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GROWTH AND FLOWERING OF GERBERA AS INFLUENCED BY VARIOUS HORTICULTURAL SUBSTRATES

IFTIKHAR AHMAD[1,*], TANVEER AHMAD[1], ARFAN GULFAM[1] AND MUHAMMAD SALEEM[1]

[1]*Institute of Horticultural Sciences, University of Agriculture, Faisalabad-38040, Pakistan*
**Corresponding author's E-mail: iftikharahmadhashmi@gmail.com*
Tel: +92 41 9201085, Fax: +92 41 9201086

Abstract

An experiment was conducted to evaluate the growth and flowering of gerbera grown in various horticultural substrates combined with conventional media (composed of garden soil, silt and sand in equal proportions) which is commonly used for its commercial production in the country. Two horticultural by-products viz. coconut coir and spent mushroom compost were tested for their suitability to be used as growing media for cut flower production. No major differences in yield were observed between conventional media and both horticultural by-products; however, flower quality was improved when both of the substrates were used in combination with conventional media. Growing substrate choice also influenced flower stalk length and diameter which revealed positive correlation of these substrates with various attributes of flower quality but not flower yield. Moreover, incorporation of coconut coir and mushroom compost lowered pH and increased available organic matter and electrical conductivity of conventional media which improved nutrient uptake by the plants.

Introduction

Soilless substrates are used in horticulture for growing seedlings, plant propagation and ornamental plant production (Noureen *et al*., 2010; Ahmad *et al*., 2012). Annual ornamental plants require growing media with adequate water retention and aeration (Erstad & Gislerǿd, 1994) and a fertilizer formulation that ensures a continuous nutrient supply (Macz *et al.,* 2001). The components of soil-less substrates must have stable physical and chemical properties during plant production. The bio-stability of alternative substrates varies considerably, which also affects the chemical properties of substrates, their management, and the growth of ornamental plants. An ideal substrate should consist of following chemical characteristics: pH = 5.2–6.3; EC (dS m^{-1}) = 0.75–3.49; OM (%) >80; NO^{-3} –N (mg ml^{-1}) = 100–199; K^+ (mg ml^{-1}) = 150–249; Na^+ (mg ml^{-1}) = <115; Cl^- (mg ml^{-1}) = <180 and SO_2 -4 –S (mg ml^{-1}) = <960 (Abad *et al.*, 2001).

Suitable growing substrates are essential for quality flower production as these affect development and maintenance of plant rooting system (Awang *et al.,* 2009). Moreover, these are necessary for sufficient anchorage of plant, provision of nutrients and water as well as gaseous exchange between roots and atmosphere outside the growing medium (Argo, 1998a,b; Abad *et al.*, 2002). Garden topsoil is commonly used by most of the growers for raising most flower crops, however, it is a non-renewable resource and sustainable flower production can not rely on non-renewable natural resources (Marianthi, 2006). Moreover, physical and infrastructural development rapidly reduces the availability of quality topsoil which necessitates use of alternate soilless substrates for flower production. Materials such as peat and natural soils are commonly used for the production of substrates for ornamental plants (Page/s & Matallana, 1984; Guerrero & Polo, 1990). But for over 25 years, container production of ornamental plants has depended almost entirely on quality soil-less media derived from both organic and inorganic constituents. Waste products such as biosolids (Gouin, 1993; Ingelmo *et al.,* 1998; Guerrero *et al.*, 2002) and wood wastes (Hicklenton *et al.,* 2001; Chen *et al.*, 2002) have frequently been used in nurseries but the availability of other materials is attracting more attention. Now a days, coco coir/ coco peat which is a horticultural by-product obtained after extraction of fiber from coconut husk (Abad *et al.,* 2002), is in high demand to be used as substrate for production of various floricultural crops. The reason is that it not only has many characteristics in common with peat (Lennartsson, 1997) but also has acceptable pH, electrical conductivity and other chemical properties (Abad *et al.,* 2002). During past few years, this material has become commercially popular and it is now being successfully used in different parts of the world as peat substitute for container-grown ornamental plants (Handreck, 1993; Stamps & Evans, 1997; Offord *et al.,* 1998; Noguera *et al.,* 2000; Abad *et al.,* 2002). The use of these materials provides environmental benefits as ecosystem damage caused by soil or peat extraction is avoided and the impact of residue accumulation is minimized (Raviv *et al.,* 1986). There are also economic benefits, as the use of residues means lower costs than those of conventional materials (Ingelmo *et al.,* 1998). Nutrients for container grown plants are applied by injecting fertilizers into irrigation systems (liquid feeding). Nitrogen concentrations of these solutions are usually high, ranging from 200 to 500 mg L^{-1} (Nelson, 1994; Rader, 1998). Greenhouse container crop production requires frequent irrigation and high fertilization rates, which can result in contamination of ground and surface water (Lang & Pannuk, 1998).

In Pakistan, floriculture industry is gaining popularity at a rapid pace. Domestic markets are flooded with fresh flowers dominated by roses as they are used in several ceremonies. Majority of the farming community has small land holdings which provide floriculture industry a golden opportunity to flourish. It is need of the present to enhance the fabrication of annuals which are used as specialty cut flowers and proceed as a valuable source of income in global cut flower trade. Commercial production of *Gerbera jamesonii* as cut flower has an outstanding demand in both national as well as international markets. Growing media play an important role in cut flower and potted plant production. Their physico-chemical properties determine the nutritional status, water holding capacity and aeration of potting media to determine the rate of plant growth. Gerbera thrives best in a light, rich and well-drained medium with a pH slightly below or above the neutral point. Vigorous growth of plants is needed to withstand the seasonal hazards. Furthermore, plants must have tensile strength to sustain low temperature and frost. Production of large number of best quality flowers is entirely based on physico-chemical properties of the growing media.

In future, gerbera may become the valuable source of foreign exchange for Pakistan if grown on commercial scale. Gerbera may be more valuable cut flower and potted plant than realized because of its diversified characteristics, ability to propagate by seed, rapid growth and minimal labor requirements. The demand of cut flower production in the country is increasing at a rapid pace, especially in early winter when very few annuals bloom during that period. In order to get desired plants with good quality flowers, the importance of growing media can not be negotiated.

Very little research has been conducted on flowering annuals to explore their potential as cut flowers in Pakistan. The need for this project was felt due to an increasing demand of specialty cut flowers particularly in early winter when there is a very small range of cut flowers available. Keeping in view the decorative and aesthetic value and rapidly increasing demand of gerbera in national and international markets, present study was carried out with the specific objective of assessing the potential of coconut coir and spent mushroom compost as growing substrates for cut gerbera production and to determine the effect of their different combinations with conventional media on growth, yield and flower quality.

Materials and Methods

This study was carried out at floriculture research greenhouse, Institute of Horticultural Sciences, University of Agriculture, Faisalabad (latitude 31°30N, longitude 73°10E and altitude 213m). *Gerbera jamesonii* cv. Hybrid Mix was grown to study the effect of different organic horticultural by-products as container media on its growth, yield and quality. Gerbera seeds were purchased from a well reputed seed agency and nursery was raised in the pots containing sand, silt and well rotten farm yard manure (1:1:1, v/v/v) during second week of September. Garden soil was amended with sand, silt, coconut coir and spent mushroom compost in various combinations and their effect was compared on growth and flowering of gerbera to test their suitability for commercial cut gerbera production. Six weeks old seedlings were transplanted in 9” pots containing different substrates viz. soil, silt, sand, coconut coir and spent mushroom compost in different combinations. A completely randomized experiment was set up with eight treatments replicated thrice. For determination of plant growth and flowering indices, each treatment unit comprised of five plants grown in separate pots. Treatments were Garden soil (Control), Soil + Silt (1:1, v/v), Soil + Sand (1:1, v/v), Silt + Sand (1:1, v/v), Soil + Silt + Sand (1:1:1, v/v/v), Soil + Silt + Sand + Coconut Coir (1:1:1:1, v/v/v/v), Soil + Silt + Sand + Mushroom Compost (1:1:1:1, v/v/v/v) and Soil + Silt + Sand + Coconut Coir + Mushroom Compost (1:1:1:1:1, v/v/v/v/v). Plants were allowed to grow after transplanting into pots containing different media and observations on plant height (cm), number of leaves plant^{-1}, leaf area (cm^2), days to flower emergence, number of flowers plant^{-1}, flower diameter (cm), flower stalk length (cm), flower stalk diameter (cm), fresh weight of a flower (g), dry weight of a flower (g) and fresh and dry weight ratio were recorded using standard procedures. Moreover, flower quality was judged according to the method described by Cooper and Spokas (1991) and Dest and Guillard (1987) using a scale ranging from 1 to 9 where, 1 = poor quality, 5 = medium quality and 9 = good quality. All data were analyzed statistically by using Fisher’s analysis of variance technique and treatment means were compared by applying Duncan’s multiple range test at 5% probability level (Steel *et al.,* 1997).

Physico-chemical properties of various substrates were also determined which are known to affect plant growth and development. These were pH, electrical conductivity, available organic matter, available phosphorus and available potassium contents of the medium. Media samples were collected after substrate preparation and used for determination of above mentioned characteristics. pH was measured by using digital ion analyzer (pH meter) (United States Salinity Laboratory Staff, 1954). Electrical conductivity was measured using EC meter in desi seimen per meter (dS m^{-1}). Available phosphorus was calculated by Olsen Method (Olsen *et al.,* 1954) using following formula:

$$\text{ppm of P} = \text{ppm from curve} \times 25 \text{ ml} / 1.25 \text{ g} \times 5 \text{ ml} / 1 \text{ ml}$$

While available potassium was estimated by flame photometer (United States Salinity Laboratory Staff, 1954).

$$\text{Meq} / 1 \text{ of } K^+ = \text{Meq} / 1 \text{ of } K^+ \text{ by calibration curve} \times 50 \text{ ml of sample}$$

Results

The observations recorded on plant height indicated that growing substrate in combination of soil + silt + sand produced tallest plants with 10.25 cm height followed by soil + silt and soil + silt + sand + coconut coir + mushroom compost (9.54 cm and 9.23 cm, respectively). Garden soil (control) produced short statured plants with minimum height (7.32 cm) and was statistically at par with silt + sand (7.37 cm) followed by soil + silt + sand + coconut coir (8.16 cm) as shown in Fig. 1. Data pertaining to number of leaves plant^{-1} presented non significant results ($p>0.05$). Comparison of treatments indicated that soil + silt, soil + silt + sand + mushroom compost, soil + silt + sand, soil + sand and soil + silt + sand + coconut coir produced 4.45, 4.30, 4.17, 4.11 and 4.09 leaves plant^{-1} and were statistically at par with each other (Fig. 1).

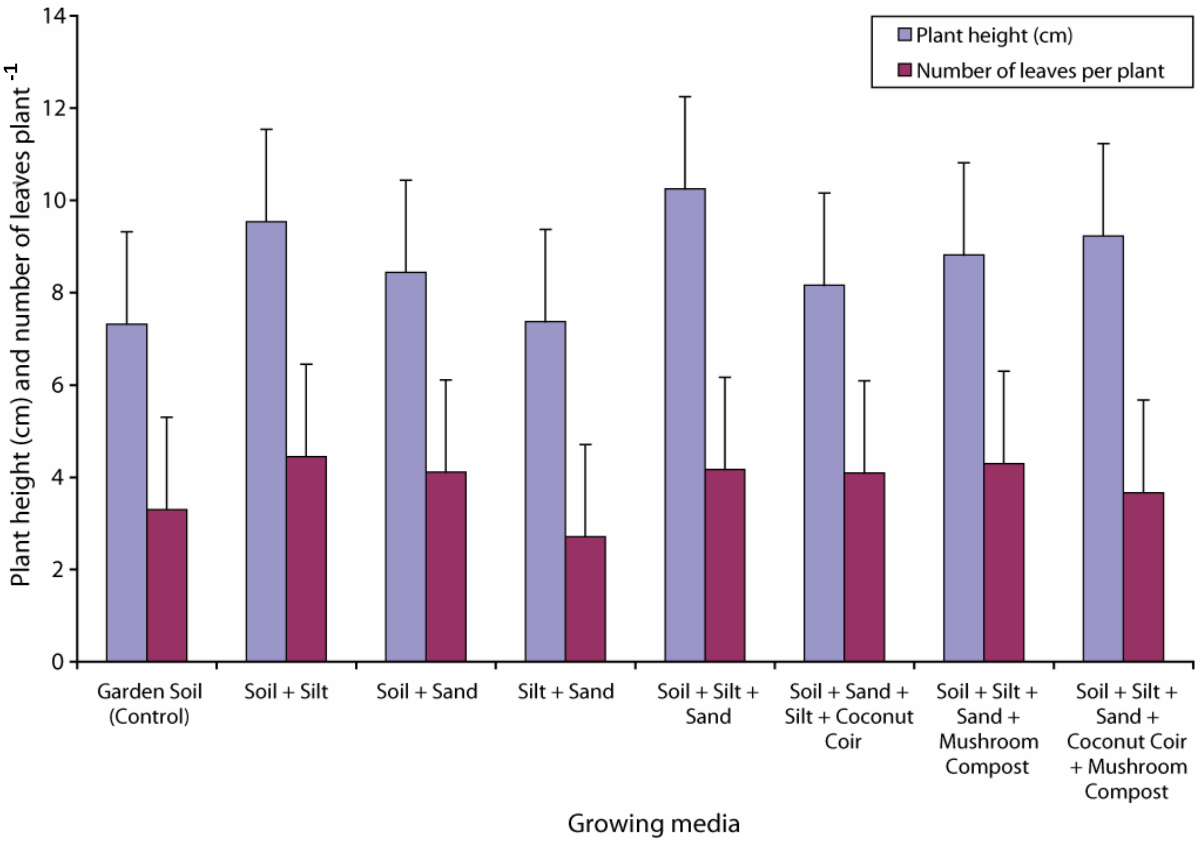

Fig. 1. Plant height (cm) and number of leaves plant^{-1} of gerbera as influenced by various growing substrates.
Y-error bars indicate the standard error (SE) among the three parallel replicates, which differ significantly at $p \leq 0.05$

Information procured on leaf area exhibited that soil + silt produced maximum leaf area (39.24 cm^2) followed by soil + silt + sand + coconut coir + mushroom compost (38.55 cm^2), soil + silt + sand (33.44 cm^2) and soil + sand (32.24 cm^2). Minimum leaf area was observed in plants grown in garden soil (control) and silt + sand (14.81 cm^2 and 26.41 cm^2, respectively) as shown in Fig. 2. Regarding days to flower emergence, soil + silt + sand + coconut coir + mushroom compost, soil + silt, soil + silt + sand + coconut coir, silt + sand and soil + sand initiated flowering after maximum days (92.33 - 89.67 days) and proved statistically at par with each other followed by soil + silt + sand + mushroom compost with 89.00 days and soil + silt + sand with 88.00 days for flower emergence which were also statistically at par with each other. Control (garden soil) produced early flowering with minimum days for flower emergence (84.67 days) (Fig. 2).

Data related to number of flowers plant^{-1} depicted that soil + silt produced maximum flowers plant^{-1} (3.50) followed by soil + silt + sand + coconut coir + mushroom compost (2.66). Soil + silt + sand + mushroom compost was statistically at par with soil + silt + sand + coconut coir, silt + sand and soil + silt + sand with 1.25, 1.25, 1.25 and 1.16 flowers plant^{-1}, respectively (Fig. 3). While garden soil (control) and soil + sand produced minimum flowers plant^{-1} (1.00 each) which confirmed the findings of Nowak & Strojny (2003). Plants grown in soil + silt produced maximum flower diameter (7.52 cm) followed by soil + sand, soil + silt + sand + coconut coir + mushroom compost, silt + sand and soil + silt + sand) (7.45, 7.18, 6.88 and 6.73 cm, respectively). Control (garden soil) produced minimum flower diameter (6.17 cm) followed by soil + silt + sand + mushroom compost and soil + silt + sand + coconut coir (6.57 and 6.67 cm, respectively) as shown in Fig. 3.

Data regarding flower stalk length exhibited that soil + silt + sand + coconut coir + mushroom compost produced longest flower stalks (29.10 cm) followed by soil + silt + sand + coconut coir (23.20 cm) and soil + silt + sand + mushroom compost (23.00 cm). Minimum flower stalk length (17.5 cm) was produced by control (garden soil) and it was statistically at par with soil + sand and soil + silt which produced 17.62 and 18.76 cm long stalks, respectively (Fig. 4). Data pertaining to flower stalk diameter illustrated that soil + silt + sand + coconut coir and soil + silt + sand + coconut coir + mushroom compost produced maximum flower stalk diameter (0.42 cm) followed by soil + silt + sand + mushroom compost and soil + silt which produced 0.37 and 0.34 cm thick flower stalks, respectively, and were statistically at par with each other. Plants raised in garden soil (control) and soil + silt + sand resulted in minimum flower stalk diameter (0.28 cm each) as shown in Fig. 5. Results obtained on flowers quality indicated that soil + silt + sand + coconut coir + mushroom compost produced best flower quality (7.33) followed by soil + silt, soil + sand, soil + silt + sand and silt + sand with 7.03, 6.50, 6.33 and 6.03, respectively. Control (garden soil) turned out into poor quality flowers (4.03). Soil + silt + sand + coconut coir and soil + silt + sand + mushroom compost were statistically at par with each other with 5.03 and 4.50 (Fig. 4).

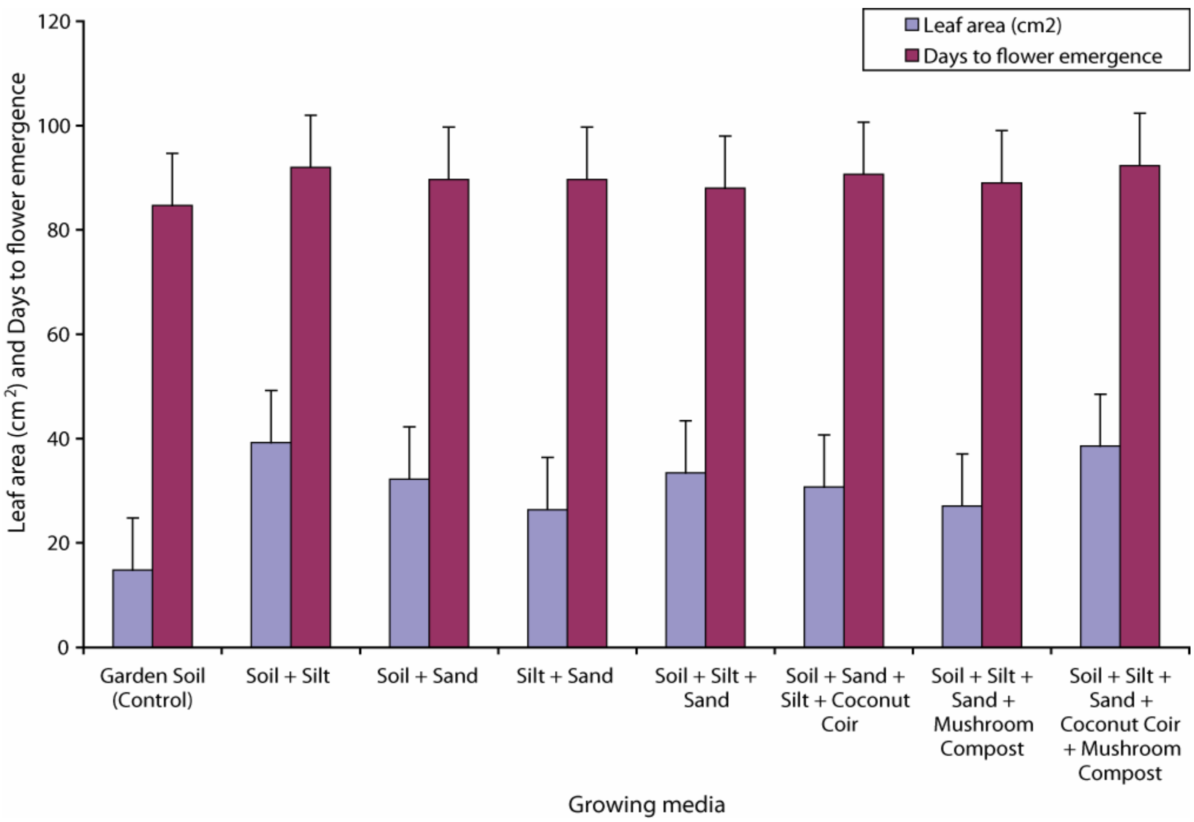

Fig. 2. Leaf area (cm^2) and days to flower emergence of gerbera as affected by various growing substrates.
Y-error bars indicate the standard error (SE) among the three parallel replicates, which differ significantly at $p \leq 0.05$.

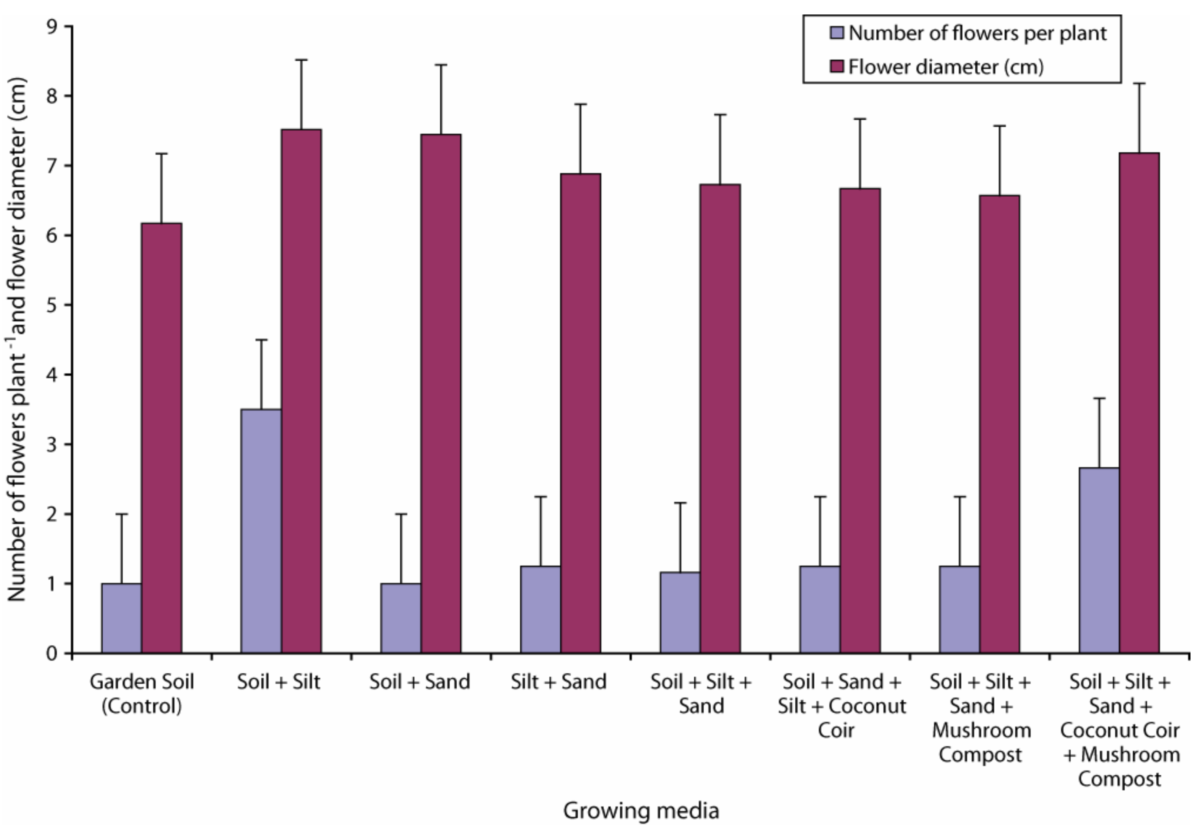

Fig. 3. Number of flowers plant^{-1} and flower diameter (cm) of gerbera as influenced by various growing substrates.
Y-error bars indicate the standard error (SE) among the three parallel replicates, which differ significantly at $p \leq 0.05$.

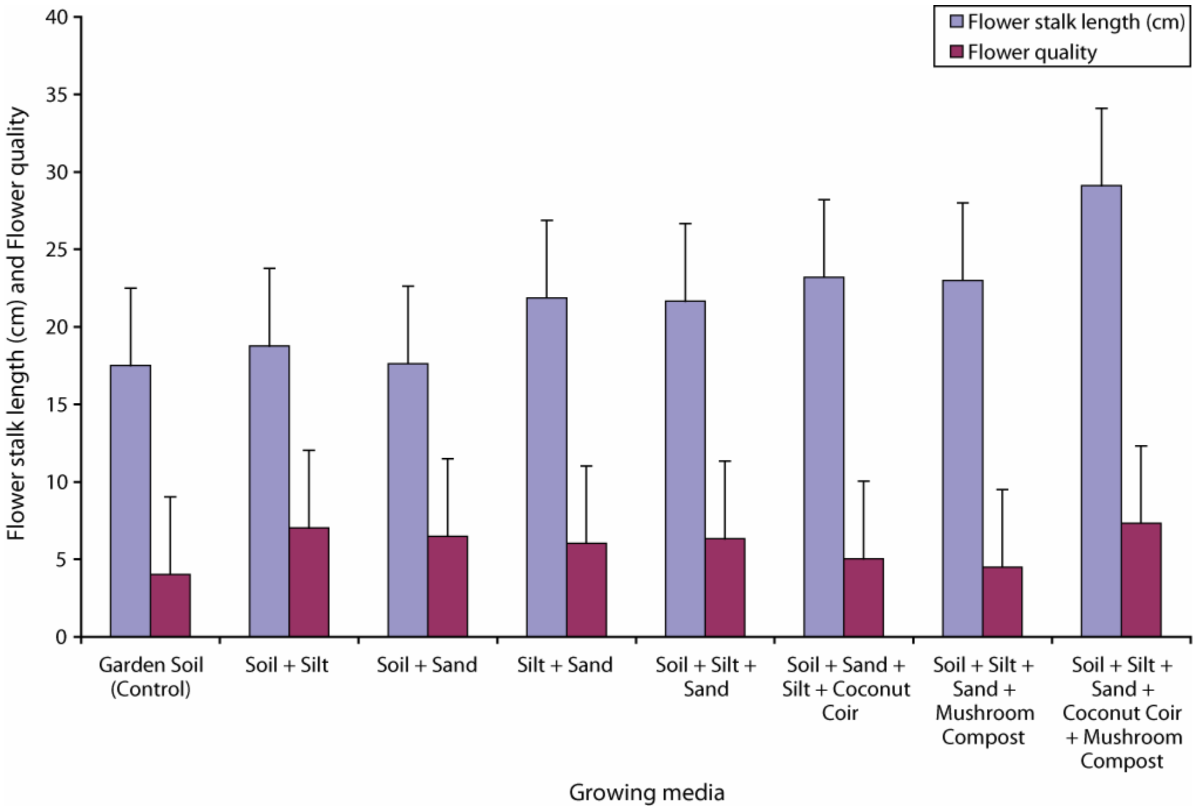

Fig. 4. Flower stalk length (cm) and flower quality of gerbera as affected by various growing substrates.
Y-error bars indicate the standard error (SE) among the three parallel replicates, which differ significantly at $p \leq 0.05$.

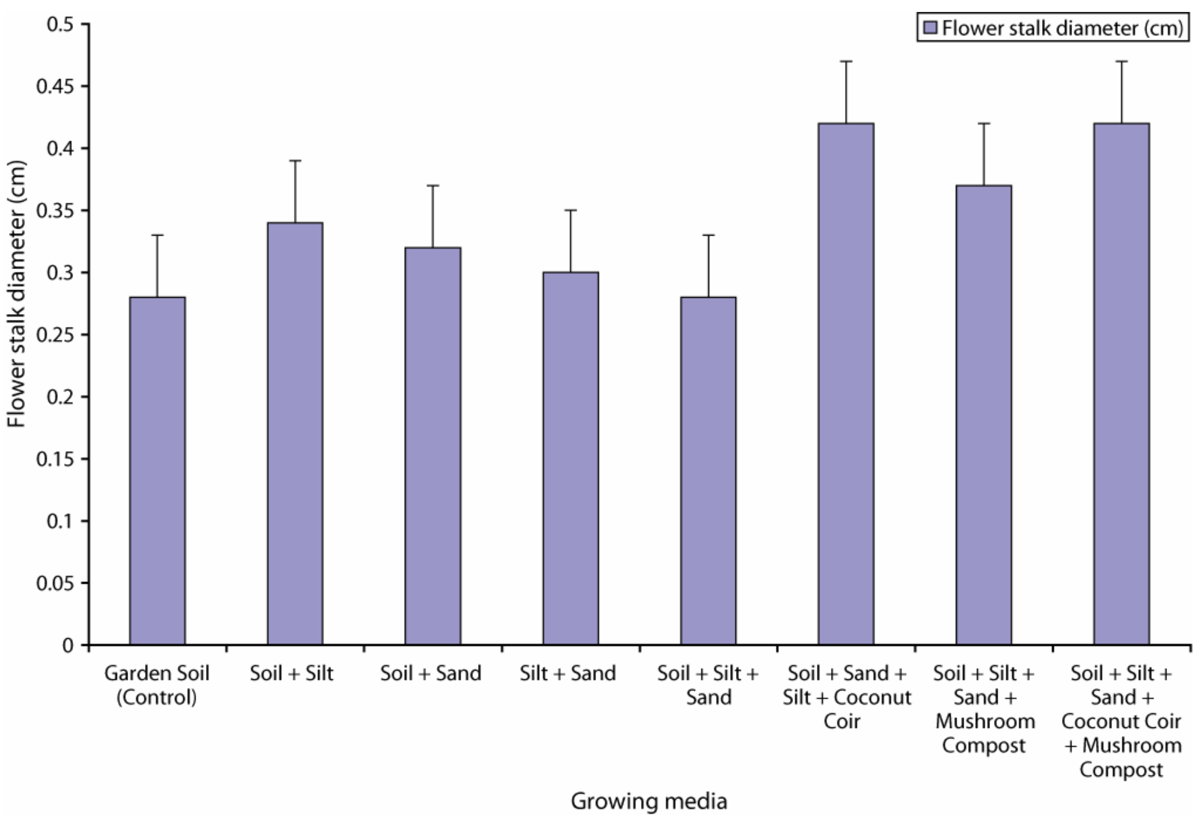

Fig. 5. Flower stalk diameter (cm) of gerbera as influenced by various growing substrates.
Y-error bars indicate the standard error (SE) among the three parallel replicates, which differ significantly at $p \leq 0.05$.

Data obtained on fresh weight of a flower revealed that soil + silt, soil + sand and soil + silt + sand + mushroom compost produced maximum fresh weight (3.60, 3.60 and 3.58 g, respectively) and were statistically at par with each other. Soil + silt + sand + coconut coir and silt + sand produced reasonably higher fresh weight of the flowers (3.27 and 3.07 g, respectively). Minimum fresh weight was observed in control (garden soil) and soil + silt + sand + coconut coir + mushroom compost with 2.73 and 2.79 g fresh weight, respectively, which were statistically at par with each other. Regarding dry weight of a flower, soil + silt produced maximum dry weight (0.93 g) followed by soil + silt + sand + coconut coir and silt + sand with 0.92 and 0.88 g, respectively. Soil + silt + sand + coconut coir + mushroom compost produced minimum dry weight of a flower (0.42 g) followed by soil + silt_+ sand + mushroom compost (0.56 g) as shown in Fig. 6 which was similar as observed by Caballero *et al.,* (2009). Control (garden soil), soil + sand and soil + silt + sand produced 0.83 g dry weight of a flower each and were statistically at par with each other. As for as fresh and dry weight ratio of a flower was concerned, soil + silt + sand + coconut coir + mushroom compost exhibited maximum fresh and dry weight ratio (6.73) of flowers followed by soil + silt + sand + mushroom compost (4.28) and soil + sand (3.78). Minimum fresh and dry weight ratio (3.29) was recorded in control (garden soil) followed by soil + silt, soil + silt + sand and soil + silt + sand + coconut coir (3.55, 3.59 and 3.61, respectively) which were statistically at par with each other (Fig. 6).

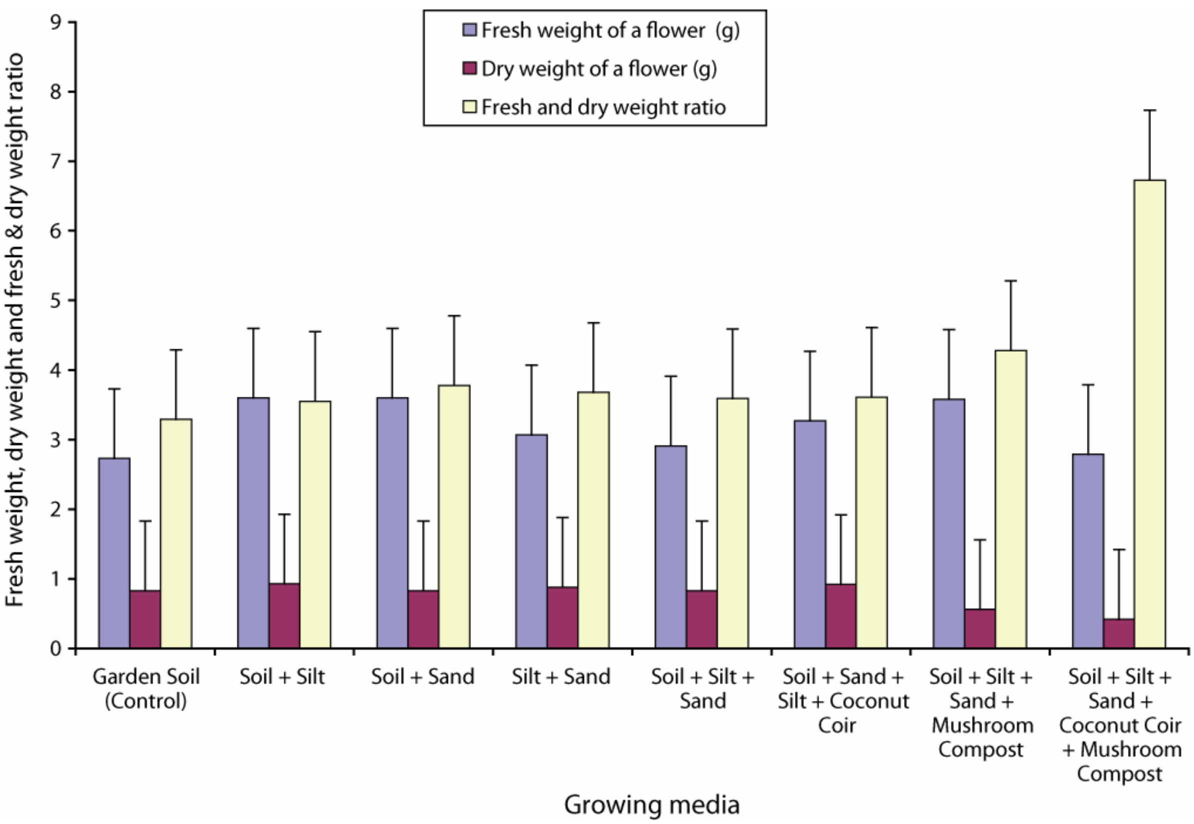

Fig. 6. Fresh & dry weight of a flower (g) and fresh and dry weight ratio of gerbera as affected by various growing substrates
Y-error bars indicate the standard error (SE) among the three parallel replicates, which differ significantly at $p \leq 0.05$.

Regarding physico-chemical comparison of various growing media, maximum pH (8.4) was observed in control (garden soil) while minimum pH was found in soil + silt + sand + coconut coir + mushroom compost, soil + silt + sand + mushroom compost and soil + silt + sand + coconut coir (7.6 each) which were statistically at par with each other. Similarly, soil + silt and soil + sand had pH of 8.2 and were statistically at par with each other. Silt + sand and soil + silt + sand had 8.1 and 7.9 pH and were statistically similar to each other (Table 1). In case of available organic matter, maximum organic matter (1.97%) was recorded in soil + silt + sand + mushroom compost followed by soil + silt + sand + coconut coir + mushroom compost (1.93%). Minimum organic matter (0.41%) was observed in soil + silt + sand garden soil (control) and soil + sand (0.52% each) as shown in Table. 1. Data regarding electrical conductivity of the media depicted that maximum EC (0.73 dS m^{-1}) was observed in soil + silt + sand + mushroom compost, soil + silt + sand + coconut coir + mushroom compost and soil + silt + sand (0.59 dS m^{-1} each). Minimum EC (0.36 dS m^{-1}) was recorded in soil + sand, and soil + silt (0.38 dS m^{-1}) (Table 1).

Data pertaining to available phosphorus revealed maximum available phosphorus (27 mg L^{-1}) in soil + silt + sand + mushroom compost followed by soil + silt + sand + coconut coir + mushroom compost (25 mg L^{-1}). Minimum available phosphorus (14.2 mg L^{-1}) was observed in silt + sand followed by soil + silt + sand + coconut coir and soil + sand (15.52 and 16.5 mg L^{-1}) (Table 1). Results regarding available potassium depicted maximum available potassium (500 mg L^{-1}) in soil + silt + sand + coconut coir + mushroom compost, soil + silt + sand + mushroom compost and soil + silt + sand + coconut coir which were statistically at par with each other. Minimum available potassium (120 mg L^{-1}) was recorded in silt + sand (Table 1).

Table 1. Physico-chemical characteristics of various substrates.

	pH	EC (dS m^{-1})	Organic Matter (%)	Phosphorus (mg L^{-1})	Potassium (mg L^{-1})
Garden soil	8.4 a	0.46 c	0.52 d	21.30 c	290 b
Soil + Silt	8.2 ab	0.38 d	0.62 c	19.20 d	250 c
Soil + Sand	8.2 ab	0.36 d	0.52 d	16.50 e	220 d
Silt + Sand	8.1 b	0.46 c	0.62 c	14.20 f	120 e
Soil + Silt + Sand	7.9 b	0.59 b	0.41 e	16.80 e	230 cd
Soil + Sand + Silt + Coconut Coir	7.6 c	0.47 c	0.82 b	25.20 b	500 a
Soil + Silt + Sand + M. Compost	7.6 c	0.73 a	1.97 a	27.00 a	500 a
Soil + Silt + Sand + Coco Coir + M. Compost	7.6 c	0.59 b	1.93 a	25.00 b	500 a

Means not sharing similar letters are significantly different ($p \leq 0.05$)

Discussion

The improved quality attributes and similar growth indices with the substrates containing coconut coir and spent mushroom compost are consistent with previous findings. It has been well established that maximum growth and best quality yield can be achieved by a combination of proper concentrations of nutrients alongwith growing media. Results regarding plant height exhibited superiority of soil + silt + sand (conventional media) over rest of the substrates which were in agreement with the results of Martinez *et al.,* (1982) who obtained maximum plant height of dieffenbachia by using peat + bark as media. The number of leaves in gerbera might be influenced when grown under certain environmental conditions. Any deviation in the environment, of course, exerts its influence on growth and development of plants. These results confirmed the findings of Deboodt & Verdonek (1971) and Fascella & Zizzo (2005) who observed similar number of leaves of *Monstera deleciosa* and roses grown in peat and coco coir.

Regarding leaf area, different substrates behaved statistically different while similar trend was observed in relation to the number of leaves. This can hardly be reconciled because the number of leaves could be considered as the most important rather than other factors contributing towards leaf area. Similar trends have also been reported by Deboodt & Verdonek (1971) who observed longer leaves of *Moranta* spp. by using peat + polyether as potting media, Martinez *et al.,* (1982) of *Dieffenbachia spp.* when grown in peat + bark and Paradiso & de Pascale (2008) in gerbera when grown in a substrate containing coco fiber along with perlite.

The results regarding days to flower emergence depicted that treatments having nutrient rich media promoted vegetative growth and slightly delayed plant maturity as a result of which plants grown in these media took comparatively more time to initiate flowering while the substrates having poor nutrition exhibited early maturity and flowered earlier as compared to other substrates. Results in Fig. 2 revealed that variation in media composition did not significantly affect the number of days required for flowering. All plants grown in various media except control began to produce flower buds after 88-92 days of transplanting. These findings are in alliance with the observations of Grassotti *et al.,* (2003) who claimed early flower emergence in gladiolus and lily when grown in traditional media. Potting media having a combination of soil + silt produced large sized flowers which exhibited superiority of conventional media being practiced in the country over horticultural by-products for this parameter of study.

Flower growth and development is mainly influenced by the availability of phosphorus to plant in a growing medium which ultimately resulted in increased flower stalk length. Plants grown in substrates containing coconut coir and/or mushroom compost produced longer flower stalks which are in line with the findings of Fascella & Zizzo (2005) who observed longest stalks of roses when grown in combination of perlite with coco fiber. Differences in various substrates composition markedly affected flower stalk length and diameter. Media which had more phosphorus contents produced thicker stalks as compared to other treatments. These findings confirmed the findings of Grassotti *et al.*, (2003) who observed thick flower stalks of gladiolus and lily when grown in various nutrient rich media. As these quality attributes were positively affected by substrates containing coconut coir and mushroom compost, flower quality was also good. Differences in media composition markedly affected flower quality and media rich in nutrients and with favorable physico-chemical properties produced best quality blooms as compared to rest of the treatments. These results confirmed the findings of Nowak & Strojny (2003) who claimed best quality gerbera production in coir dust. Flower fresh and dry weights are also important indices which affect postharvest longevity of the flowers. No clear pattern of these weights was observed in different treatments as shown in Fig. 6.

Initial pH and EC of a substrate are two important characteristics which directly affect nutrient availability. Variability in composition of a substrate reasonably affected initial pH and EC values of various media as shown in Table 1. It was observed that all substrates had

EC levels well below harmful level of > 4 dS m^{-1}. Similar trend is reported by Awang ***et al.,*** (2009) and Caballero *et al*., (2009) who observed minimum pH and acceptable electrical conductivity in coco fiber while comparing various substrates for celosia and gerbera production.

Nutrient availability is one of major factor which determines the suitability of a substrate to be used for growing plants (Caballero ***et al.,*** 2007). It not only depends on the nutrient composition of the media but also on other factors like nutrient form, pH, adsorption capacity and dissolved organic compounds (Caballero ***et al.,*** 2007). This may be due to high available organic matter percentage and various nutrients like P and K. Similar trends have also been reported by Caballero *et al*., (2009) who observed maximum available phosphorus in coco fiber and potassium in spent mushroom compost while comparing various substrates for gerbera production.

Conclusion

In conclusion, incorporation of coconut coir and mushroom compost improved certain physico-chemical properties of conventional media (soil, silt and sand, 1:1:1, v/v/v) which enhanced nutrient availability to plants in turn improving growth and quality. Positive effect of mushroom compost on P availability and high EC and of both coconut coir and mushroom compost on K availability, low pH and high organic matter was observed which were also reflected in better flower quality but not flower yield. These findings suggest that these horticultural by-products can be incorporated in growing substrates to improve flower quality as well as nutrient availability.

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