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Studies on vertical garden system: A new landscape concept for urban living space

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ABSTRACT

Vertical gardens are becoming a common component in contemporary garden designs at urban living space because of shrinking land spaces. Successful growing of plants in vertical garden systems depends up on growing container, plants chosen, growing media, etc. Hence a study was carried out in the Department of Horticulture, Annamalai University, with the objectives to study the influence of Coir pith, Stockosorb and Geohumus as components of growing media along with FYM, Vermicompost and Leaf mould compost on growth and performance of ornamental plants for establishment of vertical garden and to study the performance of ornamental plants viz., *Philodendron erubescens* Cv. 'Gold', *Chlorophytum comosum* Cv. 'Variegatum' and *Polyscias fruticosa* plants in wooden containers for establishment of vertical garden. The experiment was laid out in Completely Randomized Design in wooden containers, with ten treatment combinations of various growing media mixtures comprising red soil, river sand as basic components in combination with organic manures (FYM, vermicompost, leaf mould compost, coir pith) and hydrogels (Stockosorb and Geohumus). The plant growth characters and ornamental value index were observed. Among the three ornamental plants used, *Polyscias fruticosa* and *Philodendron erubescens* are performed better as ornamental plants in vertical garden system with the growing media of Red soil: River sand: Vermicompost @ 1:1:1/2 + Stockosorb(25g).

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INTRODUCTION

Climate change has made the concept of changing our living ambiance very important to make quality living. Vertical gardens are the tools that can be employed to enhance the quality of air, solve the heat problems in urban areas and the same time improve aesthetics of our living places. Vertical gardens are becoming a common component in contemporary garden designs because of shrinking land spaces and multiplying high-rises with scanty space available for gardening. Though, the idea of vertical garden began in 600 BC from Hanging Gardens of Babylon and then it was not used often by successive gardeners like Persians, Mughals, Europeans and others. Today, with the rapid growth of industrial cities and for want of horizontal space for other utilities this concept was picked up rapidly by contemporary gardeners. Vertical gardens are living walls which are covered with vegetation. Successful growing of plants in vertical garden systems depends up on design of the vertical garden system, growing container, irrigation arrangement, plants chosen, growing media, etc. The shade loving indoor ornamental plants like *Philodendron sp.*, *Asparagus sp.*, *Chlorophytum sp.*, *Polyscias fruticosa*, *Aglaonema*, *Rhoeo spathacea*, *Sempervivum*, etc. are considered as suitable options based on their ornamental

features, however, studies revealing the suitability of plants for vertical garden system is lacking in India. The members of Araceae, Asparagaceae and Araliaceae families viz., *Philodendron erubescens*, *Chlorophytum comosum* and *Polyscias fruticosa* respectively are used in this study by virtue of their textural properties and easy adoptability in tropical to sub tropical conditions.

The growing medium is the most important component that decides the success of a vertical garden system. Increasing cost of these media components and shortage of the mineral media like peat, perlite and vermiculite are the reasons to find suitable alternative components from organic manures and hydrogel compounds for plant growing containers used in vertical garden system. Further, restricted volume of media and competition due to higher planting density may cause a confined root system. In due course of maintenance this system needs heavy applications of fertilizer and water to maintain proper plant growth. In line with the above facts a study was carried out with the objectives to study the influence of Coir pith, Stockosorb and Geohumus as components of growing media along with FYM, Vermicompost and Leaf mould compost on growth and performance of ornamental plants in wooden containers for

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establishment of vertical garden and to standardize the growing media mixtures suitable for establishment of vertical garden.

MATERIAL AND METHODS

In this experiment living wall system of vertical garden was established with fabricated iron frames to hold the planter boxes made in country wood in alternate rows. The wooden box was fabricated with two slits in the front side to accommodate two rows of plants to cover the sides of the wall. On top of the planter box another row of ornamental plant was planted to cover the gap existing in alternate rows of the vertical frame. The vertical garden system made of wooden box container (90cm×30cm×30cm) was designed to grow 24 numbers of plants that is essential to establish a green cover over the surface of container (Plate 1). The experiment was laid out in Completely Randomized Design, replicated thrice with ten treatment combinations of various growing media mixtures comprising red soil, river sand as basic components in combination with organic manures (FYM, vermicompost, leaf mould compost, coir pith) and hydrogels (Stockosorb and Geohumus). Control treatment was maintained with normal soil. The plant growth characters like days taken for establishment, plant height, number of shoots, shoot girth, number of leaves per plant, leaf area, biomass production, chlorophyll content and ornamental value index were observed. Ornamental value index was given to the plants in each treatment by visually assessing the ornamental features of the plants in terms of their foliage colour, compactness, texture, height and overall look. Ten point Headonic scoring technique was adopted to grade the ornamental value of the plants.

Grade No.	Ornamental features	Grade point
G1	Establishment: Shoots and leaves growing and stretching against geotropic movement.	10, 9 to 1 and 0
G2	Compactness : From densely packed foliage to space loose fronds and dried up plant	10, 9 to 1 and 0
G3	Number of stems per poly bag : from 10 to 3 and dried up plant	10, 9 to 1 and 0
G4	Texture : from fine to course and dried up plant	10, 9 to 1 and 0
G5	Freshness of plants: from firm turgid to flaccid condition and dried leaves	10, 9 to 1 and 0
G6	Overall out look	10, 9 to 1 and 0

$$\text{Ornamental value index} = \frac{GP1+GP2+GP3+GP4+GP5+GP6}{6}$$

The statistical analysis of data was done by adopting the standard statistical procedure given by Panse and Sukhatme (1967).

RESULT AND DISCUSSION

Results of the present experiment envisaged that the growth parameters viz., days taken for establishment, plant height, number of shoots/branches, shoot girth, number of leaves plant⁻¹



Plate 1: Fabrication of planter boxes for vertical garden system

and leaf area were significantly increased due to the addition of organic growing media components and hydrogels (Table 1). In general, addition of hydrogels viz., Stockosorb and Geohumus performed better than the coir pith in growing media as a component. Among the organic components used in media, vermicompost performed better in terms of all the growth parameters of the ornamental plants. In all the three ornamental plants, T₉ [Red soil + River sand + Vermicompost (1:1:1/2) + Stockosorb (25g)] has exhibited greater influence in terms of all the growth parameters with quicker establishment of plants. This was followed by T₁₀ [Red soil + River sand + Vermicompost (1:1:1/2) + Geohumus (25g)]. Enhancement of growth in all the three ornamental plants due to above mentioned two growing media combinations might be attributed to the addition of vermicompost and hyogels particularly Stockosorb and Geohumus in addition to normal components of a growing media like red soil and river sand. Enhancement in the growth attributes due to vermicompost in the present research is in line with the reports of (Rajamanickam *et al.* 2008) who revealed enhanced growth parameters in plants grown in potting mixture, treated with vermicompost. The report of (Golchin *et al.* 2006) in pistachio nut seedlings was also in conformity of the present research. Further, the enhanced performance of ornamental plants grown in media containing vermicompost could be attributed by the fact that vermicompost contains major and minor nutrients for the plants in available forms besides enzymes, antibiotics, vitamins, beneficial microorganisms and other plant growth hormones and have definite advantage over other organic; manures in respect of growth (Meerabai and Raj, 2001).

Table 1: Effect of growing media on growth of different ornamental plant species grown in vertical garden system

Treatment No.	<i>Philodendron erubescens</i>						<i>Chlorophytum comosum</i>						<i>Polyscias fruticosa</i>					
	Plant height (cm)	No. of branches plant ⁻¹	shoot girth (cm)	No. of leaves plant ⁻¹	leaf area (cm ²)	Plant height (cm)	No. of branches plant ⁻¹	shoot girth (cm)	No. of leaves plant ⁻¹	leaf area (cm ²)	Plant height (cm)	No. of branches plant ⁻¹	shoot girth (cm)	No. of leaves plant ⁻¹	Leaf area (cm ²)			
T1	32.32	1.98	3.25	13.56	17.24	13.74	4.78	2.14	17.34	7.39	34.15	6.90	3.14	236.34	9.85			
T2	40.39	2.79	3.88	15.39	18.37	14.72	5.87	2.76	20.22	8.99	46.62	8.32	3.76	260.57	12.11			
T3	42.15	3.61	4.65	17.29	20.64	15.54	7.05	3.53	23.35	10.93	49.32	9.97	4.53	286.45	14.61			
T4	41.24	3.21	4.22	16.29	19.67	15.15	6.46	3.10	21.67	10.03	48.13	9.13	4.10	272.91	13.38			
T5	39.53	2.39	3.56	14.58	18.03	14.31	5.33	2.72	18.87	8.28	45.18	7.62	3.42	249.55	11.09			
T6	41.31	3.18	4.28	16.46	19.91	15.02	6.58	3.16	21.91	10.22	48.21	9.32	4.16	274.15	13.52			
T7	40.28	2.81	3.87	15.51	18.96	14.75	5.89	2.70	20.12	9.13	46.78	8.46	3.70	261.36	12.34			
T8	43.01	4.02	5.08	18.06	21.35	15.93	7.63	3.86	24.74	11.67	50.97	10.81	4.86	297.87	15.63			
T9	44.78	4.82	5.72	19.67	22.95	16.76	8.75	4.14	27.64	13.26	54.37	12.61	5.61	322.04	18.02			
T10	43.85	4.45	5.40	18.86	22.04	16.34	8.19	4.09	26.08	12.41	52.86	11.67	5.25	309.02	16.77			
SED	0.41	0.17	0.15	0.37	0.33	0.18	0.26	0.18	0.65	0.33	0.53	0.30	0.14	5.21	0.46			
CD	0.83	0.36	0.31	0.76	0.68	0.38	0.53	0.36	1.32	0.68	1.07	0.61	0.27	10.54	0.93			

(P=0.05)

T1-Control (Normal soil without any amendments), T6-Red soil + River sand + Leaf mould compost (1:1:1) + Stockosorb (25 g), T2-Red soil + River sand + FYM + Coir pith (1:1:1:1), T7-Red soil + River sand + Leaf mould compost (1:1:1) + Geohumus (25 g), T3-Red soil + River sand + FYM (1:1:1) + Stockosorb (25 g), T8-Red soil + River sand + Vermicompost + Coir pith (1:1:1/2:1), T4-Red soil + River sand + FYM (1:1:1) + Geohumus (25 g), T9-Red soil + River sand + Vermicompost (1:1:1/2) + Stockosorb (25 g), T5-Red soil + River sand + Leaf mould compost + Coir pith (1:1:1:1), T10-Red soil + River sand + Vermicompost (1:1:1/2) + Geohumus (25 g)

The positive influence of hydrogel compounds on ornamental plants in the vertical plant growing containers might be due to the facts that hydrogels maintain a conductive soil environment. The highly cross-linked polyacrylamide hydrogels can absorb and hold up to 400 times their weight of water (Bouranis *et al.*, 1995), which aid faster establishment of ornamental plants in containers where media volume is restricted. As reported by Sarvas (2003); Abedi-Koupai and Asadkazemi (2006) in different experiments on the effects of hydrogels on plant growth, the present experiment also indicated increased growth attributes like total bio mass under limited water availability.

The quality parameters of the ornamental plants grown in vertical garden containers can be determined by assessing the total chlorophyll content and ornamental value index. These values of all the three ornamental plants were significantly varied due to different combinations of growing media mixtures (Table 2). The highest total chlorophyll content (2.73 mg g⁻¹, 2.62 mg g⁻¹ and 2.91 mg g⁻¹ respectively for *Philodendron sp*, *Chlorophytum sp* and *Polyscias sp*) and ornamental value index (8.54, 7.30 and 9.56 respectively for *Philodendron sp*, *Chlorophytum sp* and *Polyscias sp*) were observed in the plants grown in T₉ [Red soil + River sand + Vermicompost (1:1:1/2) + Stockosorb (25g)]. The next best treatment in terms of the results obtained in these parameters was T₁₀ [Red soil + River sand + Vermicompost (1:1:1/2) + Geohumus (25g)].

The best results obtained in these quality parameters might be attributed to the enhanced growth in terms of plant height, number of shoot plant⁻¹, number of leaves plant⁻¹, leaf area and total biomass plant⁻¹. Best performance of all the three ornamental plants with highest values in quality parameters in the present study due to addition of organic growing components like vermicompost and leaf mould compost is in accordance with the reports of Meerabai and Raj (2001) in ornamental plants and Hidalgo and Harkess (2002) in poinsettia. Enhancement in the quality parameters of the ornamental plants due to addition of hydrogels like Stockosorb and Geohumus might be attributed to the enhanced water availability in the medium which increased the turgidity and freshness of the foliage (Bouranis *et al.*, 1995).

By considering the mean performance of all the three ornamental plants (Table 3) it is concluded that *Polyscias fruticosa* and *Philodendron erubescens* plants can be used as ornamental plants for establishment of vertical garden system. To use *Chlorophytum comosum* as a component in this system a modification in the planting position is needed. The physiochemical properties of the growing media mixtures and growth attributes and quality parameters of the three ornamental plants evinced that media combinations of Red soil + River sand + Vermicompost (1:1:1/2) + Stockosorb (T₉) or Red soil + River sand + Vermicompost (1:1:1/2) + Geohumus (T₁₀) can be used to establish the above ornamental plants in wooden containers of a vertical garden system fabricated in iron frames.

Table 2: Effect of growing media on growth of different ornamental plant species grown in vertical garden system

Treatment No.	<i>Philodendron erubescens</i>			<i>Chlorophytum comosum</i>			<i>Polyscias fruticosa</i>		
	Total biomass g plant ⁻¹	Chlorophyll content (mg g ⁻¹)	Ornamental value index	Total biomass g plant ⁻¹	Chlorophyll content (mg g ⁻¹)	Ornamental value index	Total biomass g plant ⁻¹	Chlorophyll content (mg g ⁻¹)	Ornamental value index
T1	162.23	1.53	5.39	41.31	1.49	4.03	282.06	1.65	6.12
T2	185.02	2.34	7.08	48.00	2.22	5.61	336.70	2.53	8.39
T3	215.10	1.98	7.69	55.39	1.94	6.25	393.86	2.20	8.93
T4	199.45	2.41	7.36	51.75	2.31	5.92	366.41	2.42	8.66
T5	174.15	2.65	6.82	44.98	2.54	5.35	312.15	2.83	8.13
T6	203.68	2.36	7.43	52.33	2.24	5.96	371.44	2.50	8.70
T7	188.64	2.57	7.12	48.38	2.43	5.66	343.36	2.72	8.42
T8	226.25	2.45	7.96	58.56	2.33	6.51	359.50	2.65	9.19
T9	249.35	2.73	8.54	64.09	2.62	7.30	570.20	2.91	9.56
T10	238.14	2.58	8.25	61.64	2.46	6.82	417.56	2.77	9.46
SED	4.70	0.08	0.11	1.42	0.09	0.12	9.56	0.08	0.10
CD	9.51	0.17	0.22	2.88	0.18	0.24	19.34	0.17	0.20

(P=0.05)

T1-Control (Normal soil without any amendments), T6-Red soil + River sand + Leaf mould compost (1:1:1) + Stockosorb (25 g), T2-Red soil + River sand+FYM + Coir pith (1:1:1:1), T7-Red soil + River sand + Leaf mould compost (1:1:1) + Geohumus (25 g), T3-Red soil + River sand+FYM (1:1:1)+ Stockosorb (25 g), T8-Red soil + River sand + Vermicompost + Coir pith (1:1:1/2:1), T4-Red soil + River sand+FYM (1:1:1)+ Geohumus (25 g), T9-Red soil + River sand + Vermicompost (1:1:1/2) + Stockosorb (25 g), T5-Red soil + River sand + Leaf mould compost + Coir pith (1:1:1:1), T10-Red soil + River sand + Vermicompost (1:1:1/2) + Geohumus (25 g)

Table 3: Mean Performance of Ornamental plants grown in wooden containers of vertical garden system

Ornamental features and growth parameters	<i>Philodendron erubescens</i>	<i>Chlorophytum comosum</i>	<i>Polyscias fruticosa</i>
Planting position in planter box	Side slit bottom layer (Horizontal)	Side slit top layer (Horizontal)	Top side (Normal planting)
Plant Texture	Coarse	Fine	Medium coarse
Days Taken for Establishment	17.77	25.33	9.27
Total biomass (g plant ⁻¹)	204.20	52.64	375.32
Dry matter Production (g plant ⁻¹)	40.65	10.71	74.04
Chlorophyll content (mg g ⁻¹)	2.36	2.25	2.51
Ornamental value index	7.36	5.94	8.55
Performance ranking	II	III	I

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