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ORIGINAL RESEARCH

Evaluating sustainable and environment friendly substrates for quality production of potted *Caladium*

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Abstract
Purpose Effect of various combinations of potting substrates was assessed to enhance vegetative growth, plant productivity and mineral composition of *Caladium bicolor*.
Methods Different substrates like leaf compost, farmyard manure, coconut compost, compost and perlite were used in different combinations with silt. Bulbs were sown in pots filled with different combinations of potting substrates, which were arranged under completely randomized design (CRD), with three replications, and totally there were ten treatment combinations.
Results Application of different treatments of growing media either alone or in combinations led to considerable improvement in plant growth characteristics as compared to respective control. However, response differed according to the type of media manipulation. The highest stimulatory effect with maximum plant growth in terms of early sprouting, plant height, leaf area, chlorophyll contents, fresh and dry weights of tubers was observed in plants treated with silt+leaf compost+perlite combination; this combination significantly enhanced plant growth (30−150%) as compared to control. In case of NPK and protein contents, treatment combination of silt+leaf compost+coconut compost was greatly affected which lowered the pH, increased available organic matter and consequently maximized nutrient uptake by the plants.
Conclusions The best selection of conventional organic and inorganic potting media is the key to successful mass propagation of containerized plants. Generally, it could be concluded that application of potting mixes with silt, perlite, leaf composts and coco-based residues is a good cultural practice to improve the crop productivity and provide a better growing environment for plants.

Keywords Foliage plants · Organic · Inorganic substrates · Potting medium · Caladium

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Introduction

Caladium (*Caladium bicolor* L.) is an excellent ornamental plant, commonly known as “Angel’s Wing” which belongs to family Araceae. This genus is mostly grown for its spectacular foliage features with symmetrically marked in a variety of colors and patterns. Its heart shaped leaves vary in size from six inches to two feet and edged in green-red, green-white and red with white marks (Zhu et al. 1993). Due to its magnificent decorative foliage beauty and color versatility, it is considered as unique addition in indoor and outdoor beautification as it is used in borders, beddings, rockeries, pots, as a filler, window boxes and fresh flower arrangement (Deng and Harbaugh 2006).

Cultivation of foliage ornamental plants contributes to the biggest segment of the floriculture industry followed by potted flowering and nursery plants, flowering bulbs and other plant material for propagation purposes (Dole and Wilkins 2005). Foliage plants need suitable rooting atmosphere for better growth whereas traditional soils generally have some inherent problems, especially for the production of plants in containers in terms of poor aeration and drainage, and may contain insects, weed seeds and disease causing organisms. The frequent water demanded by container plants will cause various soils to compact into a tight, brick-like mass (Tariq et al. 2012) and nutrition management is also more difficult because indigenous soils have their own nutritional status, which interferes with the plant nutrient uptake ability for the growth and development (Younis et al. 2013a). Nursery production of container plants and greenhouse plant production mainly depends on a number of soilless cultural practices (Wilson et al. 2003; Younis et al. 2011). One of them, most important cultural input is growing media that is the basic prerequisite for better growth and development of horticultural plants (Younis et al. 2013b).

Growing media or components for potting soil mixes have gained popularity for several decades and have been successfully used in the cut flower industry with aim to intensify the commercial production (Maloupa et al. 1992). An ideal growing mix used to produce greenhouse floricultural crops should have four basic functions, deliver aeration and water, provide suitable anchorage for maximum root growth, physically support the plant and create a reservoir of adequate nutrient uptake (Tariq et al. 2012). Now various organic ingredients like peat moss, green compost, animal manures, coco peat and inorganic/mineral potting substrates such as sand, gravel, perlite and silt are being utilized for domestic and commercial purposes. Several studies advocated that it is much easier to handle soilless growing media and it is also good for growth and development of plants as compared to soil environment (Yasmeen et al. 2012). In case of Caladium, it should be planted in porous soils that contain organic matter so that aeration, drainage and sufficient water holding capacity of soil ensures proper growth (Thomas 2009).

Numerous studies revealed that peat can be substituted by synthetic fertilizers without any negative effects on a variety of ornamental plant growth and development raised in these substrates (Abad et al. 2002; Linderman and Davis 2003; Larcher and Scariot 2009; Riaz et al. 2008; Younis et al. 2010). Diverse mineral substrates have distinctive traits which could have direct or indirect effects on plant growth and development (Younis et al. 2013a). Similarly, perlite and clay were incorporated with peat and compost as a part of growing medium. It was determined that growing media statistically affected morphological and reproductive attributes (Savvas et al. 2004; Ghazvini et al. 2007). Diversified composition of growing media has a profound effect on physical, chemical and biological properties of the substrate. This diversified composition also alters the activities of microorganisms which ultimately decreases the nitrogen losses and increases the cation exchange capacity (Alidoust et al. 2012; Younis et al. 2013b). Compost or mixture of these substrates acts as an excellent soil conditioner (Bulluck et al. 2002), applied in different ratio had significant effects on plant biomass (Arancon et al. 2004; Younis et al. 2011), cultivars heights (Beeson, 1996), number of leaves (Eklind et al. 2001), chlorophyll index (Hashemimajd et al. 2004), plant fresh and dry weight (Wang and Lin 2006), greater availability of mineral nutrients to plants (Zaller 2009).

However, particular scientific findings regarding this specific ornamental plant are insufficient, therefore, keeping in view the aesthetic importance of the *Caladium* and role of substrates in its growth, the current study was planned to check the efficacy of diversified composed growing media having the following components (compost, silt, farmyard manure, peat moss, leaf compost and perlite) in different proportions for the growth, physiology and quality characters of the *Caladium bicolor*.

Materials and methods

Experimental setup and treatment plan

The experiment was carried out at the floriculture research area in the Institute of Horticultural Sciences, University of Agriculture, Faisalabad during the year 2011–2012 (latitude 31°30′′N, longitude 73°10′′E and altitude 213 m) to evaluate six growing substrates viz. Leaf manure, farm yard manure, compost, coco peat, peat moss and perlite for *Caladium bicolor* cv. John Peed. Bulbs were sown in clay pots (8 in. diameter from top and 10 in. height) on 01-04-2011. Nine treatment combinations were made in different ratios by volume from these six growing substrates and treatments for this experiment were T_0, Silt (S); T_1 silt+leaf compost (SLC); T_2 silt+farm yard manure (SFYM); T_3 silt+coco peat (SCP); T_4 silt+compost (SC); T_5 silt+perlite (SP); T_6 silt+farm yard manure+leaf compost (1:1:1); T_7 silt+coco peat+leaf compost (SCPLC); T_8 silt+perlite+leaf compost (SPLC) in 1:1:1 ratio and T_9 silt+peat moss+compost (1:1:1). Treatment T_0, which contained silt only, was considered the standard. For compost formation, garden residues (leaf pruning and clippings) were used after 90 days of decomposition process kept under 62 °C temperature in compost bin. Two grams of soluble NPK fertilizer (19-19-19) was applied to each pot once after transplantation.

During whole growth period, all the cultural practices weeding, fertilizer application, pesticide application and irrigation application were kept same for all the experimental units. The design used for experiment was completely randomized design (CRD), with three replications and there were total ten treatments. There were total ninety plants in this experiment with nine plants each treatment.

Physio-chemical analysis for potting media

Before start of experiment, the different media compositions were subjected to analysis for chemical properties like EC, pH, organic matter contents and N, P and K contents presented in (Table 1). The electrical conductivity (EC) was measured in dS m^{-1} with a conductivity meter and a pH meter (digital ion analyzer) was used to measure the pH of the potting media (Thomas 1996). The total nitrogen in the media sample was determined by distillation in Kjeldahl's apparatus and titration was carried out with standard H_2SO_4. Boric acid and methyl red were used as indicators (Jackson 1962; Bremner and Mulvaney 1982). Olsen's method was used to determine the available phosphorus in the media (Watanabe and Olsen 1965; Olsen et al. 1984) and for the assessment of potassium the United States Salinity Laboratory Staff's (1954) method of flame photometer was used.

Plant growth characteristics

Following observations on plant vegetative growth characteristics were taken during the course of study like days to bulb sprouting (days), plant height (cm), leaf area (cm^2), leaf thickness (mm), petiole diameter (cm), number of shoots $plant^{-1}$, leaf fresh weight (g), leaf dry weight (g), tuber fresh weight (g) and tuber dry weight (g).

Leaf nutrient sampling and measurements

Leaves of Caladium were analyzed for following physiological parameters chlorophyll contents (SPAD value), nitrogen contents (%), phosphorus contents (mg/L), potassium contents (mg/L) and total soluble proteins (%). Chlorophyll contents were measured with chlorophyll meter (SPAD 502, Minolta, Japan), nitrogen was estimated by the method described by Chapman and Parker (1961). Phosphorus was determined using spectrometer (Model U 2020) and potassium was determined by flame photometer (Flame Photometer 410) by the method described by Chapman and Parker (1961). Total proteins in the samples were estimated using the same procedure as for nitrogen. The following formula was used.

$$\text{Protein}\ \% = N\% \times 6.25$$

Statistical analysis

The collected data for the morphological and physiological traits of the plants were statistically analyzed by using analysis of variance (ANOVA) technique to check any differences between the means. Significant means were compared using least significance test (LSD) at a 5% probability level (Steel et al. 1997).

Results

The collected data regarding the morphological traits by using different potting substrates were analyzed statistically at a 5% level of probability. Treatments means were

Table 1 Physical–chemical characteristics of various potting substrates utilized for growing *Caladium*

Treatments	pH	EC (dS m^{-1})	Organic matter (%)	N%	P (mg/L)	K (mg/L)
T_0	6.50	1.28	0.67	0.28	3.05	130
T_1	6.80	2.48	0.88	1.97	2.47	190
T_2	6.80	2.98	1.66	1.44	20.14	250
T_3	6.80	4.62	2.28	1.08	21.23	220
T_4	6.70	2.61	2.43	1.06	22.32	200
T_5	6.60	3.65	2.12	1.48	23.41	500
T_6	6.60	3.43	1.55	1.40	24.54	330
T_7	6.40	3.92	1.52	1.31	25.66	310
T_8	6.30	2.16	2.84	2.40	26.77	450
T_9	6.90	5.36	1.05	1.09	27.85	300

Treatment description: T_0 (Control), T_1 (Silt+Leaf compost), T_2 (Silt+Farmyard manure), T_3 (Silt+Coconut compost), T_4 (Silt+Compost), T_5 (Silt+Perlite), T_6 (Silt+Leaf Compost+Farmyard manure), T_7 (Silt+Leaf Compost+Coconut compost), T_8 (Silt+Leaf Compost+Perlite), T_9 (Silt+Compost+Peat moss) subjected to least significance difference (LSD) test and each treatment showed different responses. Results regarding morphological attributes, fresh and dry weights, biochemical traits and protein contents of Caladium are as follows.

Morphological attributes of *Caladium*

Days to germination

The results for days to germination showed that T_8 (silt+perlite+leaf manure) used as a growing medium during *Caladium* forcing showed early germination, took minimum days to sprouting (16 days) with respect to other treatments. Among treatment comparison, non-significant effect was noticed in T_6 and T_9 took 18 days, similarly T_1 and T_4 took 23 days to germination. The bulbs sown in T_0 (control) took maximum days (24 days) to sprout in as shown in Table 2.

Plant height

Results for data pertaining to plant height indicated that treatment combination (T_8) consisting of silt+perlite+leaf manure showed the significant superiority with maximum plant height 52.25 cm followed by all treatments. While, minimum plant height (28.83 cm) was observed in T_0 (Silt).

Leaf area

In response to different growing media, significant difference in leaf area of *Caladium* plants was observed. It was recorded that silt+perlite+leaf manure comprises in T_8 presented maximum leaf area (715.46 cm^2), which was followed by T_7 (silt+leaf compost+coconut compost), T_6 (silt+leaf compost+farmyard manure), T_2 (silt+farmyard manure), T_9 (silt+compost+peat moss) and T_3 (silt+coconut compost) taking 612.38, 504.37, 461.36, 428.36 and 404.69 cm^2 leaf area, respectively. The least leaf area (284.46 cm^2) was counted in control treatment in which only silt was used as a potting medium.

Chlorophyll contents

Statistical variations in leaf chlorophyll contents were observed in the plants treated with various combinations of potting media. Combine application of silt+perlite+leaf manure (T_8) in equal proportion increased the chlorophyll contents in leaves 51.59 SPAD while treatment comparison, T_4 and T_5 in which mixture of silt with perlite and compost was almost same in chlorophyll increment which was 42.07 and 42.88 SPAD value. Minimum leaf chlorophyll (37.13) was noticed in T_0 where only silt was applied (Table 2).

Petiole diameter

The variations in petiole diameter were observed with application of various combinations of potting media. Combine application of silt+perlite+leaf manure (T_8) in equal proportion increases the petiole diameter 12.37 cm as compared to other potting mixes combination. While treatment comparison showed that T_0, T_4, T_1, T_5 were not statistically different. Minimum petiole diameter (4.58 cm) was noticed in T_0 (silt) (Table 2).

Number of shoots

Results regarding shoot increment stated highly significant response in treatment T_8 (silt+leaf compost+perlite) which counted 17 shoots. The plants grown under T_5 treatment in

Table 2 Effect of different potting substrates on plant characteristics of *Caladium*

Treatments	Days to sprouting (days)	Plant height (cm)	Leaf area (cm^2)	Chlorophyll contents (SPAD)	Petiole diameter (cm)
T_0	24 ± 0.72 a	28.83 ± 0.11 j	285.46 ± 0.57 j	38.37 ± 0.46 g	4.58 ± 0.33 f
T_1	23 ± 0.64 ab	33.51 ± 0.88 h	334.17 ± 0.95 h	41.18 ± 0.33 f	5.04 ± 0.28 f
T_2	19 ± 0.69 de	42.79 ± 0.42 d	461.36 ± 0.87 d	46.37 ± 0.60 c	8.49 ± 0.24 c
T_3	20 ± 0.14 cd	38.81 ± 0.54 f	404.69 ± 0.58 f	44.55 ± 0.70 d	6.13 ± 0.88 de
T_4	23 ± 0.69 ab	31.11 ± 0.35 i	314.84 ± 0.86 i	42.07 ± 0.41 ef	4.87 ± 0.43 f
T_5	22 ± 0.67 bc	35.85 ± 0.57 g	357.94 ± 0.98 g	42.88 ± 0.36 e	5.16 ± 0.17 ef
T_6	18 ± 0.61 e	46.12 ± 0.46 c	504.37 ± 0.87 c	50.57 ± 0.40 a	9.62 ± 0.33 b
T_7	17 ± 0.29 f	49.21 ± 0.31 b	612.38 ± 0.49 b	48.46 ± 0.32 b	10.37 ± 0.59 b
T_8	16 ± 0.63 f	52.25 ± 0.58 a	715.46 ± 0.75 a	51.59 ± 0.67 a	12.36 ± 0.40 a
T_9	18 ± 0.60 e	40.92 ± 0.36 e	428.38 ± 0.81 e	45.73 ± 0.58 cd	6.71 ± 0.27 d

The data present as different traits in caladium plants and mean ± standard error. Letters (a–z) in each column exhibit significant difference among means at $P < 0.05$ (LSD$_{0.05}$)

which only inorganic media (silt+perlite 1:1) was incorporated, exhibited highest effect than T_0, T_1 and T_4. Beside this, T_6 and T_7 produced similar number of shoots per plant (16) where no statistical difference was found.

Fresh and dry weights of Leaves

Results in Table 3 shows that leaf fresh and dry weight of plants increased in potting media combination containing silt+leaf compost+perlite (T_8) than other potting mixes combination. In comparative evaluation among treatments, the treatment T_2 and T_9 exhibited satisfactory results for gain in fresh weight but their effect was not different to each other at $P < 0.05$. Leaf dry weight did not show significant variation among top treatment assessment. Statistically similar results were observed for T_6, T_7 and T_8 producing 6.00, 6.22 and 6.72 g leaves dry weight, respectively.

Fresh and dry weights of tubers

In case of tuber weights, it was observed that potting media treatments including organic and inorganic application affected tuber fresh and dry weights (Table 3). The addition of silt+perlite+leaf manure increased tuber fresh and dry weights in comparison to mixtures. Treatment T_6, T_7 and T_8 showed highly significant difference for increase in fresh weight but their significant effect was not observed in case of tuber dry weight. The treatment T_8 produced maximum tuber fresh and dry weight (95.56 g and 11.70 g).

Nitrogen contents

The results presented in Table 4 indicated that the combined use of growing media had positive effect for nitrogen absorption in this experiment. Plants grown in media containing silt+leaf compost+coconut compost combination (T_7) absorbed highest nitrogen uptake (1.55%) by leaves. The plants in pots provided silt+leaf compost+perlite media combination also increased the N-contents up to (1.47%) and its effect was higher but not highly significant than others treatment.

Phosphorous contents

Soilless growing media with appropriate combination could prove constructive approach towards phosphorous uptake by the plants. Table 4 shows the increase in phosphorous contents of leaves with the application of organic and inorganic. The growing media which had combination of silt+leaf compost+coconut compost (T_7) showed maximum P-contents (30.46 mg/L) than rest of all treatments. All treatments in which we added different soilless growing media with different proportion have performed better for P uptake except control which gave lowest mineral absorption. So, normal or garden soil can easily replace by addition of potting media for proper nutrients absorption.

Potassium contents

In case of Potassium contents, Table 4 showed increase of potassium contents in leaves in response to the application of organic and inorganic mixes than control. The maximum K-contents (139.29 mg/L) were found in growing media which had silt+leaf compost+coconut compost (T_7). All other treatments with different soilless growing media performed better in K uptake except control whose effect was lowest in mineral absorption.

Protein contents

Result regarding protein contents of leaves in response to different growing media are given in Table 4 as treatment

Table 3 Effect of different potting substrates on plant biomass of *Caladium*

Treatments	Number of shoots plant^{-1}	Leaf fresh weight (g)	Leaf dry weight (g)	Tuber fresh weight (g)	Tuber dry weight (g)
T_0	6 ± 0.57 g	44.99 ± 0.88 h	2.31 ± 0.89 d	64.97 ± 0.25 i	5.01 ± 0.46 f
T_1	9 ± 0.53 ef	58.13 ± 0.45 g	3.59 ± 0.10 cd	76.76 ± 0.90 g	6.69 ± 0.33 de
T_2	14 ± 0.66 bc	69.11 ± 0.92 d	5.78 ± 0.39 ab	86.85 ± 0.29 cd	8.86 ± 0.63 c
T_3	12 ± 0.33 d	64.29 ± 0.58 e	5.50 ± 0.20 ab	82.78 ± 0.66 e	7.65 ± 0.57 cde
T_4	8 ± 0.56 f	56.16 ± 0.87 g	3.01 ± 0.29 d	71.83 ± 0.87 h	6.10 ± 0.58 ef
T_5	5 ± 0.51 e	61.73 ± 0.84 f	4.62 ± 0.33 bc	79.35 ± 0.67 f	7.13 ± 0.59 de
T_6	16 ± 0.54 ab	71.78 ± 0.78 c	6.00 ± 0.06 a	88.85 ± 0.88 c	9.19 ± 0.33 bc
T_7	16 ± 0.88 ab	76.97 ± 0.88 b	6.22 ± 0.38 a	91.64 ± 0.54 b	10.47 ± 0.58 ab
T_8	17 ± 0.63 a	87.40 ± 0.70 a	6.72 ± 0.58 a	95.56 ± 0.66 a	11.70 ± 0.57 a
T_9	13 ± 0.31 cd	67.25 ± 0.57 d	5.61 ± 0.57 ab	85.06 ± 0.87 d	8.12 ± 0.50 cd

The data present as different traits in caladium plants and mean ± standard error. Letters (a–z) in each column exhibit significant difference among means at $P < 0.05$ ($LSD_{0.05}$)

Table 4 Effect of different potting substrates on NPK contents and total soluble proteins of *Caladium*

Treatments	Nitrogen contents (%)	Phosphorus contents (mg/L)	Potassium contents (mg/L)	Total soluble proteins (%)
T_0	0.98 ± 0.01 j	9.63 ± 0.60 j	81.64 ± 2.01 j	1.20 ± 0.37 h
T_1	1.26 ± 0.04 h	17.48 ± 2.08 g	123.72 ± 5.01 g	3.87 ± 0.26 f
T_2	1.35 ± 0.01 c	21.66 ± 2.01 de	130.58 ± 5.68 e	5.43 ± 0.21 d
T_3	1.31 ± 0.08 e	20.96 ± 1.00 f	127.17 ± 4.17 f	4.40 ± 0.28 e
T_4	1.15 ± 0.03 d	12.43 ± 1.00 i	113.55 ± 2.51 i	2.68 ± 0.21 g
T_5	1.23 ± 0.02 g	14.39 ± 1.53 h	119.39 ± 2.09 h	3.47 ± 0.20 f
T_6	1.45 ± 0.03 f	25.23 ± 1.00 c	134.47 ± 3.11 cd	7.35 ± 0.13 c
T_7	1.56 ± 0.06 a	30.46 ± 1.16 a	139.29 ± 5.04 a	10.05 ± 0.15 a
T_8	1.48 ± 0.04 b	27.56 ± 1.53 b	136.11 ± 4.73 b	8.03 ± 0.31 bc
T_9	1.37 ± 0.06 i	23.79 ± 1.16 d	133.01 ± 0.01 d	5.89 ± 0.22 d

The data present as different traits in caladium plants and mean ± standard error. Letters (a–z) in each column exhibit significant difference among means at $P < 0.05$ ($LSD_{0.05}$)

mean. The significant results were obtained in the treatment T_7 (silt+leaf compost+coconut compost) where 10.05% protein contents were observed. Other potting media combination of T_8, and T_6 showed remarkable contribution to protein contents increment 8.02 and 7.34% respectively and significant effect was examined in this study trial. In comparison with different media combination, the lowest effect was recorded in T_4 in which silt+-compost were used.

Discussion

This pot study was visualized with the observation to monitor Caladium growth and find out some good combination of potting media to have the positive effect on crop growth. It was observed from this experiment that vegetative growth and plant biomass were positively affected when plants grown under all different media concentration than control. However, the comparative performance of all potting combination showed that T_8 (silt+leaf compost+perlite) and T_7 (silt+leaf compost+coconut compost) were approved to be most suitable mixture which significantly improve the overall growth and biomass of *Caladium*. Soilless potting substrates are commonly used for better seedling growth and quick germination in greenhouse bedding and potted plants (Baiyeri 2003; Younis et al. 2008). From this experiment, it was perceived that potting media with a combination of organic (leaf manure) and inorganic (perlite) with silt reduced the mean germination time and showed fast bulb growth compared to other media combinations and control treatment. It can be concluded that the combinations of the above growing media are best because different media are rich in different nutrients and multi-nutrient substrates are good for the soil chemical, physical and biological properties. In different plant species early sprouting depends upon the air, water content and temperature of the medium (Guerin et al. 2001). Similar findings were observed by Shah et al. (2006) where FYM, leaf compost and silt at 1:1:1 ratio as growing substrate for *Ficus binnendijkii* c.v. Amstel Queen gave highest sprouting percentage. Results are also in accordance with the outcomes of Riaz et al. (2008) who observed the early seedling germination in *Zinnia elegans* under influence of silt, compost, and leaf manure media. It is suggested to use balanced potting substrates for ornamental plants in order to get maximum plant height. All potting media combinations showed highly significant effect for this growth character. The highest stimulatory effect and the maximum enhancement in plant height was noticed in pots mixed with silt, perlite, and leaf manure in 1:1:1 ratio as a potting media (Table 1). This combination performed best because in this combination pH and amount of nitrogen was optimum, these finding are in relation with the findings of Grassoti et al. (2003), they found that *Lilium* as a cut flower give maximum plant height when different media were used as potting substrate. Results also showed that different media with different combinations have more effects on plant height. Treder (2008) also confirmed the above findings where plants attained maximum height when grown in media containing perlite.

Leaf area and leaf chlorophyll activities are important components of growth, which directly target plant photosynthetic activates (Younis et al. 2015). In this study, results showed that leaf area was significantly increased by treating plants with different potting media combinations compared to control, however, plants grown in silt, perlite, and leaf manure with equal proportion depicted the highest leaf area expansion among treatment comparison. These results are similar to that of Khan et al. (2002) who also observed maximum leaf area in gladiolus flowers where they used media containing silt, perlite and farm yard manure. Similarly, Nowak and Strojny (2003) on *Gerbera* and Khayyat et al. (2007) on Pothos got the maximum leaf area in plants when grown in different combinations of media. Leaf chlorophyll contents greatly depend upon leaf size and area. Plants having more leaf area had the highest number of chlorophyll contents which might helped to enhance photosynthetic actives. Leaf chlorophyll contents of *Caladium* plants showed positive responses to all potting media treatments as depicted in Table 1, therefore, the media composition with farmyard manure, leaf compost, perlite and silt, greatly influenced chlorophyll contents in comparison with the control treatment. This increase in chlorophyll contents is mainly due to the assimilation of nitrogen from the growing substances. Nitrogen has great effect on the photosynthetic pigments and increases the rate of photochemical reactions (Kumar et al. 1988). Similar findings were witnessed by Mahgoub et al. (2006), according to them nitrogen may be responsible for the increase of chlorophyll contents in Iris leaves. Petiole diameter and number of shoots per plants showed less significant response to all soilless potting substrates combination, but their effect was higher than control. These outcomes are in line with the results of Younis et al. (2010), who stated that the petiole diameter of croton plant was influenced by media having leaf compost, coco coir dust, farmyard manure and perlite as components. Side shoots per plants were vigorously growing in media rich in nutrients, therefore, the growth of plants was higher in the media having leaf compost as substrate. In the same way, numbers of shoots were more in media having compost and silt as components. All these results are in accordance with Riaz et al. (2008) who found the maximum number of side shoots in growing substrates having leaf compost, silt and leaf manure as components.

Fresh and dry weight of leaves were also affected under different potting media applications in this study, where perlite, compost and silt as components showed maximum leaf fresh and dry weight. The results are in line with Awang et al. (2010) who got the maximum values for leaf fresh and dry weights using different organic media in *Celosia cristata*. The increase in fresh and dry weight was also reported by Eklind et al. (2001) when test plants were grown in silt and leaf manure combination. Potting media has great importance not only for leaf growth but also for proper roots and tuber growth. As roots and tubers are in direct contact with potting media and any change in their surrounding environment can affect its growth, therefore, its formulation should be such that it may provide balance between solid particles and pore spaces (Riaz et al. 2014). The treatment T_8 gave maximum growth in case of tuber fresh and dry weight as this media not only provided better aeration, moisture and provision of nutrients. Healthy growth of tubers may be due to storage of food in the tubers by the sink source action. Plants growing in leaf compost, perlite and silt had greater leaf area and had large tuber size. The greater leaf area means more chlorophyll contents, it enabled plants to produce more photosynthate which ultimately resulted in larger tuber size due to more food storage (Riaz et al. 2015). The genetic potential of cultivar may affect the tuber size due to nutrient utilizing efficiency, more food production resultantly more tuber size. Khan et al. (2002) concluded that larger root tubers were in *Dahlia* growing in media containing leaf mold which was rich in organic matter and high nutritional status. This is also supported by the Younis et al. (2008), where leaf compost and silt application gave healthy growth of *Dahlia* tubers and cut flowers.

Physicochemical characteristics of *Caladium* plants with respect to treatment combination are presented in Table 4 and results indicated that different growing media had a different effect for estimation of biochemical analysis. However highly significant effect was not found in nutrient uptake (NPK) contents and protein contents when treatment compared to each other treatments. Leaf intake of NPK and protein was highest in plants grown under combination of silt, leaf compost and coconut compost. Nitrogen is chief mineral constituents required for rapid plant growth and reproduction. Maximum absorption by root is enhanced by the frequent translocation to the leaves (Zhao et al. 2005; Younis et al. 2013c; Naseem et al. 2015). Leaf and coconut compost based potting mixes contained sufficient nitrogen which regulate the plant growth directly and thereafter assembled and reflected into plant tissues (Yasmeen et al. 2012). These finding are also similar to those shown by Mathowa et al. (2014). Significant results were also obtained by Abad et al. (2002) stated that coco base compost increases nitrogen contents in container based ornamental plants. Similarly, phosphorus also plays an important role in many plant processes as nucleic acids synthesis, energy metabolism, photosynthesis, respiration, regulation of enzymes and nitrogen fixation (Raghothama 1999). For the development of flower, fruit and roots adequate supply of phosphorus is necessary. Phosphorus at high level in growing media increases the availability for the plants and increase root and shoot growth. These results are in harmony with finding of Khan et al. (2006) who also observed maximum phosphorous uptake by leaf under influence of perlite and leaf compost media. Potassium is a vital plant nutrient which affects many essential physiological and metabolic processes. Its major role in the regulation of water in plants, improve drought resistance, protein synthesis and activation of many growth related enzymes (Cerda et al. 1995). Having adequate organic matter in growing media accelerated the plant growth due to improvement in K-contents in leaves (Khayyat et al. 2007). Findings from this research are in line with

Nandeshwar and Patra (2004) and Mehmood et al. (2013) they found high potassium uptake in seedlings of other plant species grown in silt mixed with leaf compost and peat moss. Parasana et al. (2013) also reported potting mixture released nutrients specially K when seedlings grown in a mixture of silt and farm yard manure residues. These results are also supported by the finding of other experiments, which collectively hypothesized that using soilless fusions with organic and inorganic constituents such as silt with leaf manure (Riaz et al. 2008) and perlite with farmyard manure (Sudhakara et al. 1995; Malewar et al. 1998; Parasana et al. 2013) enhanced the microbial activities, regulated nutrient availability (Peter-Onoh et al. 2014), media increased protein contents (Poole and Conover 1989) and boosted seedling production (Baiyeri 2003).

Conclusion

According to this experiment, influence of different combinations of growing media proved to be ideal for caladium plants to grow in greenhouses for better growth and good quality of plants. The use of these ecofriendly potting media combinations in this study also helps to reduce the impact of chemicals on environment. On the bases of above findings, we can conclude that all potting combinations including organic and inorganic components greatly affect the plant growth and overall biomass which can be used for caladium propagation. Specifically, media combination of silt, leaf compost and perlite increased all the morphological and physio-chemical characteristics while protein contents were improved by application of silt, leaf compost and coconut compost in combination. It is therefore, recommended that application of potting mixes with silt, perlite, leaf composts and coco based residues are more suitable for the formation of soilless potting substances to improve growth and plant nutrition for the container production of *Caladium* plants.

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