Research Article

Effect of Various (SGS) Developed from Agricultural Waste in Foliage Indoor Plants of *Aglaonema commutatum*, *Dracaena deremensis* and *Aspidistra elatiors*

Farwa Batool[1]*, Riaz ur Rehman[1], Samia Ikram[2] and Maham Zahara[3]

[1]Directorate of Floriculture (T and R) Punjab, Lahore, Pakistan; [2]Horticultural Research Institute for Floriculture and Landscaping, Islamabad, Pakistan; [3]University of Agriculture, Faisalabad, Pakistan.

Abstract | Soil growing substrate (SGS) is the most significant factor in foliage plant production and low-cost growing substrate is critical factor in nursery business profitability. The soil substrates must be non-toxic, environmental friendly, highly sustainable and good in nutrients capacity for better plant growth and economical plant production. The agriculture waste is a good option for soil substrate source in nursery plants production. The present research is focusing on the utilization of agriculture waste with different proportions for better foliage plant growth and development. Different combinations of silt, sand, leaf compost, FYM, peat moss, sawdust and garden soil were used as (SGS) for the growth and quality of three selected foliage plants (*A. commutatum, D. deremensis* and *A. elatiors*). The plant response was observed through observing the plant height (cm), leaf length (cm), leaf area (cm), number of leaves (cm), stem diameter (mm) and survival (%). The pH, EC, potassium (K), nitrogen (N), phosphorus (P) and organic matter of different ratios of SGS were also observed prior to utilization. The maximum plant height of *A. commutatum* (46cm), *D. deremensis* (159cm), *A. elatiors* (66cm) was recorded in SGS of leaf compost + silt + sawdust + sand (2:1:1:1). While combination of peat moss + soil + silt + sand (2:2:1:1) SGS showed increased number of leaves (40.67) and diameter of stem (14.40 mm) in Aglaonema. The plant response in SGS is significantly better as compared with garden soil for plant vegetative growth. The SGS leaf compost + silt + sawdust + sand (2:1:1:1) was found significantly better in alternative medium for the growth of *A. commutatum, D. deremensis* and *A. elatiors.* The leaf compost + silt + sawdust + sand (2:1:1:1) is recommended for better yield in foliage plants.

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***Correspondence** | Farwa Batool, Directorate of Floriculture (T and R) Punjab, Lahore, Pakistan; **Email:** farwa.batool55@gmail.com
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Introduction

Foliage plants are potted plants with attractive leaves and flowers grown under shaded greenhouse or buildings as living display for interior scaping (Chen *et al*., 2002). Foliage plants are used as unique addition for the beautification of indoor and outdoor environment, because of their magnificent ornamental foliage beauty and color versatility. Foliage plants are used in rock gardens, borders, pots, bedding, fresh flower arrangement and window boxes as well (Deng and Harbaugh, 2006). Ornamental plants absorb harmful and toxic gases and therefore play an important role in eliminating pollution and producing fresh oxygen (Orwell *et al*., 2006). The production statistics of foliage plants is not precisely known; however, it is the industry of millions of dollars around the globe. Greenhouse plant production in nurseries mainly depends upon soilless substrates (Younis *et al*., 2011; Wilson *et al*., 2003). Plant growing substrate become the basic requirements for the healthy development of plant (Younis *et al*., 2013). Selection of growing substrate based upon three main factors including; performance, economics availability and environmental sustainability (Barrett *et al*., 2016). In recent years, nursery workers showed their deep concern to grow plants in potting media. A good growing substrate must have four basic functions for production of greenhouse crops; they should have the ability to transport air and water, provide proper anchorage for growth of roots, physically support to the plant and supply adequate amount of nutrients (Tariq *et al*., 2012). In potted plant production, peat moss is the most commonly used growing substrate however; increasing awareness regarding environmental concerns has persuaded the restriction for its use (Ostos *et al*., 2008). Researchers have recommended that peat moss can be competently replaced in potting media with some other agricultural waste materials including coconut coir, leaf compost and tree bark. Sewage sludge from the industrial or municipal waste water was also used as the soil base growth substrate (Sanchez-Monedero *et al*., 2004). Due to growing awareness of environmental problems, different agricultural by-products have become a source of organic nutrients for plants (Riaz *et al*., 2008; Grigatti, 2008). Now a day various organic and inorganic media like coco peat, sand, gravels, compost of leaves, perlite, peat moss and silt are being used commercially. Researchers concluded that it is easier to use a soil-free substrate compared with pure soil and soil based substrates (Yasmeen *et al*., 2012). The present research is based on utilization of different proportions of silt, sand, sawdust, FYM, leaf compost and peat moss for better plant growth and development of *A. elatior, D. deremensis* and *A. commutatum* for recommendation to farmers for commercial production.

Materials and Methods

The research was performed at Horticultural Research Institute for Floriculture and Landscaping, Rawalpindi during the year 2017-2019. *A. elatior, D. deremensis* and *A. commutatum* were planted in different ratios of common agricultural wastes for better plant growth and development. SGS were made by mixing farm yard manure (FYM), leaf compost and peat moss were major components while they were mixed in silt, sand and sawdust. The components of different mixed substrates were as T_0: garden soil, T_1: FYM + soil + silt + sand, T_2: FYM + silt + sawdust + sand, T_3: leaf compost + soil + silt + sand, T_4: leaf compost + silt + sawdust + sand, T_5: peat moss + soil + silt + sand, T_6: peat moss + silt + sawdust + sand. The soil growing substrates were analyze for chemical and physical properties such as pH, EC ($dS.m^{-1}$), N (%), P (mg/kg), K (mg/kg) and organic matter (%). Ion analyzer pH meter (Thermo Fisher Scientific, Waltham, MA, USA) was used to find out the pH of the potting medium (Thomas, 1996) and Electrical conductivity meter was used to measure EC (Rhoades, 1996). Soil nitrogen percentage was determined by distillation method in Kjeldahl's apparatus and titration was done with the help of standard H_2SO_4 (Bremner and Mulvaney, 1982). Olsen's method was used to determine the available phosphorus (Olsen *et al*., 1984) and the available potassium contents were measured by flame photometer (Blume, 1990). To find out the organic matter (%), 1g of air-dried soil sample put into a 500ml beaker, added 10ml of $K_2Cr_2O_7$ and 20ml concentrated H_2SO_4 in to the beaker and rotated the beaker to mix the solution. After 30 minutes, 10ml concentrated orthophosphoric acid was added to 200ml of distilled water and the mixture was let on to cool. Diphenylamine was used as an indicator and magnetic stirrer was used for the proper mixing. Solution was titrated with a 0.5M ferrous ammonium sulfate solution and recorded the reading until the color changed from violet blue color to green (Rowell, 2014) (Table 1).

The SGSs were filled in 12 pot with 2g of NPK (20:20:20) in each pot, while one year old plants of *A. elatior, D. deremensis* and *A. commutatum* were planted. Cultural practices including irrigation, weeding, hoeing was carried out throughout the research period. The plant response was observed plant height (cm), leaf area (cm^2), number of leaves per plant, leaf length (cm), stem diameter (mm) and plant survival (%). Visual appearance quality of foliage plants were also observed and measured (Scale ranging from 1-3) with respect to plant height, color and texture (Cooper and Spokas, 1991). The research was planned according to the completely randomized experimental design (CRD) with seven (SGS) developed with different ratios of silt, sand, sawdust, FYM, leaf compost and peat moss including garden soil (control) as treatment, while research was repeated three times. Data were analyzed using analysis of variance techniques (ANOVA). Duncan's Multiple Range (DMR) test was used to compare the averages with a 5% probability level (Steel *et al.*, 1997). The means were calculated with Statistix 8.1 data analysis software.

Results and Discussion

Effect of various SGSs on growth and development in Aglaonema commutatum

Response of *A. commutatum* was significantly different in different SGSs (Table 2). The maximum plant height (46cm) was observed in response to leaf compost + silt + sawdust + sand while minimum plant height (31cm) was shown in garden soil. Plants showed maximum numbers of leaves (40.67) in peat moss + soil + silt + sand. Among all the different treatments maximum average leaf length (23.96cm) was recorded in leaf compost + silt + sawdust + sand while lowest leaf length in garden soil (13cm) whereas significant reduction in leaf area (203.33 cm^2) was observed in garden soil. Maximum stem diameter (14.40mm) was recorded in peat moss + soil + silt + sand. On the contrary, minimum stem diameter (8.17mm) was observed in FYM + silt + sawdust + sand. Various SGS showed better effect of plant quality attributes while best quality plants were observed in leaf compost + silt + sawdust + sand while the garden soil showed lowest quality of plants. The plants planted in various SGSs showed healthy growth with no nutrient deficiency symptoms; it showed that not any SGSs are toxic for plant survival.

Effect of various SGSs on growth and development in Dracaena deremensis

The results (P<0.05) presented in Table 3 showed that consistently better plant height (159.00cm) in leaf compost + silt + sawdust + sand followed by (145.33cm) in FYM + silt + sawdust + sand, while the minimum plant height (97.27cm) was observed in garden soil. Plants grown in T_6 had the maximum numbers of leaves (13.46). Maximum leaf length

Table 1: *Chemical and Physical compositions of developed soil growing substrates.*

Soil growing substrate (SGS)	pH	EC (dS.m^{-1})	Organic matter (%)	Available nitrogen (%)	Available phosphorus (mg/Kg)	Available potassium (mg/Kg)
Garden soil	7.07	1.10	0.65	0.28	8.2	100
FYM + soil + silt + sand (2:2:1:1)	7.07	1.08	0.45	1.44	7.4	200
FYM + silt + sawdust + sand (2:1:1:1)	7.11	1.06	2.25	1.40	16.4	160
Leaf compost + soil + silt + sand (2:2:1:1)	7.12	0.87	0.40	2.40	10.2	220
Leaf compost + silt + sawdust + sand (2:1:1:1)	7.14	0.94	2.75	1.97	14.2	260
Peat moss + soil + silt + sand (2:2:1:1)	7.20	0.88	2.40	1.09	15.4	260
Peat moss + silt + sawdust + sand (2:1:1:1)	7.21	1.54	2.60	1.05	14.5	460

Table 2: *Effects of various SGSs on growth and development in Aglaonema commutatum (Mean data of 2017-2019).*

Soil Growing Substrate (SGS)	Plant height (cm)	Number of leaves per plant	Leaf length (cm)	Leaf area (cm^2)	Diameter of stem (mm)	Plant quality
Garden Soil	31.00 ^{C}	15.33 ^{F}	13.00 ^{D}	203.33 ^{D}	8.33 ^{DE}	1.00 ^{B}
FYM + soil + silt + sand (2:2:1:1)	37.90 ^{B}	19.00 ^{EF}	17.63 ^{BC}	357.33 ^{C}	12.37 ^{B}	2.00 ^{AB}
FYM + silt + sawdust + sand (2:1:1:1)	40.13 ^{B}	26.63 ^{C}	13.93 ^{CD}	495.33 ^{BC}	8.17 ^{E}	2.66 ^{A}
Leaf compost + soil + silt + sand (2:2:1:1)	39.00 ^{B}	21.3 ^{DE}	15.67 ^{BCD}	511.33 ^{B}	9.30 ^{DE}	2.66 ^{A}
Leaf compost + silt + sawdust + sand (2:1:1:1)	46.00 ^{A}	34.60 ^{B}	23.96 ^{A}	692.67 ^{A}	11.23 ^{BC}	3.00 ^{A}
Peat moss + soil + silt + sand (2:2:1:1)	39.03 ^{B}	40.67 ^{A}	18.00 ^{B}	538.67 ^{B}	14.40 ^{A}	2.33 ^{A}
Peat moss + silt + sawdust + sand (2:1:1:1)	37.00 ^{B}	23.67 ^{CD}	13.50 ^{D}	358.33 ^{C}	10.00 ^{CD}	2.33 ^{A}

Means followed by same letter are not significantly different at P< 0.05 probability using Duncan's test.

Table 3: *Effect of various SGSs on growth and development in Dracaena deremensis (mean data of 2017-2019).*

Soil growing substrate (SGS)	Plant height (cm)	Number of leaves per plant	Leaf length (cm)	Leaf area (cm^2)	Diameter of stem (mm)	Plant quality
Garden Soil	97.27 ^{E}	7.33 ^{C}	36.26 ^{C}	255.33 ^{D}	10.50 ^{D}	1.33 ^{D}
FYM + soil + silt + sand (2:2:1:1)	111.0 ^{D}	11.63 ^{B}	43.63 ^{B}	422.33 ^{A}	12.63 ^{C}	2.00 ^{CD}
FYM + silt + sawdust + sand (2:1:1:1)	145.3 ^{B}	7.50 ^{C}	42.93 ^{B}	396.3 ^{AB}	13.6 ^{BC}	2.63 ^{BC}
Leaf compost + soil + silt + sand (2:2:1:1)	121.3 ^{C}	6.63 ^{C}	43.83 ^{B}	409.0 ^{AB}	13.8 ^{BC}	2.3 ^{BCD}
Leaf compost + silt + sawdust + sand (2:1:1:1)	159.0 ^{A}	7.93 ^{C}	49.30 ^{A}	358.3 ^{BC}	17.70 ^{A}	4.06 ^{A}
Peat moss + soil + silt + sand (2:2:1:1)	127.3 ^{C}	11.00 ^{B}	37.53 ^{C}	334.67 ^{C}	14.73 ^{B}	3.16 ^{AB}
Peat moss + silt + sawdust + sand (2:1:1:1)	130.0 ^{C}	13.46 ^{A}	42.03 ^{B}	337.33 ^{C}	17.23 ^{A}	3.00 ^{BC}

Means followed by same letter are not significantly different at P< 0.05 probability using Duncan's test.

Table 4: *Effect of various SGSs on growth and development in Aspidistra elatior (Mean Data 2017-2019).*

Soil growing substrate (SGS)	Plant height (cm)	Number of leaves per plant	Leaf length (cm)	Leaf area (cm^2)	Diameter of petiole (mm)	Plant quality
Garden soil	52.67 ^{CD}	6.67 ^{C}	39.00 ^{D}	299.33 ^{E}	5.67 ^{CD}	1.17 ^{C}
FYM + soil + silt + sand (2:2:1:1)	58.00 ^{BC}	6.67 ^{C}	44.6 ^{BC}	456.7 ^{CD}	7.17 ^{B}	2.2 ^{ABC}
FYM + silt + sawdust + sand (2:1:1:1)	64.33 ^{AB}	9.33 ^{BC}	44.3 ^{BC}	525.67 ^{B}	6.63 ^{BC}	1.33 ^{C}
Leaf compost + soil + silt + sand (2:2:1:1)	57.50 ^{BC}	10.00 ^{B}	42.7 ^{CD}	632.33 ^{A}	6.0 ^{BCD}	1.67 ^{BC}
Leaf compost + silt + sawdust + sand (2:1:1:1)	66.00 ^{A}	14.50 ^{A}	52.00 ^{A}	687.33 ^{A}	8.60 ^{A}	3.17 ^{A}
Peat moss + soil + silt + sand (2:2:1:1)	57.00 ^{BC}	11.33 ^{B}	39.00 ^{D}	478.3 ^{BC}	7.20 ^{B}	2.3 ^{ABC}
Peat moss + silt + sawdust + sand (2:1:1:1)	48.00 ^{D}	7.00 ^{C}	48.0 ^{AB}	397.00 ^{D}	5.33 ^{D}	2.67 ^{AB}

Means followed by same letter are not significantly different at P< 0.05 probability using Duncan's test.

(49.30 cm) was observed in leaf compost + silt + sawdust + sand followed by minimum (36.26cm) in garden soil. The results for leaf area showed that the FYM + soil + silt + sand used as potting media showed the remarked results (422.33cm^2) while second highest result (409.0 cm^2) was observed in leaf compost + soil + silt + sand. The maximum diameter of stem (17.70 mm) was obtained in leaf compost + silt + sawdust + sand followed by peat moss + silt + sawdust + sand (17.23mm) respectively. Remarked reduction of stem diameter (10.50 mm) was recorded in garden soil. Overall, the quality of all treatments plants was good but the leaf compost + silt + sawdust + sand showed the best quality plants among various SGSs.

Effect of various SGSs on growth and development in Aspidistra elatior

As per mean data presented in Table 4, maximum plant height (66.0cm) was observed in leaf compost + silt + sawdust + sand followed by (64.3cm) in FYM + silt + sawdust + sand, although the lowest plant height (48cm) was recorded in peat moss + silt + sawdust + sand. Maximum number of leaves (14.50) were produced in leaf compost + silt + sawdust + sand and minimum (6.67) were observed in garden soil. Maximum leaf length (52cm) was recorded in leaf compost + silt + sawdust + sand and least (39cm) in garden soil and peat moss+soil+silt + sand. Significant decrease in leaf area (299.33cm^2) was noted in garden soil, while the maximum leaf area (687.3cm^2) was recorded in leaf compost+silt+sawdust+sand. Maximum increase in petiole diameter (8.60mm) was recorded in leaf compost + silt + sawdust + sand while the peat moss + silt + sawdust + sand showed the minimum petiole diameter (5.33 mm). Leaf compost + silt + sawdust + sand attained the best quality plant while the least quality plants were found in garden soil followed by FYM + silt + sawdust + sand, respectively.

The present research was carried out for identification of best (SGSs) that can be recommend for commercial nurseries for better growth and development of foliage plants. Positive response was observed for better plant biomass and good vegetative growth of foliage plants in different SGSs of agricultural waste. The comparative study of SGSs revealed that leaf compost + silt + sawdust + sand was confirmed to be most suitable soil growing substrate that increase the growth and quality of foliage plants of *A. elatior*, *D. deremensis* and *A. commutatum*. Soilless growing substrates are commonly used for rapid germination and initial growth of plants in greenhouse (Baiyeri, 2003). Soil substrates mentioned above is the best for the foliage plants growth in terms of plant height that is the most important for the potted indoor plants. The best plant height in *A. elatior*, *D. deremensis* and *A. commutatum* were recorded in those plants, planted in leaf compost + sand + silt + sawdust that means a remarkable recycling of agricultural wastes, and provide a cheap media for nurseries. The results of the present study is confirmed by Riaz *et al.* (2008) who reported that better plant height in *Zinnia elegans* cv. Blue point was observed in a soil growing substrates containing leaf manure. This may be due to the high level of nitrogen, potassium and organic matter content in substrate; these nutrient contents are ample in spent compost mushroom (Ali *et al.*, 2011). Numbers of leaves are also related with the nutrient availability in the growing medium as they have positive correlation regarding K and organic matter. Riaz *et al.* (2008) reported that the potting media, in which leaf manure was used, showed the maximum number of leaves per plant in the floricultural crops. Leaf compost played an important role in plant growth because it contained rotten plant residues, humus and organic matter that are available in plants. Photosynthetic activities of plants are directly related to leaf chlorophyll that fully dependent on the leaf area (Younis *et al.*, 2015) more leaf area indicates more chlorophyll contents hence more photosynthesis activity. Results of present study showed that plants of *A. elatior* and *A. commutatum* treated with different soil growing substrates showed increasing leaf area. However, the plants grown in substrates containing leaf compost + silt + sawdust + sand showed the maximum leaf area expansion compared with other treatments. The results of present study have been confirmed by Cardenas *et al.*, 2006 in carnation where number of leaves and leaf area were found to be maximum in combination of rice husk burnt + coconut fiber + leaf compost. Chemical and physical properties of substrate including NPK, pH, and organic matter are presented in the (Table 1). The ample amount of nitrogen, phosphorous and potassium has an important role in growth and quality of plants. These substances regulate the plant nutrient availability, roots penetration and water mobility in micro-edaphic environment. Higher or lower pH negatively affects the growth of plant, because the plant nutrient supply is directly related to the pH of growing media (Tariq *et al.*, 2012). Growing substrate having farmyard manure produced least growth due to its high pH (Yasmeen *et al.*, 2012). Nitrogen is one of basic and most required mineral elements for growth of plants. Nitrogen forms significant mass of plant economic and biological yield. Maximum absorption of nitrogen by root is increased by the frequent translocation to the leaves (Naseem *et al.*, 2015; Zhao *et al.*, 2005). The growth medium containing leaf compost + coconut compost has sufficient amount of nitrogen which can directly improve the growth of plants and then provide to the plant tissues (Yasmeen *et al.*, 2012). Phosphorus plays a vital role in development of flower, fruit and roots growth. The growing media containing maximum amount of phosphorus promotes roots and shoots growth. Khan *et al.* (2006) reported that maximum uptake of phosphorous occurred by leaf in presence of substrate containing perlite and leaf compost. Under the high pH of growing media, micro and macronutrient availability may not be enough to support plant growth and development. These results are similar to the findings of (Altland, 2006), who reported that minimum growth in Japanese maple and hydrangea lead to the pH-induced reduction of available phosphorus, micronutrients and nitrogen in the growing media. EC is used to diagnose the salts contents in the growth media. These EC related results were supported by Medina *et al.* (2009), they observed that the maximum EC value in the medium composed of sand, silt, coconut coir and leaf compost.

Conclusions and Recommendations

The present study on different SGS and indoor plants revealed that different soil substrates formed with different proportions of agricultural waste showed ideal response for better quality and quantitative yield of *A. elatior*, *D. deremensis* and *A. commutatum*. The use of these non-toxic eco-friendly growing substrate will help to minimize the cost of production. It is therefore concluded on the basis of above facts and figures that soil growing substrates containing inorganic and organic components have positive effect on plant quality and its growth. It is thus, recommended that combination of leaf compost + silt + sawdust + sand is the most suitable soil growing substrate to increase growth in *A. elatior*, *D. deremensis* and *A. commutatum*.

Novelty Statement

Soil growing substrates (SGS) containing inorganic and organic components have positive effect on plant quality and its growth, to which the present study is a minor addition.

Author's Contribution

Farwa Batool: Compiled data and wrote manuscript.
Riaz ur Rehman: Vetted research paper and suggested improvement.
Samia Ikram: Helped in data collection.
Maham Zahara: Helped in data analysis.

Conflict of interest
The authors have declared no conflict of interest.

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