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A REVIEW :

Alternate media for commercial foliage crops

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BACKGROUND AND OBJECTIVES

Foliage plant includes all the plants grown primarily for their foliage, utilized for interior decoration and interior landscaping purpose. The importance of foliage plants has increased manifold in recent past years. Foliage plants are often used as indoor plants owing to their attractive foliage and their ability to survive and grow even under limited light. Cut foliages are used along with flowers in bouquets, floral arrangements and floral ornaments or alone to create variability in colours, textures, unique shapes and forms.

With ever increasing population in cities and towns due to urbanization houses with garden space are becoming limited which creates a massive demand for foliage plants that can sustain even under modified climatic regions. They are in demand throughout the year and comprise 10 per cent of world floriculture trade with an annual growth rate of 4 per cent. Statistics indicates that 25-30 per cent of bouquets used consist of foliage as compared to only 5 per cent of foliage used 15 years ago.

According to Flora Holland (2011), amongst the total turnover and supply of floricultural products during 2010 (€ 4130 million), the foliage indoor plants alone contribute € 1445 million (34 %) in the world floricultural trade. The leading markets for foliage in the European Union are the United Kingdom, Germany, France, Italy, The Netherlands, Poland and Spain. The major suppliers include Costa Rica, Guatemala, China, Sri Lanka, India, Mexico and South Africa (Nair and Bharathi, 2017).

In the commercial indoor plant production, a variety of growing media are used worldwide and are known to influence the value of potted ornamental plants significantly. Though garden soil is the most readily available growing medium, owing to its bulkiness and competency from the field of construction and agriculture the availability is greatly reduced for the production of potted plants. In order to reduce the cost of production and make them more adaptable for various conditions research on alternative substrates is of great interest and several alternatives have been proposed which are mainly available as agricultural and forest by products *viz*., paddy husk, coco peat.

Soilless media have proven popular with the majority of producers because of their consistency, excellent aeration, reproducibility and low bulk density which reduces shipping and handling costs of the media and the finished plants (Nazari *et al.*, 2011). Depending upon the physical and chemical properties of potting media, various media compositions have been recommended for foliage plants rather than individual medium, which have provided better results in the aspects of vegetative growth and visual appearance (Panj *et al.*, 2014). The potting media used for house plants contains about 50 per cent to 100 per cent organic matter and 50 per cent inorganic matter. Now various organic ingredients like green compost, animal manures, coco peat and inorganic or mineral potting substrates such as sand gravel, perlite and silt are being utilized for domestic and commercial purposes. In the present study, for standardization of media, consortia soil, coco peat, vermicompost, rice husk, biochar, perlite and sand have been used in different proportion.

Research evidences regarding the growth and development of foliage crops is reviewed in this chapter.

Foliage plants:

Asparagus Fern is a member of family Asparagaceae with rounded herbaceous perennial that is used in the landscape for its attractive, fine-textured foliage. This attractive plant can be used in the landscape as a border plant, ground cover, indoor plant, hanging basket, landscape border and entry point ornamental. It can be maintained by clipping to any height upto 2 feet tall.

It grows generally 1 to 4 feet of height and produces true leaves that are scale-like and inconspicuous.The structures that are most referred as leaves are actually leaf-like branchlets called cladophylls. These tiny cladophylls are linear, flattened structures that are bright green in colour. They occur singly or in groups of 3 or more at a node. The stems of this plant emerge directly from the ground and become woody and spiny, hence while handling this species utmost care is to be taken. Extensive root system is composed of a mass of fine roots and tubers the size of grapes.

***Dracaena reflexa* 'Variegata':**

"*Dracaena reflexa* 'Variegata' is a member of family Asparagaceae (also placed in the Agavaceae, Convallariaceae, Dracaenaceae, Liliaceae, or Ruscaceae), native to Africa (Madagascar). It is widely grown ornamental potted plant under subtropical and tropical climates throughout the world. 'Variegata' is due to its variegated forms which make it unusual and excellent specimen plant that can be used indoor foliage plant for interiorscape in homes, offices, hotels, airport lounges and shopping malls.

Despite its irregular multi-stem growth habit it is popular for the formal landscape as bedding plant that may grow upto 10 feet tall or more but as interior-plant it grows upto 5 feet. Its leaves are narrow and of lanceolate to elliptic shape having parallel veins of deep green colour with yellow lime-green to creamy margins (Randrianarivelojosia *et al*., 2003).

Properties of the substrates:

The physico-chemical attributes of substrates are responsible for providing adequate support and nutrients to plants, but it should be light, porous and well drained (Noguera *et al.*, 2003).

pH:

The pH is an important index of ecological condition for terrestrial environments (Bandari *et al.*, 2010). It indicates whether the soil is acidic or alkaline. It is an important factor in the availability and uptake of nutrients. Optimal pH of a medium differs with plant species, normally vary between 5.0 and 6.5 (Robbins and Evans, 2011).

Lowest pH measured was connected to the 100 per cent coconut fibre under bicarbonate - enriched condition in gerbera (Roosta *et al.*, 2016).

Electrical conductivity:

"Electrical conductivity can be directly related to soluble salts concentration of the soil or mine waste at any particular temperature"(Bandari *et al*., 2010). According to Clarkson *et al.* (1983) addition of coir pith lowered the EC from 3.2-0.7 dS m^{-1} in saline alkaline soil.

Bandari *et al*. (2010) stated that the lowest growth rate at maximum dose of vermicompost could be attributed to the higher salty content (*i.e*. electrical conductivity) or excessive nutrient levels in the more concentrated mixtures. He also found that different doses of vermicompost showed different response on the development of petunia plants.

Effect of physical properties on growing media:

Bulk density:

"Bulk density of an ideal substrate be supposed to <0.40 g cm^{-3} (Abad *et al*., 2005). The bulk density of a growing medium can be effectively modified by addition of different substrate components of varying particle size.

Bulk density can be reduced with raise of coco peat due to low weight and better pore space. The lower bulk density facilitate easy shipping and ample ventilation to the plant (Sudhagar and Sekar, 2009).

Porosity:

Air volume of the medium is commonly used to estimate the level of aeration and the accessibility of O_2 to roots (Gliñski and Stêpniewski, 1985)." The particle size distribution is important to describe the physical quality of the material and its suitableness for plant growth. It influences the volume of air and water held by the substrate. The particle size distribution of the materials used as substrate can vary depending on their origin and grinding conditions among other factors (Ansorena, 1994).

Biochar addition caused changes to the physical characteristics of soilless medium, such as improving hydraulic conductivity and increasing air porosity (Dumroese *et al.,* 2011).

Substrate containing poultry manure resulted in higher porosity (88.69-88.90 % v/v) and air capacity (30.69-38.28 % v/v) (Dede *et al*., 2006).

Water holding capacity:

"An adequate substrate for plant growth must present high water retension capacity, fast water drainage and appropriate aeration (Ansorena, 1994).

The success of plants grown in pot culture can be summed up by the physical attributes of the growing media that influences its ability to provide sufficient water to the root systems without any oxygen shortage which is the most determining factor in containerized cultivation" (Michel, 2010).

NPK:

Abad *et al*. (2002) confirmed that concentration of existing N, Ca and Mg were low in coir dust, while those of P and K were extremely maximum 0.28-2.81 mol per m^3 and 2.97 to 52.66 mol per m^3 for P and K Scagel, (2003) reported that depending upon the cultivar, coir mixed media resulted in superior uptake or accessibility of numerous nutrients. *Petunia hybrida* 'Dream Neon Rose' shows that extracted NPK were maximum in plant developed in 60 per cent vermicompost media (Chamani *et al.,* 2008).

Effect of beneficial micro-organism in plant growth and development:

Methylobacterium species are a group of bacteria known as pink pigmented facultative methylotrops and exogenous application produces some benefits in alleviating adverse effects of drought stress and also improves germination, growth, development, quality and yield of plant (Hayat *et al.,* 2010). For ornamental plants like *Limonium sinuatum, Cupressus sempervirens* and *Camelia sinensis*, *Trichoderma* T2046, confirmed the best endophytic performance and improved growth in leaves number, leaf area and it could be taken into account as inoculants for innovative substrates (Domenico, 2016).

Effect of growing media on plant growth and development:

Soil:

Ophiopogon sp. showed a best performance in fresh weight of plants and leaf length in potting medium consisting of leaf mould: soil: sand @ ratio of 1:1:1 (Herath *et al.,* 2013). Media combination of soil + sand + farm yard manure @ 2:1:1 in *Dieffenbachia bowmannii* produced maximum plant height, large leaf length, large leaf width and plant spread. In *Dracaena reflexa*, media of soil + sand + FYM @ 2:1:1 recorded highest plant height, highest number of leaves and maximum plant height. Therefore, it is concluded that soil + sand + FYM @ 2:1:1 can be used in Dieffenbachia and Dracaena as pot plants (Sarkar *et al*., 2016).

Sand:

Different growing medium *viz*., soil, sand, silt, perlite, leaf compost, farm yard manure and spent compost (Button and Oyster) in different combination were used for growing croton plants. The best result was found in combination of sand + silt + leaf compost + spent compost (1:1:1:1) which recorded improved plant height(16.08 cm) and number of roots (37.15 cm) in croton (*Codiaeum variegatum*) (Younis *et al.,* 2010).

Potting media acts as a significant responsibility in growth and development of *Dieffenbachia* plants. According to them, vermicompost and sand (1:1) exerted maximum number of sprouts per plant and root

characters like root length, diameter, number of roots per plant, fresh and dry weight of roots (Sindhu *et al*., 2010).

Coco peat:

Soil mixture consisting of 1 part coco peat : 1 part topsoil : 1 part sand gave significantly higher vegetative fresh weight (1,246 g), more number of stems (98) secondary branches (33) as well as number of leaves (321) per plant in hanging ornamental plant (*Tradescantia* sp.) (Khelikuzzaman, 2007).

Coir mixed partially with sphagnum moss yielded greater number of foliage, fresh and dry weight of phalaenopsis cultivar 'Stripe' and 'White Red Lip' (Hwang and Jeong, 2007).

Lilies produced in coco peat media had recorded early flowering, superior quality, fresh weight of flowers and dry weight of flower, longer flower buds and superior root system (Jadwiga, 2008).

In Cock's comb 70 per cent coco peat: 30 per cent burnt rice hull gave best result in plant height (cm), leaf number, leaf area (cm^2), dry weight of flower, leaves, stem, roots and 70 per cent coco peat: 30 per cent perlite gave significant result in canopy diameter (cm) while 100 per cent coco peat gave best result in flower length (cm) and its required minimum days to flowering (days) (Awang *et al.*, 2009).

Growth parameters like visual quality, leaf area, leaf number, leaf weight, flowering stem height and root weights was superior in the combination of coco peat and sand in *Hyacinthus orientalis*. Highest photosynthesis rate and mesophyll efficiency were observed in the medium with coco peat and highest transpiration rate and stomatal conductance observed in media with sand (Nazari *et al*., 2011).

Maximum plant height (41.66 cm), leaf area (574.48 cm^2) and petiole length at the fourth week after emergence (16.29 cm) and shortest phyllachron (39.94 days), highest fresh and dry weight of leaves (5.14 and 1.2 g, respectively) and their N and K content (1.61 and 2.23, respectively) at 225 days after planting was found in sand + coir pith compost in (*Anthurium andreanum* cv. TROPICAL) (Basheer and Thekkayam, 2012).

Pot mixture containing coco peat + sand + vermicompost in 2:1:1 ratio resulted best growth parameters and quality in *Aglaonema* cv. ERNESTO'S favourite (Swetha *et al.*, 2014).

Growing of pot mums in chrysanthemum cv. SADHBHAVANA, on seven different potting media combinations found that coco peat + sand + farm yard manure + vermicompost (2:1:0.5:0.5 v/v) was found to be one of the best potting media combinations which produced maximum number of flowers per plant (192.02) with prolonged flowering duration (101.83 days) (Nair and Bharathi, 2015).

Media containing coco peat + conventional substrate increased plant height (58.2cm), number of foliage (32.5 cm), leaf area (21.7cm), leaf chlorophyll contents (51.0 cm), stem length (55.8cm), number of flowers (19.3cm), flower diameter (3.0 cm), spike length (15.9 cm) and stem fresh weight (34.3cm), stem dry weight (5.6 cm), while decreased number of days to harvest of stock. For zinnia, plant height (103.3 cm), stem length (55.8) and leaf nitrogen contents (0.39 cm) were significantly higher (Saleem *et al*., 2015).

In *Lilium longiflorum* cvs. Bach and Pavia. 100 per cent coco peat (T_1) was found best for most of the parameters *viz*., plant height, early flower buds appearance, days required for opening of first flower, total number of flower buds and vase life. (Bhandari and Srivastava, 2016).

Colombo *et al.* (2016) reported that vermiculite + coco peat fibre (1:1 v/v) gave highest result in fresh weight of stem and root, dry weight of leaves, stem, root and caudex diameter (mm) in desert rose.

In pot chrysanthemum, among the different treatments tried, coco peat + vermicompost + bio compost (2:1:1 v/v) exhibited maximum plant height (30.87 cm), number of branches (16.40), plant fresh weight (342.80 g) and dry weight (170.87 g), highest flower diameter (37.42 mm), duration of flowering (126.33 days) and highest number of flowers (66.61) (Padhiyar, 2017).

The growth parameters *viz*., plant height (60.46 cm), leaf area (36.98 cm^2), number of leaf per flowering stalk (20.23) and stalk length of cut flower (36.23 cm) were significantly increased in media combination of soil + coco peat + leaf mould (1:1:1) was followed by soil + coco peat + perlite in rose (*Rosa hybrida* L.) cv. TOP SECRET under protected condition (Chavada *et al.*, 2017).

Vermicompost:

Plant grown in 60 per cent vermicompost treatment had more fresh weight, dry weight of shoot, flower weight, yield and quality of marigold. Hence, mixing soil with 40 to 60 per cent vermicompost by volume is recommended

for marigold. Vermicompost is appropriate alternative substrates for the preparation of growth medium of pots (Shadanpour, 2011).

Rajvanshi and Dwivedi (2014) determined the outcome of different pot mixture (vermicompost, farm yard manure, sand and soil) on maturity of zinnia during the summer season crop of 2010. Among all, the (vermicompost + coarse sand + soil) combination of 3:2:0 showed best in plant height, plant spread, number of leaves, diameter of stem, length of leaf, width of leaf.

Media combination of coir compost + vermicompost (1:1) had recorded the maximum survival percentage (100%), shoot length (24.53 cm), shoot diameter (3.86 mm), number of leaves (18.6), length of leaf (5.93 cm), width of leaf (3.93 cm), fresh plant weight (26.34 g), fresh shoot weight (19.81 g), dry shoot weight (4.91 g), root length (13.16 cm), number of roots (32.33), fresh root weight (6.52 g) and dry root weight (1.72 g) in chrysanthemum (*Dendranthema grandiflora* Tzvelev.) (Baskaran *et al.,* 2016).

Effects of different potting media in different croton varieties (*Codieum variegatum*). Maximum number of leaves (8.1) and plant height was recorded in variety Rustifolia containing coco peat + vermicompost + farmyard manure in 1:2:1 combination and maximum leaf area (85.93 cm^2), root length (21.1 cm) in variety Petra were recorded with the media containing coco peat + vermicompost + farmyard manure in 1:1:2 combination (Fatmi and Singh, 2017).

Earliest sprouting, number of foliage, days taken for flowering, number of flowers/spike, duration of flowering, weight of stem and vase life was recorded best when LA hybrids bulbs were grown in media containing M_7 = M_1 (sand + soil + FYM @1:1:1,) + vermicompost + coco peat (2:1:1,v/v). However, plant height, stem length, bud length, size of flower, was recorded best when LA hybrids bulbs were grown in M_1- sand + soil + FYM, (1:1:1, v/v). Hence, it concluded that for quality flower production of LA hybrids cultivars a media of (sand + soil + FYM) + vermicompost + coco peat (2:1:1,v/v) was most suitable (Rajera *et al.,* 2017).

Effects of different rooting medium and their mixtures on rooting of carnation cuttings. Result showed that red soil + coco peat recorded less number of time for development of root initials (9.10 days), maximum percentage of rooting (97.70%) and maximum percentage of establishment of rooted cuttings (87.38%). Among the different media studied vermicompost recorded maximum number of roots per cutting (14.01) followed by coco peat (13.41) and red earth (12.85) (Renuka and Sekhar, 2017).

Biochar:

Biochar applications at a rate of 3 per cent, significantly increases plant height, fresh weight per plant, number of leaves, diameter of stem, diameter of flower and number of flower bud in *Chrysanthemum Coronarium* L. (Ali, 2017).

Adzraku *et al.* (2017) reported that the treatment with the mixture of topsoil and biochar (2:1) performed as most excellent media, in terms of physical and chemical properties and produced maximum leaves and rooted cuttings in *Ficus pumila.*

Rice husk:

Media comprising of coco peat: rice husk: vermicompost (1:2:1 v/v) gave highest result in number of leaves per plant, plant spread (cm), suckers per plant and flowers per plant in flower parameters of gerbera. (Kale *et al.,* 2009).

Rice husk medium in transparent pot enhanced plant height (7.2 cm), optimum growth and aesthetic quality of *Dieffenbachia amoena*. Rice husk medium could be used as the best alternative to topsoil for commercial production of potted *Dieffenbachia amoena* for house beautification (Olosunde *et al.*, 2015).

Seedling emergence and seedling development of 'Baixa Sortida' snapdragon seeds is favoured by the mixture of the substrates A (rice husk + vermiculite) and B (Sphagnum + torrefied rice straw + perlite) @ 1:1 (Silva *et al.,* 2017).

Perlite:

In perennial shrub, Jojoba (*Simmondsia chinensis*) the highest value of survival percentage (99.7%), height of plant (24.66cm), number of shoot (2.33) and leaves (24.33) per plant were obtained by the use of medium of peat moss: vermiculite: perlite (1:1:1) (Eed, 2016).

Substrate containing 25% coco peat + 25% vermicompost + 25% light soil + 25% perlite was the most appropriate substrate in terms of most estimated traits (lateral length of shoot, total dry weight, and shoot P and Fe content) in growth of *Araucaria excels* (Hajar *et al.,* 2016).

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