., garden soil, sand, and silt in equal proportion was studied for commercial production of gerbera. All the treatment combinations were arranged into completely randomized design with three replicates.
Result Visible variations in morphological characters were evidenced among conventional medium and agricultural waste as substrates with significant superiority of flower quality and plant growth. The presented results showed that treatment combination of silt, coconut coir dust, and top soil (SCT) produced maximum plant height while mixture of silt, Lahore compost and top soil (SLT) gave maximum number of leaves per plant and maximum flower stalk thickness. The highest values for leaf area, number of roots, flower fresh to dry weight ratio and number of flowers per plant were achieved in combination of silt, farm yard manure, and top soil (SFT) whereas silt, sand, and top soil (SST) presented maximum flower diameter, maximum fresh, and dry weight of flowers. Chemical characteristics of growing media showed superiority of silt, farm yard manure, and top soil (SFT) and silt, sand, and top soil (STL) for available phosphorus and potassium with values of 27.0 and 500 ppm, respectively.
Conclusion It was concluded that the application of waste materials in combination with silt provided positive results for vegetative and reproductive growth of *Gerbera jamesonii* plants.

Keywords Agricultural waste · Farm yard manure · Flower quality · *Gerbera jamesonii* · Leaf compost

Introduction

Gerbera (*Gerbera jamesonii*), is a herbaceous perennial plant with flowering stalks produced in between the leaves, ranging from 12 to 37 cm in height depending upon the cultivar (Weeraratne et al. 2012). Single daisy like flowers of gerbera are used for garden and home decoration in early stages but rarely used as cut flower because of their weak pedicle, bent neck, and poor vase life. The introduction of new varieties having double flowers (Torrey 1951) is considered better for cut purposes in all respects, encouraging the cut flower growers to enhance their production. It's potential as a cut flower is now widely accepted because of its ability to propagate through seed, rapid growth, and the demand for cheap labor supplies. For a better production of gerbera cut flowers, it is necessary to

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estimate all the growth factors like nutrition, growth environment, growth media, etc.

Growth media are considered among one of the most important factors affecting the production of Gerbera (Nowak and Strojny 2003; Sindhu et al. 2010; Khalaj et al. 2011; Ahmad et al. 2012). Natural soil along with peat are the most common growing substrates used for the container production of annual and perennial ornamental plants since many years (Guerrero et al. 2002; Hernandez-Apaolaza et al. 2005). In order to enhance quality and production of flowering plants chemical fertilizer are frequently applied to soils but the excessive applications of chemical fertilizers have harmful effects on soil flora, fauna, and enzymes. This ultimately leads to decrease their activity for maintaining the natural fertility of soil (Gupta et al. 2014) and increase the dependence on chemical fertilizers. As a result, there is a growing concern to reduce the application of chemical fertilizer to soils, and in order to use soil nutrients more efficiently and to overcome pollution hazards the application of organic matter is gaining acceptance among farming community.

In the past few years, usage of peat has been reduced due to environmental concerns for conservation (Abad et al. 2002). Therefore, researchers showed their interest in other organic materials like agricultural wastes which could be viable source of organic nutrients for the production of container grown plants. Agricultural waste such as rice hulls, coir, sawdust, and compost as growing media has been proved as an important substitute of simple soil for ornamental plant production (Younis et al. 2007; Wilson et al. 2009; Tariq et al. 2012) including gerbera. Furthermore, production of large sized gerbera flowers is entirely based on the structure, texture, pH, organic matter contents, as well as nitrogen, phosphorus, and potassium levels of the growth media (Rader 1998; Lang and Pannuk 1998). Organic media that are light in weight, rich in nutrients and well-drained considered ideal choices for growth and development of flowering plants like gerbera (Awang et al. 2009; Dubey et al. 2013), as these plants are notoriously ranked as heavy feeders and require abundant quantities of plant food for maximum development. It thrives best in a media with a pH slightly below or above the neutral point which helps the plants to face the seasonal hazards (Abad et al. 2002).

Currently, in Pakistan less work has been carried out on this flowering plant using different growth media sources. Most of the farmers are using chemical fertilizers and peat in order to attain maximum production of flowering plants. Both ways are eco destructive in several ways and growers in Pakistan are less familiar about the usage of other organic sources for better crop production. A less expensive and more adoptable growing media from agriculture waste not only benefits the environment but also attains meaningful production outcomes for Gerbera growers. Keeping in view, environmental concerns, economic constraints, and growers need, this study was performed to investigate the impact of various agricultural wastes as potting media on morphological characters as well as yield and quality flower production of Gerbera.

Materials and methods

The comparative study for evaluation of different potting media for *Gerbera jamsonii* cv. Hybrid Mix plants production was conducted at Floriculture Research Area, Institute of Horticultural Sciences, University of Agriculture, Faisalabad (latitude 31°30′N, longitude 73°10′E and altitude 213 m). Eight-week-old seedlings were purchased from local nursery in the month of November and 108 plants of uniform size (3 cm) having two sets of true leaves were selected to grow in pots having different combinations of FYM, coconut coir dust, Lahore compost (local produce), sand, leaf compost, silt, and garden soil. Six treatment combinations including control were made with the similar ratio by volume (Table 1).

All treatment combinations were arranged in completely randomized design (CRD) with three replicates and six plants were planted in each replication. Management practices like irrigation, weeding, and pesticide application remained same for the all treatments.

Plant growth characteristics

Following observations on plant growth characteristics were evaluated during the course of study.

Plant height The height of plants was measured in centimeters, from base to the top leaf of the plant.

Number of leaves per plant The total number of leaves per plant was counted for each media after every 15 days.

Leaf area The leaf area (cm^2) was measured with the help of LI-3000 Portable Leaf Area Meter, USA.

Days to flower emergence Number of days were counted from the date of sowing to emergence of first flower on the plant.

Number of flowers per plant Flowers per plant were counted regularly during blooming period of the crop and then average was calculated.

Flower diameter Diameter of all the flowers was measured in centimeters (cm) with the help of vernier caliper and average was estimated.

Flower stalk thickness Flower stalk thickness was measured in centimeters (cm) with the help of vernier caliper and average was calculated.

Table 1 Different treatment combinations of agricultural wastes used as growing media

Treatments	Combinations	Ratio by volume (*v*:*v*:*v*)
T_0	Control (garden soil = GS)	
T_1	Silt + farm yard manure + top soil (SFT)	1:1:1
T_2	Silt + coconut coir dust + top soil (SCT)	1:1:1
T_3	Silt + Lahore compost + top soil (SLT)	1:1:1
T_4	Silt + sand + top soil (SST)	1:1:1
T_5	Silt + top soil + leaf compost (STL)	1:1:1

Fresh weight of a flower One flower was collected at random from each plant and weighed on an electric balance (in grams) and average was computed.

Dry weight of a flower Flowers were dried in oven at 65 °C for 48 h, and then weighed again on electric balance. In this way, dry weight of flowers was recorded in grams and average was computed.

Fresh and dry weight ratio Fresh and dry weight ratio of a flower was calculated by dividing the fresh weight to dry weight of the flower.

Number of roots per plant The number of roots of plants was counted individually by uprooting the plant from the pots at mature stage.

Chemical characteristics of growing medium

The pH and Electrical conductivity (EC) in dS m^{-1} was determined by HI 9811-5 portable pH/EC/TDS/°C meter (Mclean 1982) and digital electrical conductivity (EC) meter (Lovibond Senso Direct 150). Organic matter was determined using the method of Walkley (1947), while, available phosphorus was estimated using Spectrophotometer, model spectronic 21 USA (Olsen et al. 1954). The flame photo metric method was used for estimation of Potassium (U.S. Salinity Lab. Staff 1954).

Statistical analysis

The collected data were subjected to Fisher's analysis of variance technique (Steel et al. 1997). The Duncan's multiple range (DMR) test at 0.05 % level of probability was employed to compare the differences among treatment means.

Results

Plant growth characteristics

Results regarding plant height showed significant superiority of SCT (T_2) treatment, which produced maximum plant height with 40.22 % increase as compared to control (T_0) followed by 30.50 and 20.66 % increase with SLT (T_3) and STL (T_5), respectively. Mean comparison of treatments in Table 2 regarding number of leaves per plant showed significant superiority of SLT (T_3) again with 34.85 % increase in number of leaves followed by STL (T_5) with 30.30 % more leaves, compared to minimum number of leaves (3.30) in garden soil (GS) (T_0). Therefore, maximum leaf area (39.24 cm^2) was produced in mixture of SFT (T_1) with 164.96 % increase followed by STL (T_5), SCT (T_2), and SST (T_4) with 160.50, 125.79, and 107.63 % rise, respectively as compared to conventional media i.e., GS (T_0). Growing media combination in the form of STL (T_5) presented the highest value for number of roots (6.70) followed by SST (T_4) and SCT (T_2) treatments and finally up to 148.15 % improvement over GS (T_0) was noted (Table 2).

Size of flower also improved in SST (T_4) significantly with maximum increases in flower diameter (20.75 %), in comparison to all growing media used in this study. Whereas, plants grown in SCT (T_2), SLT (T_3), and SFT (T_1) behaved similar in case of flower diameter (Fig. 1). The maximum flower stalk thickness was produced in SLT (T_3) growth media, while the least flower stalk thickness was attained in plants grown in SCT (T_2) after GS (Fig. 2). The utmost but statistically similar stalk thickness obtained in SST (T_4) and STL (T_5). There was 50 % improvement in flower stalk thickness in plants grown in SLT as compared to control treatment. On average, maximum fresh weight of flower with 31.87 % increase in weight was attained in SST (T_4) growing media compared to control (Fig. 3). The smallest count of fresh weight of flower was observed in SFT (T_1) as this growing media caused 5.49 % decrease in weight when compared with control. Similarly, results regarding dry weight of flowers showed that the SST (T_4) and SLT (T_3) gave the highest results without any significant difference. Whereas, the lowest dry weight of flowers was observed in STL (T_5) with 43.77 % decrease from control (GS) (Fig. 4). The STL (T_5) mixture possessed the highest fresh to dry weight ratio, which was 104.56 % greater than the control treatment, whereas minimum fresh/dry weight ratio was produced again by GS (T_0) (see Fig. 5).

However, difference for days to flower emergence was found to be non-significant but in general, STL (T_5) mixture attained least days to first flower emergence and showed 8.30 % earliness in this regard than control

Table 2 Effect of growing substrates on plant height, number of leaves per plant, leaf area and number of roots of *Gerbera jamesonii*

Treatments	Plant height (cm)	Number of leaves per plant	Leaf area (cm^2)	Number of roots
T_0	7.31 ± 0.81f	3.30 ± 0.88d	14.81 ± 2.06f	2.70 ± 0.45f
T_1	7.86 ± 1.36e	4.09 ± 0.34c	39.24 ± 1.79a	3.66 ± 0.41e
T_2	10.25 ± 0.75a	4.15 ± 0.40c	33.44 ± 1.69c	4.45 ± 0.20c
T_3	9.54 ± 1.04b	4.45 ± 0.70a	30.75 ± 2.00e	4.07 ± 0.04d
T_4	8.44 ± 0.94d	4.11 ± 0.36c	32.24 ± 1.49d	5.79 ± 0.03b
T_5	8.82 ± 1.32c	4.30 ± 0.75b	38.58 ± 2.08b	6.70 ± 0.57a
F value	1436**	104**	26,562**	512**
p value	3.16×10^{-16}	1.23×10^{-11}	7.97×10^{-24}	2.13×10^{-13}

NS non significant, ±SE

* Significant ($P < 0.05$)

** Highly significant ($P < 0.01$)

Letters (a–f) exhibit significant difference among means at $P < 0.05$

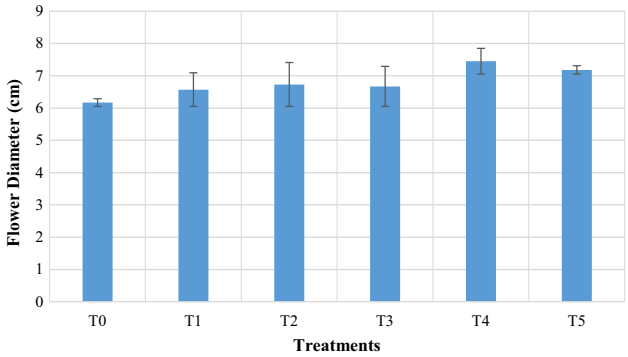

Fig. 1 Effect of different growing media on flower diameter of *Gerbera jamesonii*

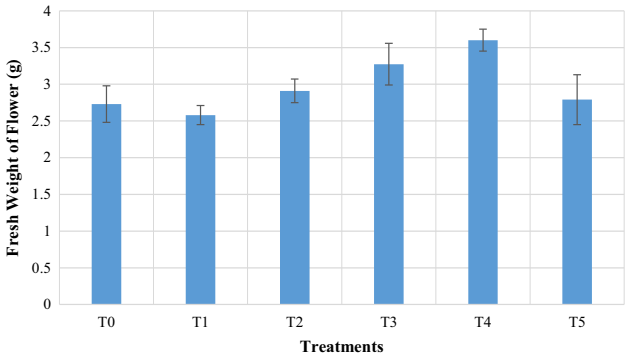

Fig. 3 Effect of different growing media on fresh weight of flower of *Gerbera jamesonii*

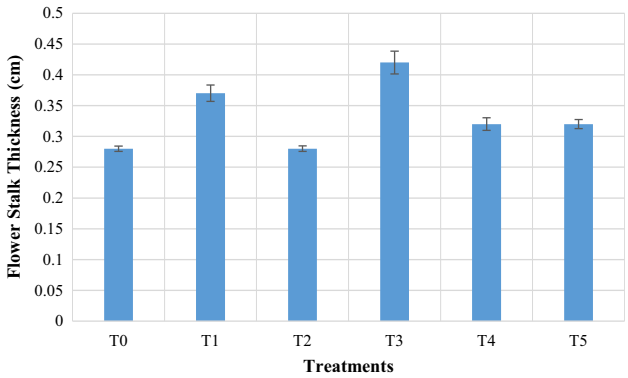

Fig. 2 Effect of different growing media on flower stalk thickness of *Gerbera jamesonii*

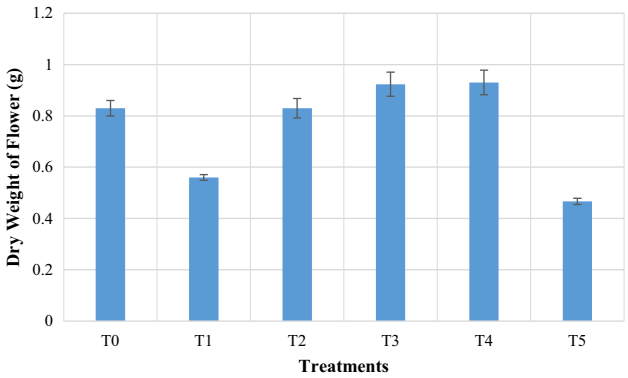

Fig. 4 Effect of different growing media on dry weight of flower of *Gerbera jamesonii*

(Fig. 6). Likewise, the mixture STL (T_5) again proved the superiority (34.85 %) regarding flowers per plant over control (GS) which produced the least flowers per plant (Fig. 7). Other mixtures including SCT (T_2), SST (T_4), and SFT (T_1) were statistically not different from each other with 23 to 30 % increase in flowers per plant compared to control (GS) (T_0).

Chemical characteristics of growing medium

The highly significant differences among organic matter contents, available potash (K), available phosphorus (P), pH and EC were observed in all the growth media used in this investigation. Growing media with SFT (T_1) combination provided better P (27 %) and K (72 %) contents

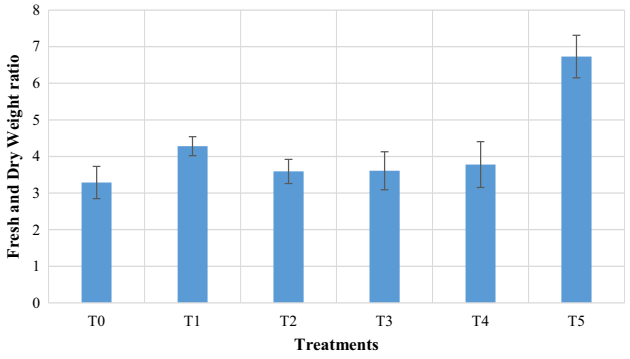

Fig. 5 Effect of different growing media on fresh and dry weight ratio of flower of *Gerbera jamesonii*

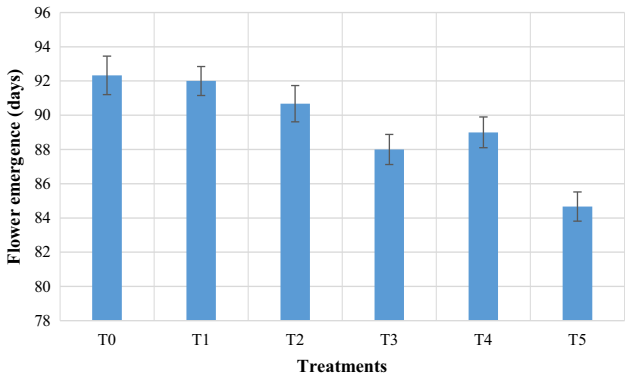

Fig. 6 Effect of different growing media on flower emergence of *Gerbera jamesonii*

compared to other growing media. While, maximum increase (up to 86.54 % over control) in organic matter contents was found again in SFT (T_1) and STL (T_5) mixtures without any significant difference. The SCT potting media gave the least percentage of available organic matter compared to other growing media treatments. Results regarding pH level of growing media exhibited that GS (T_0) gave the maximum value (9.54) while SST (T_4) and SFT (T_1) occupied 2nd position. The minimum level regarding pH (29 % less than control) was recorded in treatment containing SCT (T_2). The highest EC value (0.73) with 58.70 % increase over control was noticed with SFT (T_1) potting media whereas, GS (T_0) and SST (T_4) gave the lowest EC values (0.36) (see Table 3).

Discussion

Improved quality characters and growth traits of gerbera plants observed in this study with different growing substrates having garden soil, farm yard manure, coconut coir dust, a local made organic compost, and leaf compost are related to the previous findings (Saijeen et al. 2009; Ahmad

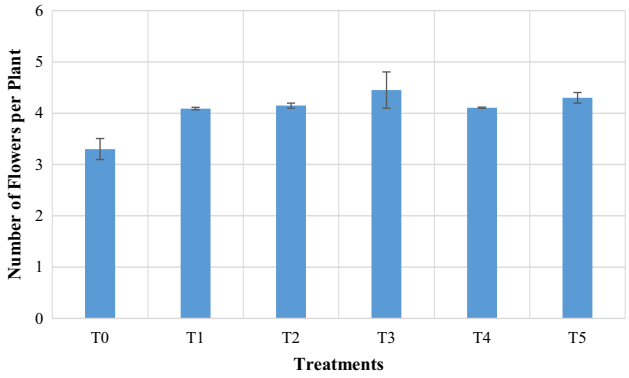

Fig. 7 Effect of different growing media on flowers per plant of *Gerbera jamesonii*

et al. 2012). Appropriate concentration of nutrients in conjunction with growing medium has advancing effects on best flower growth and yield.

Results exhibited in previous section showed that balanced rooting media using agricultural waste can greatly affect the plant height and are essential for attaining maximum of it. These results are in accordance with Treder (2008) and Dubsky and Sramek (2008) who reported excellent growth of perennials in leaf mold and peat substrate with the addition of rock wool and observed maximum plant height. Though, number of leaves is influenced mainly by environmental conditions, nutrients present in growth media are also one of the factors which have prime importance in this regard. More number of leaves in plants reflect good vigor and their suitability to environment and growth media. Since nitrogen in growing media significantly affects the plant growth, increase in number of leaves of plants can also be due to adequate availability of nitrogen content in growing substrate (Benito et al. 2005; Khayyat et al. 2007; Riaz et al. 2008). More number of leaves could not be considered as factor contributing toward leaf area but it is mainly due to adequate supply of nutrients. Therefore, the nutrient rich substrate can be used to achieve significant results as maximum increase in size of leaves shows adaptability of plants to soil or growth media (Cardens et al. 2006; Riaz et al. 2014). Increase in number of shoots per plant highlighted the vigorous vegetative plant growth and only nutrient-rich growing media promote such growth in plants. Above mentioned results help to conclude that growing media in a combination of STL presented the best results for the number of shoots (Bashir et al. 2007).

Results regarding number of roots reflect that treatments containing mainly leaf compost represented superiority in promoting roots number. Similar trend has also been noticed by Lopez (2006) who found that root growth of geranium, petunia, and coleus was increased as the proportion of sewage sludge plus straw compost increased up to 50 % in peat. Maximum flowering as well as increase in flower bud

Table 3 Effect of growing substrates on organic matter, available potash, available phosphorus, pH and EC of *Gerbera jamesonii*

Treatments	Organic matter %	Available potash (ppm)	Available phosphorus (ppm)	pH	EC of media (dSm^{-1})
T_0	52 ± 1.07d	290 ± 11.99b	21.3 ± 0.76b	9.54 ± 0.39e	0.46 ± 0.048c
T_1	97 ± 1.93a	500 ± 8.91a	27 ± 1.36a	7.36 ± 0.49c	0.73 ± 0.02a
T_2	41 ± 8.02e	230 ± 8.49c	16.8 ± 1.42c	6.75 ± 0.67a	0.59 ± 0.05b
T_3	82 ± 3.21b	500 ± 13.89a	15.2 ± 1.19c	6.81 ± 0.22b	0.49 ± 0.004c
T_4	62 ± 2.13c	220 ± 6.94c	16.5 ± 2.72c	7.94 ± 0.71d	0.36 ± 0.01d
T_5	93 ± 7.01a	500 ± 10.02a	25 ± 2.02a	6.82 ± 0.1b	0.59 ± 0.08b
F value	1597**	952**	18.1**	154**	123**
p value	1.67×10^{-16}	3.70×10^{-15}	3.22×10^{-05}	1.88×10^{-10}	6.86×10^{-10}

* Significant ($P < 0.05$)

** Highly significant ($P < 0.01$), ±SE

Letters (a–f) exhibit significant difference among means at $P < 0.05$

diameter and subsequently increase in flower diameter indicates suitability of that growing medium, where organic matter in growing substrate and optimum amount of NPK manipulate plant growth and flower size (Kiran et al. 2007). Growing media containing silt and Lahore compost exhibited their superiority for stalk thickness, stem diameter, flower fresh and dry weights, and its ratio contrast to conventional media which proves that this kind of media can be used for gerbera production effectively. These results are in consistent with Grassotti et al. (2003) and Caballero et al. (2009) who observed that growing media having combination of silt + compost and manure can produce the maximum flower stalk thickness, fresh, and dry weights of gladiolus and lily. Similarly, the combination of sand, mushroom compost, coconut coir, and peat produced the best quality of plants with considerable increase in most of the growth parameters (Younis et al. 2013). Khalaj et al. (2011) also observed that maximum stem diameter of Gerbera plants attained with media in combination of perlite and peat. Rich supply of nutrients like K, N, and P in growing substrate is proved to be sufficient for production of good quality flowers (Younis et al. 2014) and adequate availability of these nutrients in growing media gave significant results regarding growth and flowering indices in this experiment. Organic matter and P content in growing substrate affected the quality of flowers as well. Growing media with excellent nutrient quality influences plant growth as availability of P and K contents in growth media has positive relationship with flowering indices. In current research, excellent nutrient quality with maximum phosphorus and potassium contents (27.00 and 500 ppm, respectively) was achieved in SFT growing media. Good quality flowers obtained in this combination is a confirmatory with Grassotti et al. (2003). Treder (2008) reported that plants had long stem, and maximum flowering in growing media with optimum P and K contents, where potting media comprising farm yard manure can give maximum amount of P and K contents (Strojny and Nowak 2004; Younis et al. 2007). Organic matter in growing media can individually promotes the plant growth due to high availability of nutrients (Fascella and Zizzo 2005; Younis et al. 2010), where maximum organic matter was found in farm yard manure containing substrates while other treatments showed no significant results. Physio-chemical attributes of high organic matter encourage the plant growth and improves substrate quality (Abad et al. 2001) which has been seen in this research work.

Various substrates having farm yard manure and compost are responsible to reduce pH and EC due to high nutrient supply (Bi et al. 2009; Diacono and Montemurro 2010). Actually, accessibility of nutrients to plants in growing media is coupled with the changes in media pH as increase or decrease in pH alters the solubility of nutrients and has direct effect on plant growth and development. Changes in pH above or lower than the optimum range adversely affected plants by damaging roots and decreasing nutrients availability (Altland 2006; Awang et al. 2009). The best range of dissolved salt contents i.e., EC in soil supports the better plant growth (Awang et al. 2009). Higher EC levels were not found to inhibit plant growth however; it decreased the biological activity of soil than the threshold value which negatively impacts plant growth (Miller 2001; Ribeiro et al. 2002). Suitable use of substrates for nutrient accessibility by plants not only depends upon nutrient composition but also on pH, nutrient form, organic compounds, and adsorption capacity of the growing media due to the presence of high organic matter content, P and K.

Conclusion

Results of this study indicated that application of coconut coir dust in combination with silt produced maximum plant height while addition of Lahore compost to substrate gave

maximum number of leaves per plant and maximum flower stalk thickness. The addition of farm yard manure to silt and top soil produced maximum leaf area, highest value for number of roots, maximum fresh to dry weight ratio, and maximum flowers per plant, whereas maximum flower diameter, maximum fresh and dry weights of flower, resulted with mixture of sand with silt and top soil. All these organic waste substrates showed positive attribute to growth and flowering of gerbera with readily availability of nutrients for uptake. Therefore, it is concluded that suggested agricultural waste material can be used as growing media for better *Gerbera jamesonii* growth and can be explored further for other combinations.

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