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Significance of growing medium in protected floriculture: A review

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Abstract
Quality cut flowers are possible only when a large number of flowers borne on long stems with healthy, pest and disease free foliage. These influence the successful marketing of flowers. The cultivation of greenhouse crops comprises a number of cultural operations. Among them, the medium which used for growing is the basic and most important for the survival of the crops. Due to relatively the plants are planted in the shallow depth of soil, growing medium has to be amended with organic and inorganic nutrients to provide the appropriate physical and chemical properties essential for the plant growth.

Keywords: Protected cultivation, growing media, physical and chemical constituents

1. Importance of growing media to make plants more vegetative or generative

Growing media companies have high production standards to achieve consistent quality of final products. Basically, vegetative growth is where plants need more leaves, top growth and roots to establish themselves. Generative growth is where plant starts producing flowers and fruits. Many growing media have added biological agents to provide disease reduction possibilities and improve root health. A few basic quality aspects of a growing medium are discussed below.

1.1 Cation Exchange Capacity (CEC)

The capacity of the media to hold and make available nutrients is affected by the cation exchange capacity (CEC) and the media pH. Cation exchange capacity refers to the media's ability to hold nutrients having a positive charge, such as NH4, Ca, Mg and K. The term "buffering capacity" is often used interchangeably with CEC. It refers to the ability of the media, as a result of its CEC, to resist changes in pH and nutrient levels.

1.2 Air Porosity (AP)

Air porosity is a measurement of the volume of pore space occupied by air after a saturated growing medium is allowed to drain. For the most part, packaged growing media products have a low bulk density, since the majority are made with a base of sphagnum peat moss and have a higher water holding capacity. Bark-based media are heavyweight products that are suitable when high drainage and container stability are required. Both products typically have good air porosity which is in a range of 10% – 18% by volume for most growing media.

1.3 Water Holding Capacity (WHC)

Water holding capacity is the volume percentage of water retained after a saturated growing medium is allowed to drain.

Three stages are applied to water holding capacity: saturation, container or field capacity, and wilting or permanent wilting point [28]. At saturation, most pores are full of water during irrigation. Gravitational water drains from the macropores due to gravity, and these pores refill with air. At container or field capacity, gravitational water has drained, and the medium contains available water for plant growth. Capillary action allows the micropores to retain water. At wilting point or permanent wilting point, no more water is available to plants and most plants wilt and fail to recover turgor when irrigated. All water between container or field capacity and wilting point is available water.

Different media components contribute to water holding capacity at various levels. Consider the following ingredients: coir, rock wool, peat, pine bark, vermiculite, perlite, and sand.

Each lends unique characteristics with respect to saturation, container capacity, and the amount of water held. For example, components with smaller, finer particles and pores, such as Canadian Sphagnum peat moss, processed coconut coir, and rock wool, hold more water. In contrast, those with larger, coarser particles, such as pine bark, perlite, and sand hold little water. The percentage of each component making up the mix will determine the duration of container or field capacity.

1.4 pH and EC

The initial pH of the growing should be between 5.8 and 6.2. Since most components of media are acidic, dolomitic limestone (calcium and magnesium carbonates) is added to start at an acceptable pH range and provide Ca and Mg for plant growth. The smaller the particle size of the ground limestone, the quicker is the increase in media pH.

Good quality can be obtained if growth factors are brought under control. Realizing the vast potential of the crop, there is an urgent need to pave way for enhancing its yield and quality. Such information is altogether lacking in Tamil Nadu. Hence, in relevance to the present study, the available information related to the objectives on chrysanthemum and other flower crops is reviewed here.

2. Growing media consortia for optimum growth, yield and quality

Bowe [14] opined that growing media should have a property to drain excess water attained at field capacity which creates congenial root environment and results in healthy growth of plant. Padaganur *et al* [45] reported that organic manures in the growing media seem to act directly by supplying nitrogen and phosphorus in available form to plants through biological decomposition. These indirectly improve physical properties of soils such as aggregation, aeration, permeability and water holding capacity.

2.1 Coco peat

The use of soil as growing media in protected cultivation has started to face serious limitations. The selection of a particular material used as a growing substrate depends on its availability, cost and local experience on its use. Recently, coconut waste being commercially used as an environmentally sound peat substitute for cut flowers [36-37,42]. Cocopeat or coir dust is a byproduct separated during processing of coconut (*Cocos nucifera* L.) coir. As a byproduct of coir manufacturing, cocopeat is often unutilized or burnt in the open. Of late, due to environmental concerns and diminishing supply of peat soils for horticultural substrates, cocopeat is being considered as a renewable peat substitute for use in horticulture. However, in its raw form, cocopeat has been reported to contain phytotoxic elements which inhibit plant growth [70]. Total water holding capacity in coir waste is lower than peat. Coir dust contains more lignin and cellulose, but less hemicellulose when compared with peat. The amount of naturally occurring available nutrients is low, especially mineral nitrogen, calcium and magnesium. On the other hand, indigenous phosphorus and potassium content in coir waste were extremely high [42].

Coir dust has been demonstrated to be suitable for use in substrates through numerous production trials [20, 37, 58, 66]. Sreerama *et al.* [64] observed that the root length of plants was significantly greater in cocopeat than in other media in the chrysanthemum cv. Sunny Reagan. Saravanan [56] reported that the *Dendrobium* hybrid cv. Sonia-17 recorded the maximum score for plant height, number of roots per plant, earliness, number of spikes per plant and spike length in coconut dust media.

Sreerama *et al*. [63] noted that the carnation cultivar 'Malaga' recorded maximum rooting (50.24 %) and length of roots (1.15 cm) under cocopeat media. Studies on the effect of different substrates on vegetative growth in *Anthurium andreanum* cv. Tropical Red showed higher number of leaves per plant (6.58) and maximum flower size (63.25 cm) under coconut coir pieces and coconut coir pieces + wooden charcoal media respectively[48].

Ritu and Grewal [55] studied the use of cocopeat medium for *Aglaonema commutatum* and found that better growth in respect of general appearance and vegetative parameters in cocopeat medium may be attributed to better water holding capacity and high nutrient status of this medium. Cocopeat combined with compost (1:1) produced flowers with the highest net returns in gerbera grown under protected cultivation [9]. Arumugam *et al*. [3] found that the maximum plant height, number of leaves, number of shoots, number of spikes per plant and spike length for *Dendrobium* hybrid cv. Sonia-17 grown in coconut fibre as media substrate.

Coconut fibre either singly or as a mixture recorded greater dimension of inflorescence and increases the number of buds; length and weight increase in the stem of Lily hybrids in soilless culture [26]

Gupta *et al*. [27] reported that cocopeat, saw dust and sand (1:1:1 v/v) was found to be best with respect to number of days required for bud initiation (75.00 days), flower diameter (9.47 cm), flower stalk length (35.31 cm), number of flowers per plant (29.55 cm), number of flowers per sq.m (21.00) and vase life (13.35 days) in gerbera cv. Paganini. [4] reported that media containing 100 % cocopeat supplied with nutrient solution having an EC of 1.8 ds m^{-1} produced good quality flowers in gerbera cv. Av 101. Among the different production modules, cocopeat: soil: sand (2:1:1) found to be better for stem thickness (4.33 mm), flower strength (6.28^0 angle) and vase life (7.67 days) in carnation [6].

Neeraja Rani *et al.* [40] revealed that Lilium cv. Elite produced more number of leaves (37.37 per stem) and longest bud (7.60 cm) grown in mixture of soil and coco peat. [29] reported that growing media combinations of soil + compost + cocopeat (2:1:1) recorded maximum plant height (87.00 cm), leaf area (62.32 cm^2), number of flowers per spray (13), diameter of flower (9.5 x 4.5 cm) and stem girth (0.45 cm). In Chrysanthemum, nutrient uptake studies conducted by[19] found that plants growing on coco peat + compost (1:1) recorded maximum leaf nitrogen content (5.25 %), phosphorus content (0.55 %), sulphur content (0.15 %) and boron content (62.98 ppm).

A study was carried out to investigate the effect of growth regulators and growing media on bulblets formation in Lilium hybrids cultivars Pollyanna and Parto. Number of roots was recorded more (5.8) in both the cultivars in cocopeat with IBA 500 and 1000 ppm. The root length was recorded maximum (15.0 cm) in cv. Prato with cocopeat[18].

Treder [68] revealed that Lilium cv. Star Gazer grown in cocopeat medium recorded earlier flowering (96.20 days), higher fresh and dry weight of flowers (32.5 and 3.56 g /plant) and leaves (24.1 and 2.77 g /plant), longer flower buds and better root system. The number of bulb roots (34 %) and total root length (118 %) were higher in cocopeat than in control medium. Borrero *et al.* [13] reported that coir fibre as growing medium recorded highest plant height (28.3 cm), fresh weight (13.59 g) and dry weight (2.00 g) but failed to suppress the Fusarium wilt pathogen in medium. In anthurium cv. Flame, combinations of growing medium containing saw dust + wooden charcoal + soil + sand + FYM (2:1:1:1:1) recorded highest petiole length (21.31 cm), stalk length (36.16 cm), number of suckers per plant (5.00) and number of flowers per stem [61].

2.2 Farm yard manure

Farm yard manure occupies an important position among organic manures. The cattle excrete based FYM in India can potentially supply approximately 33 million tonnes of N, P and K per year. The FYM seems to act directly by increasing crop yield either by acceleration of respiratory process or by cell permeability or by hormonal growth action. It supplies N, P and K in available form to the plants through biological decomposition and it contains 0.50, 0.17 and 0.55 per cent of N, P and K respectively [24].

Maloupa *et al*. [33] reported that the two rose varieties "Binaca" and "First Red" showed better yield and Atam Prakash *et al*. [5] recorded increased plant height (36.30 cm), number of branches (8.02 / plant) and plant spread (22.87 cm) with application of FYM at 10 t / ha compared to control (34.64 cm, 6.18/plant and 20.20 cm respectively) in marigold. [62]reported that application of FYM at 5 kg per square metre delayed the days to bud appearance (127.75 days) and recorded more weight of flowers (487.70 g / m^2) during 1^{st} flush compared to control (106.52 days and 448.33 g/m^2 respectively) in rose.

Singh [60] observed delayed flowering (82.72 days), maximum number of flowers (28.61 / plant) and yield of flowers (2,522.15 g / m^2) with the application of FYM at 5 kg /m^2 compared to control (81.33 days, 25.26/plant and 2,149,37 g/m^2 respectively) in rose.

Anil *et al.* [1] reported that sand and FYM (1:1) produced maximum plant height, number of sprouts per plant, number of leaves per plant, diameter of shoot, number of flowers per plant, number of roots per plant, length and diameter of root and dry weight of roots per plant in wax Begonia. Paramveer Singh *et al*. [46] reported that growing medium comprising of saw dust, brick pieces, wooden charcoal, soil, sand and FYM in the ratio of 2:1:1:1:1:1 recorded best for almost all the parameters like leaf area, petiole length, minimum days to flowering, stalk length, spathe length, spathe width and number of flowers per plant in Anthurium cv. Flame.

2.3 Vermicompost

Vermicomposting is a process of recycling of organic wastes in an environmentally safe method and is cost effective. Vermicompost is a mixture of worm casts which are rich source of micro and macro nutrients. The worm casts apart from increasing the density of microbes also provide the required nutrients to plants. It contains plant growth promoting substances such as NAA, cytokinins, gibberellins, *etc*. It also increases the efficiency of added fertilizers in the soil.

A process related to composting which can improve the beneficial utilization of organic wastes is vermicomposting. It is a non-thermophilic process by which organic materials are converted by earthworms and microorganisms into rich soil amendments with greatly increased microbial activity and nutrient availability [43].

Pablo and Richard [44] have indicated that the bulk density, percentage of pore space, and water holding capacity increased as vermicompost content increased while the percentage of air space decreased. At 100% vermicompost, water holding capacity and bulk density were greatest in vermicompost from sheep manure. Plants grown in mixtures of 50% vermicompost from sheep had a greater growth index at harvest, foliar area, number of flowers per pot, and dry weight and fewer days for flower development than plants grown in other substrates. Vermicompost from sheep manure added at 50% by volume was most effective as a substrate amendment for chrysanthemum production.

Atiyeh *et al*. [6] reported that relatively low concentration of vermicompost could promote plant growth in marigold. In the same crop plants applied with vermicompost (15 tonnes per hectare) + 100 per cent NPK produced maximum number of flowers per plant with greater flower diameter and flower yield than plants without vermicompost and fertilizer application [35].

Sashikanth [57] noticed in marigold that the application of vermicompost @ 5.0 t ha^{-1} along with recommended dose of fertilizer had increased flower yield (13.9 t ha^{-1}). In the same crop maximum number of flower buds / plant, individual flower weight and flower yield / m^2 were recorded with the application of vermicompost at 1000 g/m^2 [16]. Balaji *et al*. [7] reported that application of vermicompost (2.5 to 5.0 t/ha) helped to reduce the inorganic fertilizer requirement of China aster to the tune of 25-50 % without affecting the yield. Warade *et al.* [73] observed that, the growth of dahlia in respect of height of plant, number of leaves per plant, spread of plant, earliness of flowering and yield of flower was superior in the plants receiving vermicompost 500 g with PSB 35 g $plot^{-1}$.

In carnation cv. Desio, Renukaradya *et al.*[54] reported that plants receiving 50 percent RDF, vermicompost (250 g/m^2), 3 % manchurian tea and 3 % panchakavya recorded significantly higher number of branches per plant (6.50), maximum duration of flowering (59.20 days), number of flowers per plant per year (6.54) and number of flowers per sq.m (132.33).

Padaganur *et al.* [45] reported that maximum spike yield (1.14 lakhs/ha) and loose flower yield (5.57 t /ha) was recorded from the plants applied with 50 percent RDF + 3 kg vermicompost per sq.m than control in tuberose cv. Single. Shankar Lal *et al*.[59] opined that in tuberose cv. Single, vermicompost and phosphobacteria @ 1 kg/m^2 and 2 g/bulb respectively produced maximum spike length, number of spikes/plant, weight of bulbs/plant and longevity of spikes. Carnation cv. Raggio-de-Sole produced maximum plant height, number of flowers, length of stalk, flower size, earliness in flowering, maximum vase life when it was grown on a culture having soil + sand + vermicompost (1:1:1) + inorganic fertilizer + biofertilizers *viz.*, Azospirillum and Phosphobacteria. The treatments having vermicompost was found to be better compared to treatments having FYM and municipal compost [10].

Chauhan *et al*. [16] in marigold cv. Pusa Narangi Gainda, reported that the application of vermicompost @1000 g/m^2 recorded higher yield of flowers (1757.76 g/m^2) compared to application of vermicompost @ 500 g/m^2 (1429.00 g/m^2) alone. Application of vermicompost at the rate of 10 t ha^{-1} and 100 percent recommended dose of NPK (100:50:50 kg ha^{-1}) produced maximum plant height, more number of leaves and highest flower yield in golden rod [32]. A significant increase in plant height, leaf number, spike length and number of florets per spike in gladiolus was obtained in the plots treated with a combination of vermicompost @ 10 t ha^{-1} and 80 per cent recommended dose of NPK @ 100: 60: 60 NPK ha^{-1} [23].

In marigold, the plants applied with vermicompost (15 t/ha) and 100 per cent recommended dose of NPK produced

maximum number of flowers per plant with greater flower diameter and flower yield than the plants in control [35].
Srinivas and Gowda [65], opined that application of vermicompost and FYM with recommended dose of NPK increased the plant height, number of leaves, number of branches and flower yield in china aster. Kale *et al.* [31] opined that the worm casts contributed beneficially on stem girth in China aster and salvia, due to higher mycorrhizal root colonization.

2.4 Perlite
Grassotti *et al.* [26] reported that perlite as growing substrate in soilless lily culture required the largest quantity of nutrient solution. In six cultivars of Asiatic hybrid lilies (Orlando, Amarone, Pink Superior, Salsa, Pollyana and Vignola), cultivating bed made up of peat and perlite increased the shoot length (78.00 cm) significantly. However, growing medium had no significant effects on the number of floral buds, flowering time and chlorophyll content of leaves [38].

3. Effect of combination of growing media
Ganesh *et al.* [21] revealed that combination of soil + FYM + Cocopeat + Perlite + Vermicompost + microbial consortia have influenced the growth and flowering parameters. The Cocopeat present in the media composition withholds the optimum moisture level for a longer time and porosity encourages good aeration for the root growth and its effect on the availability of nutrients. These are potential alternatives to inorganic nutrient sources and eco-friendly products which contain growth promoting hormones like IAA, IBA, NAA, GA and vitamins which induce the better growth of the plants. The growing media consortia containing Soil + FYM + Coco peat + Perlite + Vermicompost + Microbial consortia was found to be better in enhancing and sustaining the productivity per unit area under protected conditions [22].
Rajasekar and Suresh [51] have indicated that the physical and chemical properties of growing media determine the nutritional status, water holding capacity and aeration which determine the rate of growth and suitability. The cultivar Pink (V2) ranked first for the plant height and number of branches per plant. The variety Summer Snow (V3) ranked first for the trait plant spread N×S (20.14 cm) whereas, the variety Red Kudthki (V1) adjudged as the best for plant spread E×W (20.37 cm. Chavadha *et al* [17] reported that the proportion of potting media viz., soil + cocopeat + leaf mould (1:1:1) can be used for getting maximum plant growth, flower yield and quality of rose cv. Top Secret under protected condition.

4. Effect of biofertilizers and biocontrol agents on flower crops
French marigold seedlings, inoculated with VAM exhibited the increased foliar phosphorus level besides the enhanced content of N, P, K, Mg and Zn [8]. Application of nitrogenous fertilizer with the inoculation of azospirillum and phosphate solubilizing bacteria increased plant height, number of tertiary branches, shoot and leaf area, dry weight, root biomass, flower weight and yield in *J. sambac* [34]. Vasanthi [69] obtained increased corolla length, tube length, bud width, petal breadth, flower diameter and advanced flowering in plants inoculated with azospirillum in *J. grandiflorum* cv. CO 2. Application of azospirillum and phosphobacteria alone or in combination with inorganic fertilizers increased the number of flowers per spike and yield in Crossandra [53].
Nethra[41] observed in China aster that the maximum plant height, number of leaves and highest flower yield was recorded the application of vermicompost @ 10 t ha^{-1} along with recommended dose of NPK (180: 120: 100 kg ha^{-1}). Bhavanisankar and Vanangamudi [12] reported that the combined application of 100 percent of nitrogen as urea and azospirillum resulted in maximum spike length (3.53 cm) and number of flowers per spike (5.66) in crossandra. Rajadurai *et al.* [50] found increased growth with respect to plant height (144.50 cm), number of leaves (156.20) and number of laterals per plant (28.03) in pot culture experiments with the application of NPK (45:45:37.5 mg /pot) along with combined inoculation of azospirillum and VAM in marigold.
Maximum availability and uptake of nutrients by crossandra cv. Dindigul local was attributed to the application of 100 percent NPK with azospirillum and Phosphobacteria [39]. Ravi *et al*. [52] studied the effect of azospirillum along with 100 per cent recommended dose of nitrogen and found that it significantly produced maximum flower yield (35.25 t h^{-1}), biomass yield (7.26 g $plant^{-1}$ at maximum flowering stage) and nitrogen uptake (71.23 kg ha^{-1}). Anil and Yesh Pal Singh [2] reported that the application of biofertilizers azotobacter resulted in maximum plant height, number of flowers and yield/ha compared to application of chemical fertilizers alone. Gayathiri *et al.* [25] reported the effect of biofertilizers *viz.*, vermicompost + azotobacter + PSB along with 50 % of recommended N, P and 100 % K to realize the significant increase in plant height and higher yield of quality spikes in statice. Bhatia and Gupta[11] revealed that combined application of azospirillum and VAM along with water soluble fertilizers in carnation produced highest number of flowers per square metre (180) and maximum vase life (10.81 days). China aster cv. Shashank performed better when vermicompost applied along with VAM inoculation. Progressive improvement in growth and yield attributes of China aster were noticed with increased levels of vermicompost and VAM inoculation from zero to 10 t ha^{-1} and 3 to 5 g per plant respectively [72].
China aster cv. Kamini performed better when RDF was reduced to 50 per cent and integrated with application of azospirillum, phosphobacteria and vermicompost as compared to 100 percent RDF [47]. Chandra *et al.* [15] indicated that application of full dose of phosphatic fertilizer (150 kg ha^{-1}) along with VAM and PSF recorded the highest plant girth (99.1 cm), number of branches per plant (22), plant height (24.2 cm), shoot fresh weight (140.50 g) and shoot dry weight (27.12 g) in chrysanthemum. Verma *et al*. [71] revealed that application of azospirillum, phosphate solubilizing bacteria (PSB), vermicompost and 50 per cent recommended NPK recorded the highest plant height (63.39 cm), number of branches (20.08), plant spread (33.20 cm) and flower yield (13.12 t ha^{-1}) in chrysanthemum cv. Raja.
Combined application of phosphorus solubilizing bacteria @ 200 g/l + boron @ 0.6 per cent recorded maximum number of leaves per clump (63.37), plant height excluding spike (63.37 cm), number of florets per spike (41.11), floret length (6.50 cm), rachis length (28.37 cm) and spike length (90.22 cm) in tuberose cv. Pearl Double [30]. Prasad *et al*. [49] reported that inoculation of plants with *A. laevis* + *P. fluorescens* at medium concentration (40 kg h^{-1}) of superphosphate showed maximum height (57.20 cm), fresh and dry root weight (6.40 g and 1.09 g), AM root colonization (93.48 per cent) and the percent phosphorus uptake in shoot and root (1.48 and 1.76).
In modern agriculture, use of chemical fertilizers is becoming essential for higher yield, but is not ecofriendly. At present the flower growers are not able to maintain quality and production of this flower due to high cost of production. The

current trend is to explore the possibility of supplementing chemical fertilizers with organics especially microorganisms. The use of farm yard manure, vermicompost and coco peat along with bio fertilizers (VAM, PSB and Azospirillum) and bio control agents with the existing soil become important and will reduce the cost of production. Hence, research on formulation of growing media consortia and need to develop farmer's friendly technologies to increase the profit and production.

References

1. Anil KS, Gupta S, Singh AK. Influence of various potting media on vegetative and root characteristics in wax begonia. J Orn. Hort. 2009; 12(2):111-115.
2. Anil KS, Yesh Pal Singh. Leaf nutrient status, growth and flower yield in rose as influenced by organic and inorganic sources. J Orn. Hort. 2003; 6(3):229-233.
3. Arumugam T, Jawaharlal M, Vijayakumar M, Subramanian S. Effect of media on growth and yield of Dendrobium. National Symposium on Indian Floriculture in the New Millennium IARI, New Delhi, 2002).
4. Aswath C, Pillai P. Effect of cocopeat medium and electrical conductivity on production of gerbera. J Orn. Hort. 2004; 7(1):15-22.
5. Atam Prakash, Sindhu SS, Sharma SK, Sangwan PS. Effect of phosphorus and FYM on growth of marigold in chloride dominated saline soil. Haryana J Hort. Sci. 2001; 31(1&2):54-56.
6. Atiyeh RM, Edwads CA, Subler S, Metzer JD. Earthworm processed organic wasters as components of Horticultural potting media for growing marigold and vegetable seedlings. Compost Science and Utilization. 2000; 8:215-233.
7. Balaji S Kulharni, Reddy BS, Patil BC, Divakara A. Influence of vermicompost and in situ vermiculture on the quality attributes and saleable yield in China aster. Scientia Hort. 2006; 10:217-221.
8. Balasubramaniam J. Studies on the combined effect of azospirillum, VAM and inorganic fertilizers on the growth and performance of French marigold (*Tagetes petula*) M.Sc., (Hort.) Thesis, Tamil Nadu Agricultural University, Coimbatore, 1987.
9. Barreto MS, Jagtap KB. Assessment of substrate media for the economical production of gerbera flowers under protected cultivation. National Symposium on Indian Floriculture in the New Millennium IARI, New Delhi, 2002.
10. Bhalla R, Sandeep Dharma, Dhiman SR, Jain R. Effect of biofertilizers on growth and biostimulants on growth and flowering in standard carnation (*Dianthus caryophyllus* L.). J. Orn. Hort. 2016; 9(4):282-285.
11. Bhatia S, Gupta YC. Studies on use of biofertilizers in carnation (*Dianthus caryophyllus* Linn.) flower production. J. Orn. Hort. 2007; 10(2):131-132.
12. Bhavanisankar K, Vanangamudi K. Integrated nutrient management in gundumalli (*Jasminum sambac* Ait). South Indian Hort., 1999; 47(2):111-114.
13. Borrero C, Trillas I, Aviles M. Carnation Fusarium wilt suppression in four composts. Eur. J Plant Pathol. 2009; 123:425-433.
14. Bowe R. Characteristics of standard growing media. Dtsche Gertenb. 1964; 11:160-162.
15. Chandra S, Srivastava N, Narayan RP, Sharma N. Efficacy of microbial inoculants on reducing the phosphatic fertilizer input in chrysanthemum. Indian J. Hort. 2009; 66(1):83-87.
16. Chauhan S, Singh CN, Singh AK. Effect of vermicompost and pinching on growth and flowering in marigold cv. Pusa Narangi Gainda. Prog. Hort. 2005; 37(2):419-422.
17. Chavada JR, Thumar BV, Vihol AN, Patel VS, Padhiyar BM. Effect of potting media on growth, flower yield and quality of rose (*Rosa hybrida* L.) CV. Top secret under protected condition, Int. J. Pure App. Biosci. 2017; 5(5):821-827.
18. Dhiman MR, Sindhu SS. Effect of propagation media and growth regulators on bulblet formation through scale propagation of Lilium. J. Orn. Hort. 2007; 10(3):181-183.
19. Dutt M, Sonawane, PS. Nutrient uptake in chrysanthemum grown on various substrates. Indian J Hort. 2006; 63(1):66-69.
20. Evans MR, Stamps RH. Growth of bedding plants in Sphagnum peat and coir dust based substrates. J Environ. Hort. 1996; 14:187-190.
21. Ganesh S, Kannan M, Jawaharlal M, Arulmozhiyan R, Jeyakumar P. Standardization of growing medium for cut chrysanthemum (*Dendranthema grandiflor*a Tzvelev) cv. Amalfi under protected conditions. J. of Orn. Hort. 2015a; 18(1&2):48-55.
22. Ganesh S, Kannan M, Jawaharlal M. Growth, physiology and yield parameters as affected by growing media consortia on Chrysanthemum var. Amalfi under naturally ventilated polyhouse. Green Farming, 2015b; 6(4):883-887.
23. Gangadharan GD, Gopinath G. Effect of organic and inorganic fertilizers on growth, flowering and quality of gladiolus cv. White Prosperity. Karnataka J Agric. Sci. 2000; 13(2):401-405.
24. Gaur AC. Response of rice to organic matter. Indian experience. In organic matter and rice, IRRI, Philippines, 1984, 504-516.
25. Gayathiri MN, Jayaprasad KV, Narayanaswamy P. Response of biofertilizers and their combined application with different levels of inorganic fertilizers in statice (*Limonium caspia*). J Orn. Hort. 2004; 7(1):70-74.
26. Grassotti A, Nesi B, Maletta M, Magnani G. Effects of growing media and planting time on Lily hybrids in soil less culture. Acta Hort. 2003; 609:395-399.
27. Gupta YC, Dein LQ, Dhiman SR, Jain R. Standardization of growing medium under protected environment of gerbera in mid-hill of Himachal Pradesh. J Orn. Hort. 2004; 7:99-102. http://www.sungro.com/air-porosity-and-water-holding-ability-of-media-components/
28. Janakiram T, Mahantesh Murgod I, Prabhakar BS. Standardization of agro techniques for production of Chrysanthemum under low cost polyhouse. Acta Hort. 2006; 710:321-328.
29. Jitendra Kumar, Pradeep Kumar, Krishnan Pal. Effect of biofertilizers and micronutrients on growth and flowering of tuberose (*Polianthes tuberosa* L.) cv. Pearl Double. Agric. Sci. Digest. 2012; 32(2):164-167.
30. Kale RD, Kubra Banu, Sreenivas MN, Bagyaraj DJ. Influence of worm cast on the growth and mycorrhizal colonization of two ornamental plants. South Indian Hort. 1987; 35(6):433-437.
31. Kusuma G. Effect of organic and inorganic fertilizers on growth, yield and quality of golden rod (*Solidago canadensis* L.) M.Sc., (Ag.) Thesis. University of Agricultural Sciences, Bangalore, 2001.

32. Maloupa E, Kheliti S, Zervaki D. Effect of growing media on the production and quality of two rose Varieties. Acta Hort. 2001; 548:79-83.
33. Manonmani R. Effect of soil inoculation of azospirillum and phosphobacteria and graded level of nitrogen and phosphorus biofertilizers on growth and yield of *Jasminum sambac* Ait cv. Gundumalli M. Sc., (Hort.) Thesis. Tamil Nadu Agricultural University, Coimbatore, 1992.
34. Mashaldi A. Effect of organic and inorganic fertilizers on growth, yield and post-harvest life of marigold (*Tagetes erecta* L.) cv. Double Orange. M. Sc., (Ag.) Thesis, University of Agricultural Sciences, Bangalore, 2000.
35. Meerow AW. Coir dust - a viable alternative to peat moss. Greenhouse product News, 1997, 17-21.
36. Meerow AW. Growth of two tropical foliage plants using coir dust as a container medium amendment. Hort Technology. 1995; 5:237-239.
37. Moazzam Hassanpour Asil. Effects of growing medium in some postharvest characteristics of cut flowers in six cultivars of Asiatic hybrid lilies (*Lilium longiforum* L.), J. Fd. Agric. Environ. 2008; 6(2):442-446.
38. Narasimharaju S, Haripriya K. Integrated nutrient management in crossandra (*Crossandra infundibuliformis* L.) cv. Dindigul Local. South Indian Hort. 2001; 49(Special):1814-184.
39. Neeraja Rani N, Ramesh Kumar, Dhatt KK. Effect of nitrogen levels and growing media on growth, flowering and bulb production of Lilium cultivars. J. Orn. Hort. 2005; 8(1):36-40.
40. Nethra NN. Effect of organic and inorganic fertilizers on growth, yield and postharvest life of China aster (*Callistephus chinensis* L. Nees.) M.Sc. (Ag.) Thesis, University of Agricultural Sciences, Bangalore, 1996.
41. Noguera P, Abad M, Puchades R, Noguera, Maquieira A, Martinez J. Physical and chemical properties of coir waste and their relation to plant growth. Acta Hort. 1997; 450:365-373.
42. Norman QA, Clive AE. Effects of vermicompost on plant growth. Paper presented during the International Symposium Workshop on Vermi Technologies for Developing Countries (ISWVT 2005), Los Banos, Philippines. 2005; 16(18):1-25.
43. Pablo RH, Richard LH. Earthworm Castings as a Substrate Amendment for Chrysanthemum Production, Hortscience, 2002; 37(7):1035-1039.
44. Padaganur VG, Mokashi AN, Hedge RV. Effect of vermicompost, farm yard manure and biofertilizers on growth and flower yield of tuberose (*Polianthes tuberosa* L.). Asian J. Hort. 2009; 5(3):115-117.
45. Paramveer Singh, Dhauk BK, Chawla, SL. Standardization of growing medium for Anthurium cv. Flame under protected conditions. Indian J. Hort. 2011; 68(1):86-90.
46. Patil VS, Chitra RS, Jagdesh KS. Response of China aster to organic manure, biofertilizers and their combined applications with inorganic fertilizers. J Asian Hort., 2007; 4(1):76-77.
47. Pawar GM, Patil MT, Gaikwad AM. Effect of different substrates on *Anthurium andreanum*. In: National Symposium on Indian Floriculture in the New Millennium (Feb. 25-27, 2002) IARI, New Delhi, 2002, 50-52.
48. Prasad K, Aggarwal A, Yadav K, Tanwar A. Impact of different levels of superphosphate using arbuscular *Mycorrhizal fungi* and *Pseudomonas fluorescens* on *Chrysanthemum indicum* L. J. Soil Science and Plant Nutr. 2012; 12(3):451-462.
49. Rajadurai KR, Manivannan K, Jawahralal M, Beaulah A. Effect of azospirillum and VAM on growth character of African marigold (*Tagetes erecta* L.). South Indian Hort. 2000; 48(1-6):83-87.
50. Rajasekar P, Suresh J. Effect of different growing media on growth of pot grown Rose (*Rosa chinensis* Jacq.), Res. Environ. Life Sci. 2015; 8(3):477-478.
51. Ravi G, Mukesh C, Tongmin SA. Influence of diazotrophicus Azospirillum on growth, flower yield and N uptake of Chrysanthemum. 17th WCSS, Thailand, 2002, 14-21.
52. Ravichandran R, Pappiah CM. Studies on the effect of nitrogen, azospirillum and ascorbic acid on foliar nutrients in crossandra (*Crossandra infundibluiformis*. Salisb). National Symposium on organic farming. Madurai, 1995.
53. Renukaradhya S, Pradeep Kumar CM, Santhosha HM, Dronachari M, Shashikumar RS. Effect of integrated system of plant nutrition management on growth, yield and fower quality of carnation (*Dianthus caryophyllus* L.) under greenhouse. Asian J. Hort. 2011; 6(1):106-112.
54. Ritu D, Grewal HS. Use of Cocopeat medium for Aglaonema commutatum. National Symposium on Indian Floriculture in the New Millennium (Feb. 25-27, 2002) IARI, New Delhi, 2002.
55. Saravanan S. Studies on the effect of growing media, nutrients with growth regulators and shade levels on plant growth spike yield and flower quality of Dendrobium hybrid Sonia 17. Ph.D. (Hort.) Thesis, submitted to Tamil Nadu Agricultural University, Coimbatore, 2001.
56. Sashikanth. Effect of different sources of nutrients on growth, flowering and seed yield in tall marigold (*Tagetes erecta* L.) M.Sc. (Ag.) Thesis, University of Agricultural Sciences, Dharwad, 2005.
57. Seeni S, Latha PG. Post-transplantation growth of Phalaenopsis hybrid seedlings in community pots. J. Orchid Soc. India, 1990; 4(1-2):127-133.
58. Shankar Lal, Lakhawat SS, Choudhary MK. Effect of organic manures and bio fertilizers on growth, flowering and bulb production in tuberose. Indian J. Hort. 67(4):554-556.
59. Singh AK. Effect of farmyard manure, azotobacter and nitrogen on leaf nutrient composition, growth, flowering and yield in rose. Indian J. Hort, 2006; 63(1):62-65.
60. Singh PK, Kumar V, Singh S. Management of tannery waste: Its use as planting medium for Chrysanthemum plants. J. Environ. Sci. Technol. 2011; 4:560-567.
61. Singh AK, Shiva Jauhari. Growth and flowering in rose as influenced by nitrogen, azotobacter and farmyard manure. Prog. Hort. 2005; 37(2):444-447.
62. Sreerama R, Reddy TV, Gopinath G. Studies on rooting of carnation cuttings as influenced by rooting media. National Symposium on Indian Floriculture in the New Millennium (Feb. 25-27, 2002) IARI, New Delhi, 2002.
63. Sreerama R, Reddy TV, Narayanaswamy S. Effect of cocopeat on root growth of chrysanthemum plants. Current Research - University of Agricultural Sciences, Bangalore. 1999; 28(3-4):53.
64. Srinivas KN, Gowda JVN. Effect of different organic manure on growth and flower yield of China aster (*Callistephus chinensis* L. Nees.). Crop Res. 1999; 18(1):104-107.

65. Stamps RH, Evans MR. Growth of Dieffenbachia maculata 'Camille' in growing media containing sphagnum peat or coconut coir dust. Hort Science. 1997; 32:844-847.
66. Tejaswinia, Murgod MI. Impact of production modules on vase life in carnation (*Dianthus caryophyllus* Linn.) cv. Sunrise. J. Orn. Hort. 2005; 8(1):73-74.
67. Treder J. The effects of cocopeat and fertilization on the growth and flowering of Oriental lily 'Star Gazer'. J Fruit Ornam. Plant Res. 2008; 16:361-370.
68. Vasanthi G. Studies on the effect of graded levels of nitrogen, phosphorus with azospirillum and phosphobacterium on growth and yield of jathimalli cv. Co-2 M.Sc., (Hort.) Thesis. Tamil Nadu Agricultural University, Coimbatore, 1994.
69. Verdonck O, Penninck R, De Boodt M. The physical properties of horticultural substrates. Acta Hort. 1983; 150:155-160.
70. Verma SK, Angadi SG, Patil VS, Mokashi AN, Mathad JC, Mummigatti UV. Growth, yield and quality of chrysanthemum (*Chrysanthemum morifolium* Ramat.) Cv. Raja as influenced by integrated nutrient management. Karnataka J Agric. Sci. 2011; 24(5):681-683.
71. Vijay kumar, Abjit Singh. Effect of vermicompost and VAM inoculation on vegetative growth and floral attributes in China aster. J Orn. Hort. 2007; 10(3):190-192.
72. Warade AP, Golliwar VJ, Chopde N, Lanje PW, Thakre SA. Effect of organic manures and bio fertilizers on growth, flowering and yield of Dahlia. J Soils Crops. 2007; 17(2):354-357.