STANDARDIZATION OF ALTERNATE MEDIA FOR POTTED ORNAMENTAL FOLIAGE PLANTS FOR EXPORT PURPOSE

By

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(2018 - 12 - 011)

DEPARTMENT OF FLORICULTURE AND LANDSCAPING

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KERALA, INDIA

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THESIS

Submitted in partial fulfillment of the requirement for the degree of

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DEPARTMENT OF FLORICULTURE AND LANDSCAPING

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2020

DECLARATION

I hereby declare that this thesis entitled **“Standardization of alternate media for potted ornamental foliage plants for export purpose”** is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, fellowship or other similar title, of any other University or Society.

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Date: 18-09-2020 — (2018-12-011)

CERTIFICATE

Certified that this thesis entitled **"Standardization of alternate media for potted ornamental foliage plants for export purpose"** is a record of research work done independently by **Ms. Rashidha C.K. (2018-12-011)** under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, associateship or fellowship to her.

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We, the undersigned members of the advisory committee of **Ms. Rashidha C.K. (2018-12-011)** a candidate for the degree of **Master of Science in Horticulture**, with major field in Floriculture and Landscaping, agree that the thesis **"Standardization of alternate media for potted ornamental foliage plants for export purpose"** may be submitted by **Ms. Rashidha C.K. (2018-12-011),** in partial fulfillment of the requirement for the degree.

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LIST OF ABBREVIATIONS AND SYMBOLS USED

Symbols	Abbreviations
%	Per cent
@	At the rate of
®	Trade name
^0C	Degree Celsius
Ca	Calcium
cc	Cubic centimetre
CD	Critical difference
CEC	Cation exchange capacity
cm	Centimetre
cm^2	Square centimetre
CRD	Completely Randomized Block Design
cv.	Cultivar
dSm^{-1}	Decisiemens per metre
EC	Electrical conductivity
et al.	And others
EW	East West
FYM	Farm Yard Manure
g	Gram
g $plant^{-1}$	Gram per plant
K	Potassium
KAU	Kerala Agricultural University
Kg	Kilo gram
l	Litre
m	Metre
meq	Milli equivalent

Mg	Magnesium
ml	Milli litre
mm	Milli metre
MSL	Mean Sea Level
N	Nitrogen
Na	Sodium
NS	Non- significant
NS	North South
P	Phosphorus
pH	Power of hydrogen ion
POP	Package of Practice
RH	Relative humidity
Rs.	Rupees
UV	Ultra violet
v/v	Volume by volume
var.	Variety
viz.,	Namely

Introduction

1. INTRODUCTION

Floriculture is the aesthetic branch of horticulture. As a growing sector, it is viewed as a multi-billion dollar industry providing employment opportunities in rural as well as urban areas. In India, floriculture trade comprises of flower trade, production of nursery plants, potted plants, seeds, bulbs as well as tissue culture plants.

Potted plants can either be ornamental foliage or flowering plants. Nowadays, many online nurseries are offering decorated pots and goodie bags with small potted plants as gifts. Pot plants are usually used for interiorscaping of homes, offices, commercial complexes, hotels, malls and other sites for various functions as they enhance the aesthetic view and create a stress free atmosphere indoors.

The fascination with indoor plants began in the period from 1960 as people became interested in new foliage varieties. Since then the foliage business is blooming. These plants are generally grown for their attractive foliage and can be kept for longer periods under indoor conditions. The great demand for foliage plants in both domestic and export markets can be attributed to rapid urbanization and changing lifestyles. Instant gardening is possible using potted plants as these could be easily carried to places even distant. Lack of open spaces is another reason why people depend largely on potted plants for decorating their houses and surroundings.

Aglaonema is one of the most versatile, recognizable and widely used group of tropical ornamental foliage plants popularly known as Chinese evergreen. It is native to Southeast Asia and belongs to the family Araceae. The genus Aglaonema is derived from two Greek words "*aglos*" meaning bright and "*nema*" meaning thread. They are evergreen herbaceous perennials with stems growing erect, decumbent or creeping. The stems that grow along the ground got rooted at the nodes. It has a crown of wide blades which in wild species are often variegated with silver and green colouration. This plant has been widely used by professional interior landscapers for decades. These are economically viable to commercial growers since they adapt readily to low light and low relative humidity conditions encountered under indoors.

Potting medium plays an important role in successful growth of foliage plants especially in aglaonema. Successful production of container-grown plants is largely dependent on the chemical and physical properties of the potting media. A good potting medium should provide sufficient anchorage or support to the plant, serve as reservoir of nutrients and water, and allow oxygen diffusion to the roots and gaseous exchange between the roots and atmosphere. The potting medium should be affordable, easily available and manageable. Conventionally top soil is used as a major constituent of potting medium but now unavailability of good quality top soil and risk of soil borne pathogens are promoting soilless media in the production of potted horticultural crops. It is essential to develop alternate potting media which are eco-friendly and commercially viable for pot plant trade. Nowadays, the need for light-weight growing medium has become more desirable due to its easy portability and shipment during exhibitions and flower shows to foreign countries. (Dubey *et al*., 2012).

Research on the efficacy of alternate potting media in comparison with the traditional growing mixtures in terms of their physical and chemical properties and also cost effectiveness are important to address the issues faced by the potted plant segment in the global trade. In this context, the present study was undertaken with the objective to standardize alternate media for potted ornamental foliage plants for export purpose and to work out the economics.

Review of literature

2. REVIEW OF LITERATURE

Export oriented ornamental cut flowers and foliage production is possible only if the produce meet the standards of international market in terms of its quality and quantity. Consistent production of healthy flowers and foliage are being influenced by various factors. Among them, growing media is the basic and essential component for survival of the ornamental plants as well as for the production of healthy planting materials.

A growing medium can be defined as a substance through which plant roots grow and extract water and nutrients. Selection of a good growing medium is fundamental to good nursery management and is the foundation of a healthy root system (Landis *et al.*, 2014).

The individual components constituting the growing medium have great influence on its physico-chemical characteristics. Selection of potting media components in growing mixtures largely depend upon their availability and cost effectiveness. Based on the ingredients utilized for making growing substrate, generally, there are two types of media for potted plants *viz.*, soil based and soilless media.

a. SOIL BASED MEDIA

Soil contributes the major portion of various growing substrates due to its availability and easiness to handle. An ideal soil is composed of 50 per cent soil air and soil water, 45-46 per cent minerals and 1-6 per cent organic matter. Unlike unrestricted field soil, potted plants are grown in shallow depth within small container volume, leading to limited capacity to hold water and nutrients. Many studies pointed out the fact that soil alone cannot maintain the ideal physical and chemical characteristics of growing media in this small volume contained in pots. Hence, soil should be amended with other organic and inorganic ingredients to upgrade aeration, drainage and water holding capacity.

Recently, the use of soil as an ingredient of potting media is restricted due to its limited availability, bulkiness and its weight, restricted root volume, weed problem, pest and disease incidence, *etc*. Because of all these risks associated with soil based media, growing media in nursery production largely depend upon soilless media with organic and inorganic amendments.

b. SOILLESS MEDIA

An ideal soilless medium is a composite of two or three organic or inorganic ingredients which are selected to modify the physical, chemical and biological properties of potting mixtures for sustainable production of plants. The major organic ingredients include cocopeat, vermicompost, rice husk and biochar, whereas the main inorganic components are vermiculite, perlite and sand.

Literature regarding the influence of individual organic and inorganic components of growing media, their effect on the growth and qualities of potted foliage house plants and other ornamental plants are described here under.

2.3 EFFECT OF POTTING MEDIA COMPONENTS ON ORNAMENTAL PLANT GROWTH

2.3.1 Cocopeat

Cocopeat or coir fibre pith is the by-product of coir manufacturing industry obtained after fibre extraction from coconut husk. Since late 1980s, horticulturists have been using this material as a major component of potting media. In recent past cocopeat is gaining acceptance among the growers as a best component in growing media because of its durability, excellent aeration, lightness and water holding characteristics. Cocopeat have many properties *viz.*, high moisture retention capacity (600- 800 %), low bulk density (0.18g/cc), particle density (0.8g/cc) and high CEC (20-30 meq /100 g) which enable it to retain large quantity of nutrients and high contents of exchangeable K, Na, Ca and Mg (Coir board, 2016). All these characteristics make it an apt soil amendment or mulch material in horticulture sector. Recently, with the development of commercial horticulture and soilless production system and reduction in the availability of good quality soil, coco peat has been recognized as an unavoidable component of soilless media for container grown horticultural plants.

i. Effect of cocopeat on ornamental foliage plants

Golden pothos (*Epipremnum aureum*) commonly known as money plant, is one of the popular attractive foliage house plant with trailing vine and heart shaped and variegated foliage. Khayyat *et al*. (2007), reported that foliage quality such as freshness, length of the shoot, fresh and dry weight of shoots, roots and number of roots of golden pothos were accounted maximum when it was grown in substrate containing cocopeat as the substrates.

According to Swetha *et al.* (2014), potting media containing cocopeat, sand and vermicompost in 2:1:1 ratio was found to be the best for improving growth and foliage quality of *Aglaonema* cv. Ernesto's with respect to the plant height, number of leaves, length, width and area of leaf, plant growth index, fresh and dry of roots, visual plant grade, colour grade, root grade and N, P and K content in leaf. They also reported that media composed of cocopeat, sand, farmyard manure and vermicompost in 2:1:1:0.5 proportion was as good as the above media with respect to characters such as leaf width, dry root weight, plant and colour grade, root grade and potassium content.

Sankari *et al.* (2019) conducted a study to ascertain an alternate medium for the growth of foliage filler "*Asparagus sprengeri*" under shade net condition, with eight different type of growing substrate encompassing different combinations of soil, sand, vermicompost, coco peat, rice husk, biochar, perlite and microbial consortia. *Asparagus sprengeri* planted in a medium containing soil (25%), coco peat (50%), vermicompost (15%) and sand (10%) recorded maximum plant height, number of leaves, leaf length and width, leaf area and chlorophyll content. Improvement of root characters *viz.*, root length, root spread and number of primary roots were observed in treatment involving cocopeat (75%), rice husk (10%) and vermicompost (15%). The same result was also observed when the experiment was laid out for another attractive potted ornamental foliage *Dracaena reflexa* 'Variegata' (Kavipriya *et al*., 2019).

Pradhan and Mohanty (2020) evaluated the performance of foliage house plants aglaonema and dieffenbachia in five different growing media and reported that aglaonema grown in medium containing 2 parts of FYM and 1 part of cocopeat showed the most satisfactory performance in terms of its growth characters and the same trend was also observed in the case of dieffenbachia.

ii. Effect of cocopeat on ornamental flowering plants

Basheer and Thekkayam (2012) reported that growth parameters such as plant height, leaf area and longevity, petiole length, fresh and dry weight of leaves were highest in anthurium grown in coir pith and sand based media. An improvement in characters *viz.*, number of flower per plant, size of the spathe, length and thickness of flower stalk, and prolonged vase life were also recorded in the same study.

Gupta and Dilta (2015), obtained maximum plant height and spread, inflorescences per plant, number of flowers, flowering duration and pot presentability score in *Primula malacoides* Franch.in medium consisting of equal parts of cocopeat, FYM and sand.

An investigation made by Muraleedharan and Karuppaiah (2015) proved that potting medium containing cocopeat and coconut husk improved the parameters such as plant height, plant spread, number of flowers per plant, flower stalk length, spathe length and breadth in anthurium when plants were grown under 75% shade.

A medium containing cocopeat + sand + FYM + vermicompost (2:1:0.5:0.5 v/v) was observed to be the best for increasing number of flowers and duration of flowering in chrysanthemum cv. Sadhbhavana (Nair and Bharathi, 2015).

A comparative study conducted by Singh (2018) with different cocopeat based media revealed that the medium containing cocopeat and vermicompost (1:1)) was the best for first bud appearance and for first flower harvesting along with maximum plant height, plant spread, number of leaves, length and girth of flower stalk, flower diameter, flower number and number of ray florets per flower and length of ray florets of gerbera.

Growing medium containing cocopeat and farm yard manure in 2:1 proportion was found to enhance vegetative parameters such as plant height, number of leaves and roots and suckers *Chrysanthemum morifolium* cv. Snowball (Thakur *et al.*, 2018).

2.3.2 Vermicompost

Vermicompost is the end product of breakdown of organic matter by earthworm, which is rich in all essential plant nutrients, beneficial microflora and growth hormones. Several researchers suggested that earthworm castings are very important with respect to fertility status of soil as they are the richest source of nitrogen, potassium, phosphorus, calcium, and magnesium. The nutrient status of vermicompost is 1.5 per cent N, 0.4 per cent P_2O_5 and 1.8 per cent of K_2O with a pH range of 7-8. (KAU-POP, 2016). Application of vermicompost shows beneficial effects on physico-chemical properties of growing media such as improvement of aeration, porosity, structure, drainage, and water-holding capacity.

i. Effect of vermicompost on ornamental foliage plants

According to Kayalvizhi *et al.* (2013), a growing medium consisting of soil, sand, FYM, vermicompost @ 2:1:1:0.5 resulted in enhanced plant height, shoot number, leaflet number, leaflet length, leaflet width, root number and root length in *Asparagus densiflorus* 'Meyersii'.

While studying effect of different potting media in croton, Anjana *et al.* (2017) observed increased number of leaves in *Codiaeum*.var. Rustifolia and maximum leaf area in *Codiaeum*. var. Petra with the medium containing cocopeat, vermicompost and farmyard manure in 1:2:1 (v/v).

Sandeep *et al.* (2018) conducted a comparative study to evaluate the growth of three species of Nephrolepis *viz., N. falcata, N. cordifolia duffi* and *N. multifolia* in various growing media and reported that medium consisting of equal proportion of cocopeat, sand and vermicompost (1:1:1) under 25 per cent green net was found to enhance the growth in *N. falcata.*

ii. Effect of vermicompost on ornamental flowering plants

Chamani *et al.* (2008) compared the effect of traditional base medium (a mixture of 70% farm soil and 30% sand (v/v)), incorporated with peat (30 and 60%) or vermicompost (20, 40 and 60%) on the growth and flowering of *Petunia hybrida* ‘Dream Neon Rose’ under glasshouse conditions. They reported that attributes *viz.*, number of flowers, leaf growth as well as fresh and dry weights of shoot were maximum when petunia was grown in vermicompost containing medium compared to both control and peat containing media. N, P, K, Ca and Mg content of plant tissue were the highest in petunia plants grown in the 60 per cent vermicompost medium and the lowest in 60 per cent peat based medium revealing the beneficial effects of vermicompost on the concentration of macronutrient in plant tissue.

As per study conducted by Moghadam *et al*. (2012), the addition of vermicompost @ 30 per cent resulted in the production of more number of large flowers compared to the other treatments amended with vermicompost @ 0, 10 and 20 per cent in *Lilium asiaticum* hybrid var. Navona.

Among the different levels of vermicompost at 10, 20, 30, 40, 50 and 60 per cent added in to a potting medium consisted of soil (70%) and sand (30%), 60 per cent vermicompost was observed to be the best for enhancing plant growth, number of flowers as well as carotenoid content of flowers in African marigold (Sardoei *et al*., 2014).

Rajvanshi and Dwivedi (2014) observed that a medium composed of vermicompost, coarse sand and soil in 3:2:2 ratio was the best for improving vegetative and flower parameters of zinnia.

Gupta *et al.* (2014) observed that in marigold (*Tagetes erecta*), plant height was maximum in plants grown in cow dung based vermicompost @ 20 per cent. Growth and yield parameters like plant biomass, plant height, number of buds and flowers were increased along with increasing concentration of vermicompost in potting media.

2.3.3 Biochar

Biochar is fine-grained and porous charcoal like carbon-rich material produced by pyrolysis (Johannes and Stephen, 2009). Biochar play an important role in improving physical and chemical properties of soil. Addition of biochar can improve the chemical properties including pH, EC, CEC, N, P and K and organic matter contents of the media and physical properties such as bulk density, water holding capacity and porosity of growing substrate. Several studies concluded that biochar is used as a partial or sole growing substrate for improving plant growth. Recently, biochar is used as the main substrate in cut flower crops due to its low cost and high availability.

i. Effect of biochar on ornamental foliage plants

Zhang *et al.* (2014) suggested that a high quality medium can be obtained when the composted grass waste amended with the combination of biochar and humic acid at 20 and 0.7 per cent respectively, than non-amended composted grass waste in *Calathia insignis*. This optimum combination also improved the particle-size distribution, and lowered the bulk density, enhanced porosity and water-holding capacity, nutrient contents and microbial biomass of the medium.

Evaluation of different media combination of using the compost, biochar, peat, perlite for growth and foliage quality of *Dracaena deremensis* cv. “Lemon Lime”, revealed that there was a 10-30 per cent improvement in vegetative parameters *viz.*, plant height, number of leaves, leaf area, and fresh biomass in compost biochar medium when compared to other treatments (Zulfiqar *et al*., 2019).

Zulfiquar *et al*. (2019) worked on amenability of biochar as a potting substrate on the growth of *Syngonium podophyllum* and reported highest biomass and net photosynthetic rate of syngonium grown in 20 per cent biochar incorporated peat based potting media.

ii. Effect of biochar on ornamental flowering plants

Budiarto *et al.* (2006) proved that carbonized rice husk biochar showed better rooting percentage in chrysanthemum than other treatment mixtures such as cocopeat – vermiculate and perlite - vermiculite mixture.

Kaur *et al*. (2015) evaluated 14 potting media involving mushroom compost, sewage sludge, leaf mould, paddy straw compost, saw dust, burnt rice husk, vermicompost, soil and FYM and reported that among the media ingredients, paddy straw compost along with burnt rice husk showed overall improvement in growth and flowering in terms of plant height, plant spread, duration of flowering and number of flowers compared to other treatment combinations.

Dispenza *et al.* (2016) studied the relevance of biochar application in ornamental plant production and observed improved growth and flowering of Euphorbia × Lomi potted plants in peat based medium incorporated with 60 per cent biochar compared to the other media containing peat and biochar alone.

Alvarez *et al.* (2017) observed maximum growth and flower production in geranium and petunia grown in potting medium containing low–medium levels of vermicompost (10 -30 %) and high level of biochar (8 – 12 %) than that of peat based substrate and reported combination of biochar and vermicompost as a better substitute to traditional peat based substrates.

An investigation by Guo *et al.* (2018) on the performance of poinsettia plant in response to peat based rooting media amended with various levels of biochar (0, 20, 40, 60 and 80%) and different levels of fertigation revealed that fertigation level at the range of 100 – 400 mg L^{-1} N along with biochar up to 80 per cent could be utilized as an amendment to peat based substrate without compromising quality.

2.3.4 Rice husk

Rice husk is the outer sheath or covering of rice grain and a waste material from agriculture industry obtained after rice milling process. As the growers looked for feasible way to reduce cost of production, properly processed parboiled rice husk offers several environmental, horticultural, and economic rewards without compromising the quality of the produce. Rice husk is extremely light in weight, which impart reduction in bulk density and optimum pore space to growing media.

i. Effect of rice husk on ornamental foliage plants

Abouzari *et al*. (2012) compared the impact of various soilless substrates on the growth of *Ficus benjamina* and reported that composted tea waste along with 50 per cent rice husk was found to be the best medium with respect to growth characteristics.

Olosunde *et al*. (2015) formulated a substrate for the better performance of two foliage plants *viz., Dracaena fragrans* and *Cordyline terminalis*. Among the different media evaluated, they concluded that a mixture of rice husk, topsoil and sawdust are ideal for growth of *D. fragrans* and *C. terminalis*.

ii. Effect of rice husk on ornamental flowering plants

According to Hohn *et al*. (2018) carbonated rice husk medium @ 100 per cent or raw rice husk 85 per cent along with organic amendment gave better growth characteristics whereas 100 per cent raw rice husk medium resulted in poor growth, less stem production and quality in *Gypsophylla paniculata.*

2.3.5 Farm yard manure (FYM)

Farm yard manure is a bulky organic manure which is a mixture of decomposed dung and urine of farm animals, bedding material (litter) and other miscellaneous farm wastes. In India, cattle based FYM can potentially supply about 33 million tonnes of N, P and K per year. The FYM can improve crop yield either by accelerating respiratory process, cell permeability and hormonal action. As A result of biological decomposition, FYM supplies N, P and K in available form to the plants. Nutrient status of FYM is about 0.50, 0.17 and 0.55 per cent of N, P and K, respectively (Gaur, 1984).

i. Effect of farm yard manure on potted ornamental foliage plants

Singh *et al.* (2010) reported that root characteristics of dieffenbachia such as number of roots, root length, root diameter as well as fresh and dry weight of roots were found to be improved when grown in a media composed of sand and farm yard manure.

A medium containing soil, sand and FYM at a ratio of 2:1:1 was found to be the best medium for two foliage plants *viz.*, *Dieffenbachia bowmannii* and *Dracaena reflexa* for growing under indoor conditions (Sarkar *et al.*, 2016).

Dracaena reflexa commonly known as “Song of India” is an exquisite house plant. A comparative study on the effect of potting media combinations on growth and foliage quality of *Dracaena reflexa* revealed more fresh weight of roots and shoot length was recorded when grown in a medium composed of silt and FYM (Abid *et al.*, 2017).

ii. Effect of farm yard manure on potted ornamental flowering plants

Ikram *et al.* (2012) reported an improvement in parameters such as plant spread and number of leaves in tuberose grown in medium containing sand and FYM, whereas other parameters *viz.*, plant height, leaf area and length of spike recorded were highest in the medium containing with coirpith and FYM (1:1 v/v).

Under protected cultivation, in *Gerbera jamesonii* cv. hybrid, Riaz *et al.* (2014), reported higher number of flowers per branch, leaf area, number of roots, fresh and dry weight of plants gown in FYM incorporated silt- topsoil mixture.

Rajasekar and Suresh (2015) observed greatest plant height and plant spread in miniature roses planted in soil and farm yard manure mixture. Further, they also reported that number of branches per plant were more in potting medium comprising of soil, farm yard manure and leaf manure.

An investigation on evaluation of different potting media on the bulbs and bulblets multiplication of hybrid lily revealed that soil – sand mixture supplemented with FYM as a befitting medium for obtaining more number of bulbs and bulblets with increased weight and diameter of the bulbs (Rajera and Sharma, 2017).

Fermented cocopeat along with soil, sand and farmyard manure in equal quantities was found to be ideal for in growth, flowering and other bulb characteristics and this medium was suited for pot plant production of tuberose (Nair and Bharathi, 2019).

2.3.6 Sand

Sand is the coarsest fraction of soil minerals having the particle size more than 0.02 mm diameter. Most common constituent of sand fraction is silicon dioxide (quartz). Addition of sand to a potting substrate not only improve the aeration and drainage but also imparts weight to the media. It is chemically inert and hence does not alter the chemical properties of the growing media. But the over exploitation of sand for other purposes resulted in the protection of its natural sources like river banks, natural sand dunes leading to its restricted use as a growing medium. Hence, now a days, manufactured sand obtained from quarries is used as substitute for river sand.

i. Effect of sand on ornamental foliage plants

Sand in combination with organic manure is an apt media for better growth of pot plants. Maximum plant height, number of leaves per plant and diameter of shoot were reported by Singh *et al*. (2010) in *Dieffenbachia amoena* when it was grown in media comprising of equal quantity of sand and soil. They also found that sand along with vermicompost stimulated the production of sprouts and all root parameters were significantly higher in the case of sand and FYM combination.

Okunlola and Ogungbite (2016) observed highest shoot length, stem girth, root length, and number of leaves and roots in *Sanseveria liberica* when grown in medium containing top soil and sand.

Said (2016) reported the best performance of the variegated duranta, *Duranta erecta* L. var. Variegata, a decorative foliage-pot-plant when grown in a medium containing sand with poultry manure. In the same study, highest survival rate (100 %) of duranta plants was observed when planted in sand based media either with FYM (2 : 1) or with poultry manure (3: 1 or 2: 1 v/v) and with irrigation of 300 ml pot^{-1}.

ii. Effect of sand on ornamental flowering plants

Yasmeen *et al*. (2012) reported that leaf compost with sand (1:1) was an ideal substrate for *Dianthus caryophyllus* as it provided nutrients nitrogen, potassium, optimum range of pH as well as soil structure for maintaining best growth and flowering.

According to Naik *et al.* (2018), sand containing medium improved the rooting percentage in ornamental stem cuttings such as ixora, hibiscus, crape jasmine, croton, java fig tree, acalypha, bougainvillea, golden shower, and clerodendron. They also reported maximum percentage of rooting (88.89%) in hibiscus when grown in pure sand than other rooting media.

2.3.7 Perlite

Perlite is a white coloured glassy volcanic rock material produced by subjecting to high temperature leading to production of light weight highly porous and sterile material due to the expansion of its original volume (4-20 times) (Raviv *et al*., 2019). It has unique characteristics such as high porosity (70-85%), neutral pH (pH 6 - 8.5) and high permeability which make it an ideal growing substrate for superior plant growth. Due to its neutral pH, the media become sterile and weed-free. Studies revealed that it provide success in greenhouse cultivation, landscaping applications and in interior plant scaping.

i. Effect of perlite on ornamental foliage plants

Hussain *et al.* (2017) suggested that addition of perlite to silt - leaf compost mixture was the best substrate for growing caladium. Maximum plant growth with respect to early sprouting, plant height, leaf area, chlorophyll content, fresh and dry weights of tubers were observed in plants grown in silt - leaf compost - perlite combination. This combination showed 30-50 per cent enhanced plant growth than silt alone.

ii. ***Effect of perlite on ornamental flowering plants***

Khalaj *et al.* (2011), conducted a hydroponic study to identify the impact of soilless substrate on the growth of gerbera and reported that cocopeat based medium (50 %) supplemented with perlite (25 %) and expanded clay (5 %) furnished better performance of gerbera under hydroponic system.

Experiment conducted by Asghari (2014) implied superiority in growth and yield characteristics of carnation grown in a medium provided with cocopeat, perlite, and vermicompost with a proportion of 20, 60, 20 per cent respectively.

According to Ilahi and Ahmad (2017), addition of perlite to cocopeat medium improved the physical and hydraulic characteristics of the medium. Total porosity and wettability were enhanced with the incorporation of perlite to cocopeat at a ratio of 3 part of cocopeat to 1 part perlite.

2.3.8 Vermiculite

Vermiculite is a sterile, light-weight mica product. It is a hydrated aluminium-iron-magnesium silicate. It has a very low bulk density and an extremely high water-holding capacity of about five times its weight, large quantities of nutrients needed for plant growth. Its pH is in neutral range from 6 to 8 with high CEC. It contains small amounts of potassium and magnesium. (Landis *et al.*, 2014).

According to Sindhu *et al*. (2010), soilless substrate consisting of cocopeat, vermiculite and perlite in 4:1:1 ratio amended with a soil conditioner (Samridhi®) was ideal for cut flower production of the gerbera under protected condition.

Takur *et al*. (2018) studied on the influence of media composition on the flowering of *Chrysanthemum morifolium* Ramat cv. Snowball.and reported maximum flower diameter as well as duration of flowering in vermiculite comprising medium with farm yard manure in 2:1 ratio than other media.

Materials and methods

3. MATERIALS AND METHODS

The present study entitled "Standardization of alternate media for potted ornamental foliage plants for export purpose" was carried out in the Department of Floriculture and Landscaping, College of Horticulture, Vellanikkara, Thrissur from June 2019 to June 2020. The materials used and methodology adopted for the study are mentioned in this chapter.

3.1 LOCATION OF EXPERIMENT

Geographically the experimental site is situated at 22.25 m above MSL at a latitude of $10^{0}31'$N and longitude of $76^{0}13'$E.

3.2 CLIMATE

The region is having a warm humid tropical climate with maximum temperature of 33.01 ^{0}C and minimum temperature was 21.46 ^{0}C during the period of study. The mean relative humidity was 74.38 per cent. The total rainfall recorded during the period of investigation was 3358.6 mm.

3.3 MATERIALS

3.3.1 Planting material

The study was conducted using six months old rooted cuttings of *Aglaonema commutatum* var. 'Silver frost', which is an attractive and popular ornamental foliage plant.

3.3.2 Container

Plastic pots of 8 inch size were used for growing the plants. Pots were filled with different combinations of potting media on volume by volume (v/v) basis, comprising of soil, M-sand, FYM, vermicompost, cocopeat, biochar, rice husk, perlite, and vermiculite.

3.3.3 Growing structure

The experiment was conducted in a protected structure of dimension of 21m x 6m (length x breadth) cladded with 200 micron UV stabilized film and 50 per cent shade net.

3.4 EXPERIMENTAL DESIGN AND TREATMENTS

Design of experiment	:	CRD
No. of treatments	:	10
No. of replications	:	4
No. of plants per replication	:	5

3.4.1 Treatment details

T_1: Soil, Vermicompost and Sand in 3:2:1

T_2: Soil (75%) + Vermicompost (15%) + Sand (10%)

T_3: Soil (50%) + Cocopeat (25%) + Vermicompost (15%) + Sand (10%)

T_4: Soil (25%) + Cocopeat (50%) +Vermicompost (15%) + Sand (10%)

T_5: Cocopeat (70%) + Rice husk (10%) + Vermicompost (10%) + Sand (10%)

T_6: Cocopeat (50%) + Rice husk (25%) + Vermicompost (15%) + Sand (10%)

T_7: Cocopeat (50%) + Biochar (25%) + Vermicompost (15%) + Sand (10%)

T_8: Cocopeat (25%) + Biochar (25%) + Vermicompost (25%) + Sand (15%) + Perlite (10%)

T_9: Soil: FYM: Sand (1:1:1) (Control)

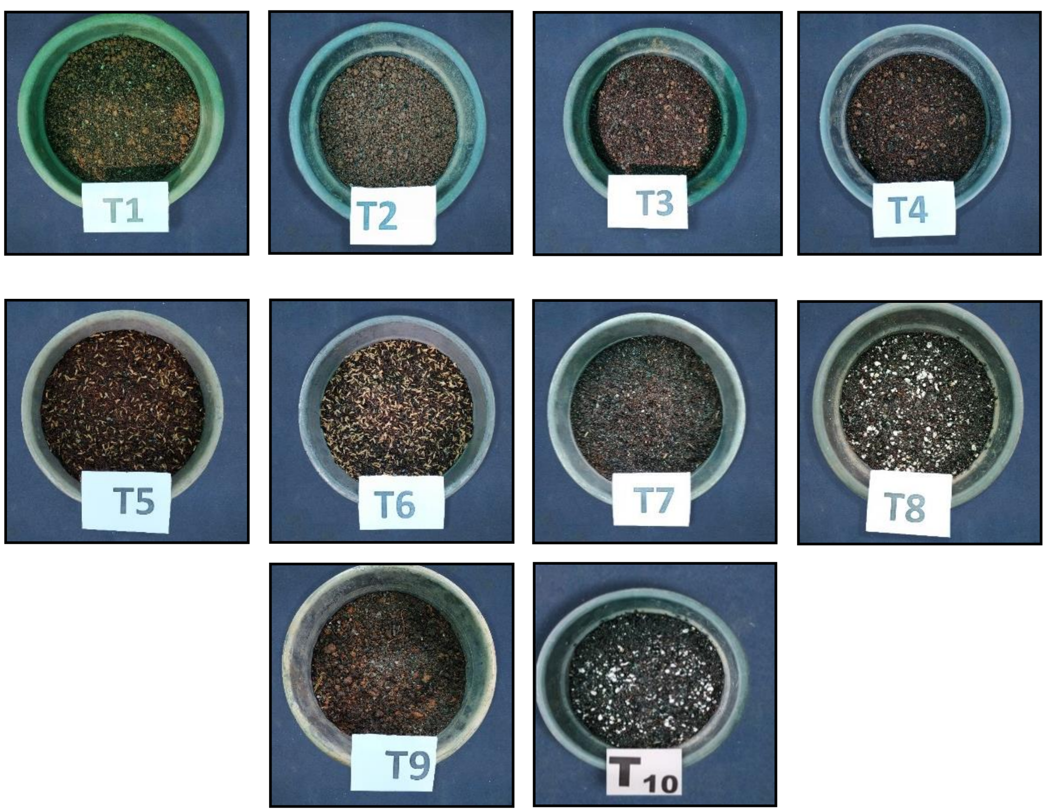
T_{10}: Cocopeat (50%) + Vermicompost (20%) + Perlite (15%) + Vermiculite (15%)

3.5 MANAGEMENT PRACTICES

Uniform management practices were adopted for all the treatments during the entire period of study. Foliar application of NPK (19:19:19) at the rate of 5g per liter^{-1} at monthly intervals were given to all treatments. During summer, irrigation was given in alternate days at the rate of 1 litre per pot for soil based treatment (T_1, T_2, T_3, T_4 and T_9) and 0.5 L per pot for treatments consisting of soilless media (T_5, T_6, T_7, T_8 and T_{10}) and mist irrigation was given once in a day for 20 minutes (20 ml per pot) on other days. Appropriate plant protection measures were adopted whenever needed.

Plate 3.1 Materials used for the experiment

Media components used for the study



Potting media used for the study

Plate 3.2 Materials used for the experiment

Crop: *Aglaonema commutatum* var. ‘Silver frost’

Planting material: Six months old rooted cutting

8 inch size pot

Plate 3.3 General view of field

At the time of planting

At 12 months after planting

3.6 OBSERVATIONS

3.6.1 Observations recorded at quarterly intervals

Observations were recorded from four plants per replication of each treatment and average was taken and expressed in corresponding units.

a. Plant height

Height of the plant was taken from base of the plant to growing tip of topmost leaf in centimetre.

b. Plant spread (NS & EW in cm)

The spread of the plant in North-South and East-West direction were measured and average was recorded in centimetre.

c. Number of leaves

Total number of leaves per plant were counted and recorded.

d. Leaf length

Length of three recently developed and fully matured leaves from base of the leaf upto tip was measured and average was taken and expressed in centimetre.

e. Leaf width

Width of the middle portion of three recently developed fully matured leaf was measured and average was taken and expressed in centimetre.

f. Petiole length

Length of the petiole of three leaves was taken and its average was worked out and expressed in centimeter.

g. Leaf area

Leaf area of whole plant was calculated using the formula 0.99 x length x breadth of the leaf where, 0.99 is a constant (Benedetto, 2006).

h. Leaf production interval

The interval between production of successive leaves were noted by regular trial visit and recorded in days.

i. Days taken for sprouting

Days taken for production of first sucker was noted and recorded

j. Number of suckers plant $^{-1}$

Number of suckers per plant was recorded during each observation.

k. Leaf longevity

The period up to which the leaf remained physiologically active in plant after its complete unfolding was noted and recorded as leaf longevity in days.

3.6.2 Observations recorded at twelve months after planting

Observations were recorded from two plants per replication of each treatment and average was taken and expressed in corresponding units.

3.6.2.1 Shoot characters

a. Shoot girth

Diameter of the shoot was taken and expressed in centimetre

b. Shoot length

Length from the base of the plant to first whorl of leaves was taken and recorded in centimetre

c. Fresh and dry weight of leaves

Fresh weight and dry weight of the leaves were recorded and expressed as g plant $^{-1}$.

3.6.2.1.1 Root characters

a. Fresh weight of roots

Fresh weight of roots of individual plants were taken and expressed in gram.

b. Root length

Length of the longest root was taken and expressed in cm.

c. Number of lateral roots

Total number of lateral roots per plant was counted and recorded.

d. Dry weight of roots

Washed and cleaned roots were oven dried and dry weight was expressed in gram.

e. Root volume

Root volume was calculated by water displacement method. The volume of water displaced by root were recorded as root volume in cm^3.

3.6.3 Media characters

Samples of potting media were collected before and after the experiment and physico-chemical properties of the media were evaluated. Physical properties of growing media including water holding capacity, bulk density and porosity were estimated before the experiment (Table. 4.7). Chemical analysis were done to find out pH, EC and the available nutrient level of N, P, and K of growing media before and after the completion of experiment(Table 4.8 and Table 4.9). Methods adopted for growing media analysis are furnished in Table 3.1.

Table 3.1 Methods adopted for nutrient analysis of growing media

Sl. No	Parameter	Methods followed	Reference
	Chemical properties		
i.	Nitrogen	**Soil based media:** Alkaline permanganometry	Subbiah and Asija, 1956
		Soilless media: Alkaline permanganate method were followed after digesting the sample with H_2SO_4 (Digestion mixture: K_2SO_4: $CuSO_4$ @10:1 ratio)	
ii.	Phosphorous	**Soil based media**: Bray No :1 Ascorbic acid reduction method	Bray and Kurtz, 1945
		Soilless media: digested with diacid (HNO_3 and $HClO_4$ in 9:4 ratio) barton's reagent extract read with spectrophoto meter	Koening and Johnson, 1942
iii.	Potassium	**Soil based media:** Neutral normal ammonium acetate extract using flame photo meter	Jackson, 1958
		Soilless media: digested with diacid (HNO_3 and $HClO_4$ in 9:4 ratio) followed by reading in Flame Photometer.	Koening and Johnson, 1942; Jackson, 1958
iv.	pH	pH meter solution (1:2.5 ratio sample	Jackson, 1958
v.	E.C	Electrical conductivity meter(1:2.5 ratio sample solution)	
	Physical properties		
	Water capacity holding	Keen Raczkowski brass cup method	Piper, 1942
ii	Bulk density		
iii	Porosity		

3.6.4 Nutrient uptake

Nutrients uptake by plants were determined at twelve months after planting and expressed in gram per plant.

Variation in Nutrient uptake of plants due to different treatments were determined by using the formula

$$\text{Nutrient uptake (g plant}^{-1}\text{)} = \frac{\text{\% of Nutrient content in plant sample X Dry matter production (g)}}{100}$$

3.6.5 Other observations

a. Pest and diseases

Incidence of pest and disease were noted

b. Physiological abnormalities if any

The plants were observed for changes in physical appearance of plant parts such as chimeras, stunted growth, and malformation.

c. Cost of the growing media

Cost of the growing media was calculated by measuring the quantity of each component per pot and multiplying it with unit cost. The cost incurred per pot was expressed in rupees.

3.7 STATISTICAL ANALYSIS

Statistical analysis were done with the help of WASP.2.0 software (Web Agri Stat Package) and data were recorded.

Results

4. RESULTS

An experiment entitled “Standardization of alternate media for potted ornamental foliage plants for export purpose” was carried out in the Dept. of Floriculture and Landscaping, College of Horticulture, Vellanikkara during June, 2019 to June, 2020. Ten different potting media were used for the experiment. The results of study are as follows.

4.1 GROWTH CHARACTERS

4.1.1 Plant height (cm)

Plant height is one of the important growth parameters as far as foliage is concerned. The current study revealed that growing media compositions have great influence on plant height (Table 4.1, Plate 4.1).

During three months after planting, the treatments $T_{3,}$ mixture of soil (50%) + cocopeat (25%) + vermicompost (15%) + sand (10%), $T_{5,}$ comprising cocopeat (70%) + rice husk (10%) + vermicompost (10%) + sand (10%), $T_{6,}$ composed of cocopeat (50%) + rice husk (25%) + vermicompost (15%) + sand (10%), $T_{1,}$ composed of soil, vermicompost and sand in 3:2:1, $T_{9,}$ composed of soil : FYM : sand (1 : 1 : 1), $T_{8,}$ comprising cocopeat (25%) + biochar (25%) + vermicompost (25%) + sand (15%) + perlite (10%), $T_{4,}$ medium composed of soil (25%) + cocopeat (50%) +vermicompost (15%) + sand (10%) and T_2, composed of soil (75%) + vermicompost (15%) + sand (10%) were found to be superior with respect to plant height which was in the range of 30.25 - 34.26 cm. There was no significant variation between the treatments during six months after planting. An improvement in plant height was observed in T_2, $T_{1,}$ T_7, T_5, T_3, T_9, and T_4 at nine months after planting in which height was varied from 44.99 - 47.36 cm. At twelve months after planting, increased plant height could be observed in T_6, T_1, T_3, T_5, T_2, T_9 and T_4 (53.95 - 56.75 cm). Even though an improvement in plant height was observed due to different treatments, T_{10} [cocopeat (50%)+ vermicompost (20%)+ perlite (15%)+ vermiculite (15%)] showed compact growth (48.89 cm) during the entire period of study which also satisfied the plant height of recommended grades and standards for foliage plants for export purpose.

4.1.2 Plant spread (cm)

There was a significant variation in plant spread during entire period of study except at six months after planting (Table 4.1, Plate 4.1). An improvement in plant spread at three months after planting was recorded in T_6 - comprising of cocopeat (50%) + rice husk (25%) + vermicompost (15%) + sand (10%), T_1 - medium consisting of soil, vermicompost and sand in 3:2:1), T_4 - medium composed of soil (25%) + cocopeat (50%) +vermicompost (15%) + sand (10%), T_3 - composed of soil (50%) + cocopeat (25%) + vermicompost (15%) + sand (10%), T_7 - medium composed of cocopeat (50%) + biochar (25%) + vermicompost (15%) + sand (10%)), T_8 - medium comprising cocopeat (25%) + biochar (25%) + vermicompost (25%) + sand (15%) + perlite (10%), T_2 - composed of soil (75%) + vermicompost (15%) + sand (10%), T_5 - medium consisting of cocopeat (70%) + rice husk (10%) + vermicompost (10%) + sand (10%) and T_9 - composed of soil: FYM : sand (1 : 1 : 1), was in the range of 36.04 - 40.55 cm. After nine months, the treatments T_8, T_2, T_6, T_7, T_5, T_9 and T_4 were superior with respect to this parameter in which plant spread varied from 50.83 - 55.04 cm. Lowest plant spread (50.70 cm) at the end of experiment was recorded in T_{10} and only this treatment satisfied the plant spread of potted aglaonema for export purpose (40.64 - 50.80cm).

Plate 4.1 Effect of potting media on plant height and plant spread at 12 months after planting

T_4 : Soil (25%) + Cocopeat (50%) +Vermicompost (15%) + Sand (10%)
T_{10} : Cocopeat (50%) + Vermicompost (20%) + Perlite(15%) + Vermiculite (15%)

Effect of potting media on plant height (cm)

T_4 : Soil (25%) + Cocopeat (50%) +Vermicompost (15%) + Sand (10%)
T_9 : Soil: FYM : Sand (1 : 1 : 1) (control)
T_5 : Cocopeat (70%) + Rice husk (10%) + Vermicompost (10%) + Sand (10%)
T_{10} : Cocopeat (50%) + Vermicompost (20%) + Perlite(15%) + Vermiculite (15%)

Effect of potting media on plant spread (cm)

Table 4.1 Effect of potting media on plant height and plant spread of Aglaonema var. 'Silver frost'

Treatments	Plant height (cm)				Plant spread (cm)			
	3 MAP	6 MAP	9 MAP	12 MAP	3 MAP	6 MAP	9 MAP	12 MAP
T_1	31.43	35.85	45.13	55.23	36.11	43.94	50.21	57.34
T_2	34.26	35.80	44.99	55.91	39.08	43.46	50.96	58.01
T_3	30.25	36.04	46.56	55.45	37.83	44.51	48.03	57.43
T_4	32.19	39.89	47.36	56.75	36.66	47.48	55.04	59.40
T_5	30.28	37.13	45.95	55.61	39.44	43.67	52.19	59.20
T_6	31.34	37.48	41.68	53.95	36.04	44.52	51.33	58.50
T_7	28.95	39.00	45.30	51.71	38.58	41.29	51.48	55.50
T_8	31.99	38.10	41.36	52.43	38.76	44.44	50.83	56.80
T_9	31.44	38.63	46.93	56.33	40.55	48.64	53.37	58.10
T_{10}	22.52	35.42	40.51	48.89	27.78	38.92	46.00	50.78
CD (0.05)	**5.30**	**NS**	**2.70**	**3.70**	**6.02**	**NS**	**4.34**	**3.32**

T_1: soil, vermicompost and sand in 3:2:1 ratio
T_2: soil (75%) + vermicompost (15%) + sand (10%)
T_3: soil (50%) + cocopeat (25%) + vermicompost (15%) + sand (10%)
T_4: soil (25%) + cocopeat (50%) +vermicompost (15%) + sand (10%)
T_5 : cocopeat (70%) + rice husk (10%) + vermicompost (10%) + sand (10%)
T_6: cocopeat (50%) + rice husk (25%) + vermicompost (15%) + sand (10%)
T_7: cocopeat (50%) + biochar (25%) + vermicompost (15%) + sand (10%)
T_8: cocopeat (25%) + biochar (25%) + vermicompost (25%) + sand (15%) + perlite (10%)
T_9: soil: FYM : sand (1:1:1) (Control)
T_{10}: cocopeat (50%) + vermicompost (20%) + perlite (15%) + vermiculite (15%).

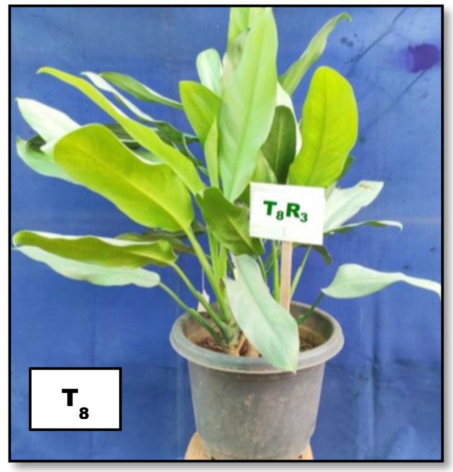
4.1.3 Number of leaves per plant

Number of leaves is one of the important growth character with reference to foliage house plants. No significant variation with respect to this parameter could be observed during initial three months. At six months after planting, T_6 - medium composed of cocopeat (50%) + rice husk (25%) + vermicompost (15%) + sand (10%), T_8 - medium comprising of cocopeat (25%) + biochar (25%) + vermicompost (25%) + sand (15%) + perlite (10%), T_4 - medium consisting of soil (25%) + cocopeat (50%) +vermicompost (15%) + sand (10%), and T_1 - medium consisting of soil, vermicompost and sand in 3:2:1, were observed to have more number of leaves ranging from 13.05–14.65 and lowest number of leaves (10.24) was observed in T_3 - composed of soil (50%), cocopeat (25%), vermicompost (15%) and sand (10%). After nine months, more number of leaves were recorded in T_2, T_{10}, T_4 and T_1 (ranges from 24.30 - 26.50). Minimum number of leaves (20.95) was observed in T_6 - medium supplemented with cocopeat (50%) + rice husk (25%) + vermicompost (15%) + sand (10%). At the end of experiment, highest number of leaves (50.60) was observed in T_{10} - medium composed of cocopeat (50%), vermicompost (20%), perlite (15%) and vermiculite (15%) and lowest leaf count (34.65) was recorded in T_8 - medium comprising cocopeat (25%) + biochar (25%) + vermicompost (25%) + sand (15%) + perlite (10%) (Table 4.2 and Plate 4.2).

4.1.4 Leaf length (cm)

Significant variation in leaf length was observed only up to three months after planting which did not vary significantly during remaining period of observation. Improvement in leaf length at three months after planting was observed in T_3 [soil (50%) + cocopeat (25%) + vermicompost (15%) + sand (10%)], T_8 - medium consisting of cocopeat (25%) + biochar (25%) + vermicompost (25%) + sand (15%) + perlite (10%), T_7 - composed of cocopeat (50%) + biochar (25%) + vermicompost (15%) + sand (10%), T_9 - composedof soil: FYM : sand (1 : 1 : 1), T_2 - consisting of soil (75%) + vermicompost (15%) + sand (10%), T_4, medium composed of soil (25%) + cocopeat (50%) +vermicompost (15%) + sand (10%), and T_5, composed of cocopeat (70%) + rice husk (10%) + vermicompost (10%)

Plate 4.2 Effect of potting media on number of leaves and number of suckers at 12 months after planting



T_{10} : Cocopeat (50%) + Vermicompost (20%) + Perlite(15%) + Vermiculite (15%)
T_8 : Cocopeat (25%) + Biochar (25%) + Vermicompost (25%) + Sand (15%) +Perlite (10%)

Emergence of first sucker

Table 4.2 Effect of potting media on number of leaves and leaf length of Aglaonema var. ‘Silver frost’

Treatments	Number of leaves				Leaf length (cm)			
	3 MAP	6 MAP	9 MAP	12 MAP	3 MAP	6 MAP	9 MAP	12 MAP
T_1	8.28	14.65	26.50	43.39	21.19	21.26	24.48	25.60
T_2	8.60	11.30	24.30	39.55	20.87	21.57	25.04	25.28
T_3	7.70	10.24	21.50	40.35	19.98	20.51	24.93	25.50
T_4	8.10	13.95	26.45	44.85	21.13	22.07	23.57	25.68
T_5	8.36	12.35	22.55	42.28	21.15	22.20	24.74	25.38
T_6	9.38	13.05	20.95	37.40	19.17	22.26	24.03	25.23
T_7	8.11	12.70	22.60	44.05	20.22	22.59	24.98	25.45
T_8	9.40	13.80	22.20	34.65	20.15	21.10	23.40	24.23
T_9	7.80	11.75	21.95	44.25	20.70	22.22	24.97	26.18
T_{10}	7.68	12.15	24.85	50.60	16.84	21.97	24.53	25.18
CD (0.05)	**NS**	**1.94**	**3.11**	**4.69**	**1.96**	**NS**	**NS**	**NS**

T_1: soil, vermicompost and sand in 3:2:1 ratio
T_2: soil (75%) + vermicompost (15%) + sand (10%)
T_3: soil (50%) + cocopeat (25%) + vermicompost (15%) + sand (10%)
T_4: soil (25%) + cocopeat (50%) +vermicompost (15%) + sand (10%)
T_5 : cocopeat (70%) + rice husk (10%) + vermicompost (10%) + sand (10%) T_6:
cocopeat (50%) + rice husk (25%) + vermicompost (15%) + sand (10%),
T_7: cocopeat (50%) + biochar (25%) + vermicompost (15%) + sand (10%)
T_8: cocopeat (25%) + biochar (25%) + vermicompost (25%) + sand (15%) + perlite (10%)
T_9: soil: FYM : sand (1:1:1) (Control)
T_{10}: cocopeat (50%) + vermicompost (20%) + perlite (15%) + vermiculite (15%

+ sand (10%) and T_1, comprising of soil, vermicompost and sand in 3:2:1 (ranged from 19.98 - 21.19 cm). The lowest value of leaf length was noted in treatment T_{10} (16.84 cm) comprising of cocopeat (50%), vermicompost (20%), perlite (15%) and vermiculite (15%) during this period (Table 4.2).

4.1.5 Leaf width (cm)

Leaf width varied significantly during the period of observation (Table 4.3). After three months, leaf width recorded was maximum in T_5 - medium consisting of cocopeat (70%) + rice husk (10%) + vermicompost (10%) + sand (10%), T_1 - comprising of soil, vermicompost and sand in 3:2:1 T_3 - consisting of soil (50%) + cocopeat (25%) + vermicompost (15%) + sand (10%), T_4 - composed of soil (25%) + cocopeat (50%) +vermicompost (15%) + sand (10%) and T_9 - composed of soil: FYM: sand in 1:1:1 ratio, which varied from 6.81 –7.60 cm. The treatments *viz.,* T_7 - composed of cocopeat (50%) + biochar (25%) + vermicompost (15%)+ sand (10%), T_6 - consisting of cocopeat (50%) + rice husk (25%) + vermicompost (15%) + sand (10%), T_4 - composed of soil (25%) + cocopeat (50%) +vermicompost (15%) + sand (10%), T_5 - consisting of cocopeat (70%) + rice husk (10%) + vermicompost (10%) + sand (10%) and T_9 - composed of soil: FYM: sand (1: 1: 1), showed more leaf width after six months which was varied from 7.31 - 7.75 cm. Lowest leaf width was recorded in T_1 (6.74 cm) during six months after planting. More leaf width at nine month after planting was recorded in all the treatments except T_1 and T_{10} which was ranging from 7.93 cm -7.35 cm. Significant improvement in leaf width due to treatments could be observed in all treatments except T_3, T_9 and T_{10} at twelve months after planting (7.29-7.89 cm).

4.1.6 Petiole length (cm)

No significant variation among treatments with respect to petiole length could be observed during the period of observation except at three month after planting (Table 4.3). Maximum value of petiole length recorded at three month after planting, was in treatment T_4- comprising of soil (25%) + cocopeat (50%) + vermicompost (15%) + sand (10%)

Table 4.3 Effect of potting media on leaf width and petiole length of Aglaonema var. 'Silver frost'

Treatments	**Leaf width (cm)**				**Petiole length (cm)**			
	3 MAP	**6 MAP**	**9 MAP**	**12 MAP**	**3 MAP**	**6 MAP**	**9 MAP**	**12 MAP**
T_1	6.84	6.74	7.06	7.40	13.45	8.10	8.08	9.90
T_2	6.45	6.84	7.87	7.57	14.39	8.71	8.16	9.35
T_3	6.99	6.77	7.82	7.25	14.01	8.07	8.05	9.53
T_4	7.23	7.58	7.62	7.89	15.59	8.04	8.24	10.83
T_5	6.81	7.6	7.48	7.29	12.36	7.78	7.96	9.40
T_6	6.55	7.45	7.93	7.58	13.31	7.57	7.04	10.65
T_7	6.58	7.31	7.35	7.29	14.56	8.33	7.73	9.45
T_8	6.45	6.78	7.36	7.48	12.36	7.53	7.56	9.65
T_9	7.60	7.75	7.73	6.75	14.98	8.34	8.05	9.07
T_{10}	5.16	7.00	7.12	6.90	10.17	6.56	7.23	8.63
CD (0.05)	**0.87**	**0.73**	**0.59**	**0.61**	**2.66**	**NS**	**NS**	**NS**

T_1: soil, vermicompost and sand in 3:2:1 ratio
T_2: soil (75%) + vermicompost (15%) + sand (10%)
T_3: soil (50%) + cocopeat (25%) + vermicompost (15%) + sand (10%)
T_4: soil (25%) + cocopeat (50%) +vermicompost (15%) + sand (10%)
T_5: cocopeat (70%) + rice husk (10%) + vermicompost (10%) + sand (10%)
T_6: cocopeat (50%) + rice husk (25%) + vermicompost (15%) + sand (10%)
T_7: cocopeat (50%) + biochar (25%) + vermicompost (15%) + sand (10%)
T_8: cocopeat (25%) + biochar (25%) + vermicompost (25%) + sand (15%) + perlite (10%)
T_9: soil: FYM : sand (1:1:1) (Control)
T_{10}: cocopeat (50%) + vermicompost (20%) + perlite (15%) + vermiculite (15%)

which was on par with all other treatments except T_8, T_5 and T_{10} which ranged from 15.59 – 13.31 cm. The lowest petiole length (10.17 cm) was recorded in T_{10} containing of cocopeat (50%), vermicompost (20%), perlite (15%) and vermiculite (15%).

4.1.7 Leaf area (cm^2)

Composition of growing media significantly influenced leaf area (Table 4.4). During three months after planting, increased leaf area ranging from 1075.19 - 1269.92 cm^2 was recorded in all treatments except T_{10}. Lowest leaf area (664.59 cm^2) was recorded in T_{10} containing cocopeat (50%), vermicompost (20%), perlite (15%) and vermiculite (15%) during this period. At six months after planting, a significant improvement in leaf area (1862.32–2321.18 cm^2) was observed in all treatments except T_2 and T_3. The treatments T_7, T_1, T_{10}, and T_4, were superior with regard to this parameter at the end of experiment which were in the range from 8091.26–8982.67cm^2 and the lowest leaf area (5775.98 cm^2) was recorded in T_8 - medium consisting of cocopeat (25%) + biochar (25%) + vermicompost (25%) + sand (15%) + perlite (10%).

4.1.8 Leaf production interval (days)

The minimum interval between the production of successive leaves was noted in T_4 [soil (25%) + cocopeat (50%) + vermicompost (15%) + sand (10%)], T_{10} [cocopeat (50%) + vermicompost (20%) + perlite (15%) + vermiculite (15%)], T_9 [soil: FYM : sand (1 : 1 : 1)], T_5 [cocopeat (70%) + rice husk (10%) + vermicompost (10%) + sand (10%)] and T_3 [soil (50%) + cocopeat (25%) + vermicompost (15%) + sand (10%)] days were ranges from 17.02 - 18.13 days). Prolonged interval (19.57 days) between the production of successive leaves was observed in T_8 containing cocopeat (25%) + biochar (25%) + vermicompost (25%) + sand (15%) + perlite (10%) (Table 4.5 and Plate 4.3).

Plate 4.3 Stages of leaf development in *Aglaonema commutatum* var.'Silver frost'

Table 4.4 Effect of potting media on leaf area (cm^2) of Aglaonema var. 'Silver frost'

Treatments	Leaf area (cm^2)			
	3 MAP	**6 MAP**	**9 MAP**	**12 MAP**
T_1	1198.35	1914.53	4526.87	8134.51
T_2	1219.65	1567.99	4799.69	7465.35
T_3	1147.93	1366.83	4364.62	7749.66
T_4	1123.86	2321.75	4532.76	8982.60
T_5	1269.92	2084.21	4128.35	7767.83
T_6	1265.02	2141.03	3947.74	7076.25
T_7	1075.19	2171.25	4230.34	8091.26
T_8	1214.23	1954.09	4007.07	5775.98
T_9	1141.59	2045.31	3956.55	7575.22
T_{10}	664.59	1862.32	4427.01	8323.73
CD (0.05)	**307.42**	**512.42**	**NS**	**1007.96**

T_1: soil, vermicompost and sand in 3:2:1 ratio
T_2: soil (75%) + vermicompost (15%) + sand (10%)
T_3: soil (50%) + cocopeat (25%) + vermicompost (15%) + sand (10%)
T_4: soil (25%) + cocopeat (50%) +vermicompost (15%) + sand (10%)
T_5: cocopeat (70%) + rice husk (10%) + vermicompost (10%) + sand (10%)
T_6: cocopeat (50%) + rice husk (25%) + vermicompost (15%) + sand (10%)
T_7: cocopeat (50%) + biochar (25%) + vermicompost (15%) + sand (10%)
T_8: cocopeat (25%) + biochar (25%) + vermicompost (25%) + sand (15%) + perlite (10%)
T_9: soil: FYM : sand (1:1:1) (Control)
T_{10}: cocopeat (50%) + vermicompost (20%) + perlite (15%) + vermiculite (15%)

4.1.1 Days taken for sprouting

Early emergence of the first sucker was observed in T_8 (94.79 days) medium composed of cocopeat (25%) + biochar (25%) + vermicompost (25%) + sand (15%) + perlite (10%), T_4 (108.17 days) [soil (25%) + cocopeat (50%)+ vermicompost (15%) + sand (10%)] and T_1 (124.33 days) [soil, vermicompost and sand in 3:2:1], whereas T_2 took maximum number of days (155.33 days) for the emergence of first sucker (Table 4.5).

4.1.2 Number of suckers plant^{-1}

Significant variation in production of sucker was noted from six months after planting (Table 4.5, Plate 4.2). Higher sucker production (20.50) observed in six months after planting was in medium T_4, composed of soil (25%), cocopeat (50%), vermicompost (15%) + sand (10%) and the lowest was noted in T_3 (0.1) containing soil (50%) + cocopeat (25%) + vermicompost (15%) + sand (10%). After nine months of planting, more sucker production was observed in T_1, comprising of soil, vermicompost and sand in 3:2:1, T_3 [soil (50%) + cocopeat (25%) + vermicompost (15%) + sand (10%)], T_7, composed of cocopeat (50%) + biochar (25%) + vermicompost (15%) + sand (10%) and T_{10} comprising cocopeat (50%) + vermicompost (20%) + perlite (15%) + vermiculite (15%) which varied from 2.50 –3.20 and the lowest number of suckers (1.80) was noted in T_6. T_{10} was found to be superior with regard to number of suckers (6.10) at 12 months after planting. Number of suckers was minimum in T_8 (3.05), medium containing cocopeat (25%), biochar (25%), vermicompost (25%) + sand (15%) + perlite (10%). As far as the entire period is concerned, consistent production of suckers was observed in T_{10}.

4.1.3 Leaf longevity (days)

There was no significant variation between treatments with respect to leaf longevity during the period of observation (Table 4.5).

Table 4.5 Effect of potting media on leaf production interval, days taken for sprouting, number of suckers per plant and leaf longevity of Aglaonema var. 'Silver frost'

Treatments	Leaf production interval (days)	Days taken for sprouting (days)	Number of suckers per plant				Leaf longevity (days)
			3 MAP	6 MAP	9 MAP	12 MAP	
T_1	18.42	124.33	-	0.60	2.50	3.950	285.00
T_2	18.33	155.33	-	0.40	2.10	3.850	288.00
T_3	18.13	151.67	-	0.10	2.65	4.050	283.00
T_4	17.02	108.17	-	2.05	2.40	3.500	281.00
T_5	17.72	144.21	-	0.60	2.15	4.450	280.50
T_6	18.32	131.45	-	0.65	1.80	3.500	287.50
T_7	18.42	149.30	-	0.90	3.00	5.000	299.00
T_8	19.57	94.79	-	1.25	1.95	3.050	287.00
T_9	17.70	138.45	-	0.50	2.30	4.718	276.00
T_{10}	17.17	135.65	-	0.70	3.20	6.100	283.00
CD (0.05)	**1.29**	**30.02**		**0.60**	**0.73**	**0.61**	**NS**

T_1: soil, vermicompost and sand in 3:2:1 ratio

T_2: soil (75%) + vermicompost (15%) + sand (10%)

T_3: soil (50%) + cocopeat (25%) + vermicompost (15%) + sand (10%)

T_4: soil (25%) + cocopeat (50%) +vermicompost (15%) + sand (10%)

T_5: cocopeat (70%) + rice husk (10%) + vermicompost (10%) + sand (10%)

T_6: cocopeat (50%) + rice husk (25%) + vermicompost (15%) + sand (10%)

T_7: cocopeat (50%) + biochar (25%) + vermicompost (15%) + sand (10%)

T_8: cocopeat (25%) + biochar (25%) + vermicompost (25%) + sand (15%) + perlite (10%)

T_9: soil: FYM: sand (1:1:1) (Control)

T_{10}: cocopeat (50%) + vermicompost (20%) + perlite (15%) + vermiculite (15%)

4.2.12 Shoot girth

No significant variation among treatments could be observed with respect to shoot girth during the period of observation (Table 4.6).

4.2.13 Shoot length

Regarding the shoot length, there was a significant variation among the treatments (Table 4.6). The lowest shoot length will provide a compact appearance to the potted plants. The treatments T_8 [cocopeat (25%), biochar (25%), vermicompost (25%), sand (15%) and perlite (10%)], T_{10} [cocopeat (50%)+ vermicompost (20%)+ perlite (15%)+ vermiculite (15%)], T_7 [cocopeat (50%)+ biochar (25%)+ vermicompost (15%)+ sand (10%)] and T_6 [cocopeat (50%)+ rice husk (25%)+ vermicompost (15%)+ sand (10%)] showed lowest shoot length which ranged from 28.69 cm – 33.56 cm at 12 months after planting.

4.2.14 Fresh weight of leaves

Fresh weight of leaves was found to be the highest in media T_8 [cocopeat (25%), biochar (25%), vermi compost (25%) + sand (15%) + perlite (10%)], T_{10} [cocopeat (50%) + vermicompost (20%) + perlite (15%) + vermiculite (15%)], T_4 [soil (25%) + cocopeat (50%) +vermicompost (15%) + sand (10%)], T_5 [cocopeat (70%) + rice husk (10%) + vermicompost (10%) + sand (10%)], T_9 [soil: FYM : sand (1 : 1 : 1)] and T_1 [soil, vermicompost and sand in 3:2:1] which varied from 335.75 - 367.50 g plant^{-1} (Table 9). The lowest value of fresh weight of leaves (250.83g plant^{-1}) was observed in the treatment in T_7 [cocopeat (50%) + biochar (25%) + vermicompost (15%) + sand (10%)] (Table 4.6).

4.2.15 Dry weight of leaves

Among multiple treatments tried, T_5 [cocopeat (70%) + rice husk (10%) + vermicompost (10%)+ sand (10%)] was found to be superior with regard to dry weight of leaves (41.20 g plant^{-1}) and the lowest dry weight of leaves (24.40 g plant^{-1}) was recorded in T_7 (24.40 g plant^{-1}) (Table 4.6).

4.2.16 Dry matter production in various treatments

Significant variation in dry matter production could observed among different treatments 12 months after planting. Increased dry matter production (74.33 gplant^{-1}) could observed in T_5 which was on par with T_9 (69.45 g plant^{-1}). The lowest dry matter production (54.40 g plant^{-1}) at 12 months after planting could observed in the treatment T_8

4.2 ROOT CHARACTERS

4.2.1 Number of lateral roots

Increased number of lateral roots was observed in T_2 medium consisting of soil (75%) + vermicompost (15%) + sand (10%), T_4 medium composed of soil (25%) + cocopeat (50%) +vermicompost (15%) + sand (10%), T_5 medium consisting of cocopeat (70%) + rice husk (10%) + vermicompost (10%) + sand (10%), T_1 composed of soil, vermicompost and sand in 3:2:1 (88.50) and T_9, medium composed of soil: FYM: sand (1: 1: 1) which varied from 77.67- 98.17. The lowest number of lateral roots (59.33) was noticed in T_7 medium containing cocopeat (50%) + biochar (25%) + vermicompost (15%) and sand (10%) (Table 4.6).

4.2.2 Root length

There was no significant variation among the treatments with regards to root length during the study period (Table 4.6).

4.2.1 Fresh weight of roots

Fresh weight of roots recorded was maximum in T_5, medium consisting of cocopeat (70%) + rice husk (10%) + vermicompost (10%) + sand (10%)) and T_4, composed of soil (25%) + cocopeat (50%) + vermicompost (15%) + sand (10%) with a range of 247.50 g - 237.94 g plant^{-1}). The lowest value for fresh weight of roots (124.42 g) was recorded in T_8, potting medium amended with cocopeat (25%) + biochar (25%)+vermicompost (25%) + sand (15%) + perlite (10%) (Table 4.6).

4.2.4 Dry weight of roots

Medium T_5, amended with cocopeat (70%) + rice husk (10%), T_2, medium consisting of soil (75%) + vermicompost (15%) + sand (10%), T_4, composed of soil (25%) + cocopeat (50%) +vermicompost (15%) + sand (10%) + vermicompost (10%), T_1 medium comprising of soil, vermicompost and sand in 3:2:1, T_9 [soil : FYM : sand in 1 : 1 :1 ratio], were found to be superior in terms of dry weight of roots (11.54 - 13.44 g plant^{-1}). The lowest dry weight (6.84 g) was noted in T_8 medium containing cocopeat (25%) + biochar (25%) + vermicompost (25%) + sand (15%) and perlite (10%) (Table 4.6).

4.2.5 Root volume

The highest root volume was observed in T_9 [soil: FYM: sand (1: 1:1)], T_5 [cocopeat (70%) + rice husk (10%), vermicompost (10%)], T_4 [soil (25%), cocopeat (50%), vermicompost (15%) and sand (10%)] and T_1 [soil, vermicompost and sand in 3:2:1], and root volume ranging from 191.25 - 230.00 cm^3. The lowest root volume (113.33cm^3) was observed in T_8, amended with cocopeat (25%), biochar (25%), vermicompost (25%), sand (15%) and perlite (10%) (Table 4.6 Plate 4.4).

As per the recommended grades and standards for potted foliage plants (FMA and FNGA, 1994), *Aglaonema commutatum* in 8 inch pot should have a height and spread of 12-16'' (40.64 cm to 50.80 cm) and number of lateral shoots 6-12. There should be more number of leaves. In the present study, the treatments T_{10} [cocopeat (50%) + vermicompost (20%) + perlite (15%) and vermiculite (15%)] was found to satisfy all these quality parameters and it was also less weight medium. Plants with compact growth and light weight medium are preferred for export purpose. Hence, this medium can be recommended as an alternate medium for export of potted plants.

Plate 4.4 Effect of potting media on root volume and root length at 12 months after planting

T_1: Soil, vermicompost and sand 3:2:1

T_4: Soil (25%) + Cocopeat (50%) +Vermicompost (15%) + Sand (10%)

T_8: Cocopeat (25%) +Biochar (25%) +Vermicompost (25%) +Sand (15%) +Perlite (10%)

Effect of potting media on root volume

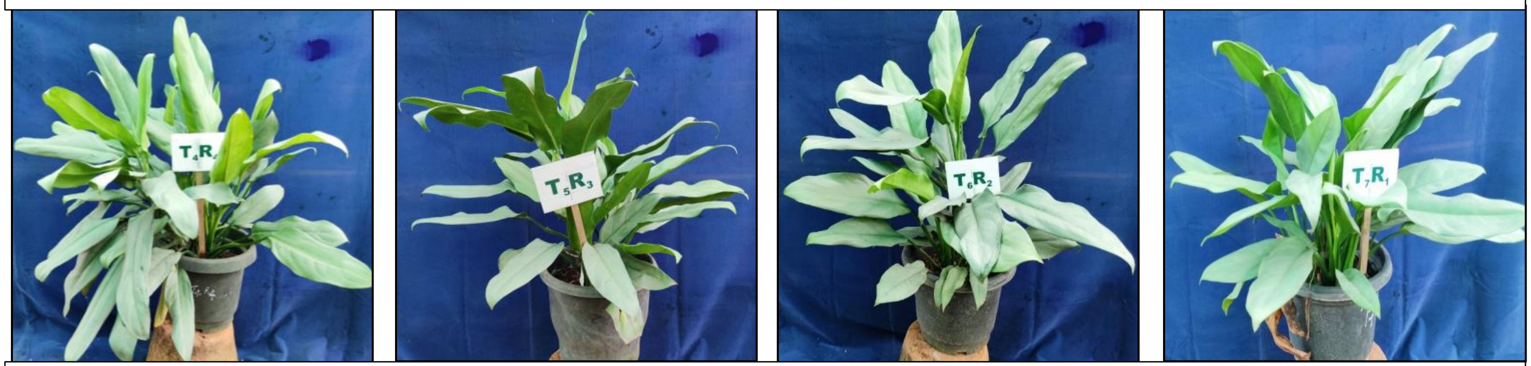
T_2 : Soil (75%) + Vermicompost (15%) + Sand (10%)

T_{10} : Cocopeat (50%) + Vermicompost (20%) + Perlite(15%) + Vermiculite (15%)

Effect of potting media on root length

Plate 4.5 Effect of potting media on overall performance of Aglaonema at 12 months after planting

Soil based media



Cocopeat based media

Table 4.6 Effect of potting media on shoot and root characters of Aglaonema var. 'Silver frost'

Treatments	Shoot girth (cm)	Shoot length (cm)	Fresh weight of leaves (g plant $^{-1}$)	Dry weight of leaves (g plant $^{-1}$)	Fresh weight of roots (g plant $^{-1}$)	Dry matter Production (g plant $^{-1}$)	Root length (cm)	Number of lateral roots	Dry weight of roots (g plant $^{-1}$)	Root volume (cm^3)
T_1	6.54	36.56	367.50	31.78	224.33	66.25	49.88	88.50	12.90	230.00
T_2	6.50	38.44	263.00	24.75	177.50	58.13	60.50	77.67	11.78	155.00
T_3	7.16	38.75	292.26	28.98	195.20	60.85	51.25	71.50	10.30	160.00
T_4	6.55	35.13	357.25	32.60	237.94	66.25	52.00	83.00	12.05	216.67
T_5	6.96	36.88	357.50	41.20	247.50	74.33	52.25	84.12	11.54	198.33
T_6	6.13	33.56	303.38	30.60	136.17	60.58	55.25	69.83	8.38	138.75
T_7	6.44	31.50	250.83	24.40	197.67	54.40	53.75	59.33	8.41	120.00
T_8	6.06	28.69	335.75	28.85	124.42	57.28	50.50	73.17	6.84	113.33
T_9	7.43	35.63	359.50	34.43	171.67	69.45	55.31	98.17	13.44	191.25
T_{10}	6.29	31.13	347.67	31.35	190.00	63.10	48.38	73.67	10.15	184.38
CD (0.05)	**NS**	**4.89**	**36.84**	**4.61**	**15.84**	**6.22**	**NS**	**15.93**	**3.05**	**40.75**

T_1 - soil, vermicompost and sand in 3:2:1 ratio; **T_2** - soil (75%) + vermicompost (15%) + sand (10%)
T_3 - soil (50%) + cocopeat (25%) + vermicompost (15%) + sand (10%), **T_4** - soil (25%) + cocopeat (50%) +vermicompost (15%) + sand (10%), **T_5** - cocopeat (70%) + rice husk (10%) + vermicompost (10%) + sand (10%), **T_6** - cocopeat (50%) + rice husk (25%) + vermicompost (15%) + sand (10%), **T_7** - cocopeat (50%) + biochar (25%) + vermicompost (15%) + sand (10%),
T_8 - cocopeat (25%) + biochar (25%) + vermicompost (25%) + sand (15%) + perlite (10%), **T_9** - soil: FYM: sand (1:1:1) (Control) and
T_{10} - cocopeat (50%) + vermicompost (20%) + perlite (15%) + vermiculite (15%)

4.4. MEDIA CHARACTERS

4.4.1 Physical properties

Data pertaining to pre planting analysis of physical properties of potting media are furnished in Table 4.7.

a. Water holding capacity (%)

The Highest water holding capacity (178.50%) was recorded in T_{10} medium comprising of cocopeat (50%) + vermicompost (20%) + perlite (15%) and vermiculite (15%) and minimum (20.50%) was noted in T_2 media amended with soil (75%) + vermicompost (15%) + sand (10%).

b. Bulk density (g/cc)

The Lowest bulk density favour the water holding capacity of the medium. In the present study, bulk density recorded was lowest (0.35g/cc) in T_{10} [cocopeat (50%), vermicompost (20%), perlite (15%) and vermiculite (15%)], whereas T_2 medium amended with soil (75%), vermicompost (15%) and sand (10%) was found to have maximum value (1.22g/cc).

c. Porosity (%)

High porosity (79.53%) was noted in T_{10} [cocopeat (50%), vermicompost (20%), perlite (15%) and vermiculite (15%)] and lowest (34.06%) in T_9 [soil: FYM: sand (1 : 1 : 1)] followed by T_2 medium amended with soil (75%), vermicompost (15%) and sand (10%) (39.00%).

Table 4.7 Physical properties of different growing media

Treatments	Water holding capacity (%)	Bulk density (g/cc)	Particle density (g/cc)	Porosity (%)
Soil based media				
T_1	24.90	1.09	1.92	42.97
T_2	20.50	1.22	2.00	39.00
T_3	29.90	0.95	2.21	57.37
T_4	34.20	0.79	2.23	64.77
T_9	25.80	1.20	1.82	34.00
Soilless media				
T_5	61.87	0.55	1.41	61.04
T_6	78.50	0.41	1.43	71.33
T_7	84.83	0.37	1.57	76.43
T_8	68.30	0.45	1.33	66.17
T_{10}	178.50	0.35	1.71	79.53

T_1: soil, vermicompost and sand in 3:2:1 ratio

T_2: soil (75%) + vermicompost (15%) + sand (10%)

T_3: soil (50%) + cocopeat (25%) + vermicompost (15%) + sand (10%)

T_4: soil (25%) + cocopeat (50%) +vermicompost (15%) + sand (10%)

T_5 : cocopeat (70%) + rice husk (10%) + vermicompost (10%) + sand (10%)

T_6: cocopeat (50%) + rice husk (25%) + vermicompost (15%) + sand (10%),

T_7: cocopeat (50%) + biochar (25%) + vermicompost (15%) + sand (10%)

T_8: cocopeat (25%) + biochar (25%) + vermicompost (25%) + sand (15%) + perlite (10%)

T_9: soil: FYM: sand (1:1:1) (Control)

T_{10}: cocopeat (50%) + vermicompost (20%) + perlite (15%) + vermiculite (15%)

4.4.2 Chemical properties

Chemical properties of potting media evaluated before planting and twelve months after planting are furnished in Table 4.8 and Table 4.9, respectively.

4.4.2.a. Pre planting analysis of potting media

a. pH

Among media evaluated, pH value towards neutral range (6.76) was recorded in T_9 [soil: FYM: sand (1: 1: 1)], whereas a value towards acidic range (4.92) was observed in T_{10} [cocopeat (50%), vermicompost (20%), perlite(15%) and vermiculite (15%)].

b. EC (dSm^{-1})

The preferred range of EC of growing media for potted foliage plants should be within the range of 1-2.5 dS m^{-1} (Chen and McConnell, 2002). In the present study, the media *viz.*, T_1 [soil, vermicompost and sand in 3:2:1], T_4 [soil (25%) + cocopeat (50%) +vermicompost (15%) + sand (10%)], T_5 [cocopeat (70%) + rice husk (10%) + vermicompost (10%) + sand (10%)], T_6 [cocopeat (50%) + rice husk (25%) + vermi compost (15%) + sand (10%)], T_7 [cocopeat (50%) + biochar (25%) + vermicompost (15%) + sand (10%)] and T_{10} [cocopeat (50%) + vermicompost (20%) + perlite (15%) + vermiculite (15%)] (1.82, 1.00, 1.24, 1.32, 2.20 dS m^{-1} respectively) were under this range.

c. Available nitrogen (%)

Among various media ingredients, T_{10} [cocopeat (50%) + vermicompost (20%), perlite (15%)) and vermiculite (15%)] was found to have highest nitrogen content (0.79%) and lowest nitrogen content (0.006%) was noted in T_3 [soil (50%) + cocopeat (25%) + vermicompost (15%) + sand (10%)].

d. Available phosphorus (%)

Treatment~~s~~ T_7~~,~~ composed of cocopeat (50%) + biochar (25%) + vermicompost (15%) + sand (10%) recorded maximum phosphorus content (0.281%) while, lowest P content (0.002%) was recorded in T_1 [soil, vermicompost and sand in 3:2:1].

e. Available potassium

Highest content of potassium (7.56 %) was recorded in T_{10} and lowest potassium concentration of 0.09% was noted in T_2.

4.4.2.b Post experiment media analysis

a. pH

A pH value near the neutral range (7.05) was observed in T_9 [soil: FYM: sand (1 : 1 : 1)] and T_{10} [cocopeat (50%) **+** vermicompost (20%) **+** perlite (15%) and vermiculite (15%)], whereas in T_8, it was in acidic range (5.13)**,** after the experiment.

b. EC (dSm^{-1})

Higher EC value was recorded in T_8 (1.02 dSm^{-1}) composed of cocopeat (25%), biochar (25%), vermicompost (25%), sand (15%), and perlite (10%) and lowest EC (0.20 dSm^{-1}) was noted in T_3 medium amended with soil (50%) + cocopeat (25%) + vermicompost (15%) + sand (10%).

c. Available nitrogen (%)

The treatment T_{10} [cocopeat (50%) + vermicompost (20%)+ perlite (15%)) and vermiculite (15%)] was found to have highest nitrogen content (3.15 %) and lowest nitrogen content (0.006%) was noted in T_2 the medium amended with soil (75%) + vermicompost (15%) + sand (10%) after the experiment.

d. Available phosphorus

The treatment T_7, composed of cocopeat (50%) + biochar (25%) + vermicompost (15%) + sand (10%) and T_8 [cocopeat (25%) + biochar (25%) + vermicompost (25%) + sand (15%) + perlite (10%)] recorded maximum phosphorous content (0.083%). Lowest P content (0.001%) was recorded in T_9 consisting of soil: FYM: sand (1: 1: 1).

e. Available potassium

Highest content of potassium (10.8 %) was noted in T_{10}, medium composed of cocopeat (50%), vermicompost (20%), perlite (15%) and vermiculite (15%) and the lowest potassium concentration (0.007%) was noted in T_3 [soil (50%) + cocopeat (25%) + vermicompost (15%) + sand (10%)] and T_4 [cocopeat (25%) + vermicompost (15%) + sand (10%)].

4.4.3 Nutrient uptake by plant (g plant $^{-1}$)

Maximum uptake of nitrogen, phosphorous and potassium uptake were recorded in T_5 [cocopeat (70%) + rice husk (10%) + vermicompost (10%) + sand (10%)] and T_9 [soil: FYM : sand (1:1:1)] which was ranged from 3.99 – 4.27 g plant-1 , 0.49- 0.52 g plant $^{-1}$ and 4.43- 4.74 g plant $^{-1}$ NP and K, respectively. Lowest nutrient uptake (N, P and K) was noted in noted in T_7 composed of cocopeat (50%) + biochar (25%) + vermicompost (15%) + sand (10%) which was about 3.13, 0.38 and 3.47 of NPK (g plant $^{-1}$) respectively (Table 4.10).

Table 4.8 Chemical properties of growing media before the experiment

Treatments	pH	EC (dS m^{-1})	N (%)	P (%)	K (%)
Soil based media					
T_1	5.54	1.82	0.014	0.002	0.11
T_2	5.78	0.58	0.007	0.007	0.09
T_3	5.71	0.78	0.006	0.004	0.13
T_4	5.81	1.00	0.008	0.005	0.15
T_9	6.76	0.73	0.009	0.015	0.13
Soilless media					
T_5	5.49	1.24	0.35	0.031	1.02
T_6	5.71	1.32	0.53	0.125	0.82
T_7	5.48	1.87	0.61	0.281	1.26
T_8	5.07	2.8	0.62	0.172	1.17
T_{10}	4.92	2.20	0.79	0.190	7.56

T_1: soil, vermicompost and sand in 3:2:1 ratio

T_2: soil (75%) + vermicompost (15%) + sand (10%)

T_3: soil (50%) + cocopeat (25%) + vermicompost (15%) + sand (10%)

T_4: soil (25%) + cocopeat (50%) +vermicompost (15%) + sand (10%)

T_5: cocopeat (70%) + rice husk (10%) + vermicompost (10%) + sand (10%)

T_6: cocopeat (50%) + rice husk (25%) + vermicompost (15%) + sand (10%),

T_7: cocopeat (50%) + biochar (25%) + vermicompost (15%) + sand (10%)

T_8: cocopeat (25%) + biochar (25%) + vermicompost (25%) + sand (15%) + perlite (10%)

T_9: soil: FYM: sand (1:1:1) (Control)

T_{10}: cocopeat (50%) + vermicompost (20%) + perlite (15%) + vermiculite (15%)

Table 4.9 Chemical properties of growing media after the experiment

Treatments	pH	EC (dS m^{-1})	N (%)	P (%)	K (%)
Soil based media					
T_1	6.02	0.24	0.024	0.006	0.009
T_2	6.3	0.35	0.006	0.003	0.011
T_3	6.27	0.20	0.014	0.005	0.007
T_4	6.5	0.27	0.013	0.005	0.007
T_9	7.05	0.22	0.012	0.001	0.042
Soilless media					
T_5	5.66	0.27	1.05	0.033	0.58
T_6	6.32	0.37	2.63	0.033	1.48
T_7	5.6	0.56	0.7	0.083	0.46
T_8	5.13	1.02	1.23	0.083	0.92
T_{10}	7.05	0.56	3.15	0.016	10.8

T_1: soil, vermicompost and sand in 3:2:1 ratio

T_2: soil (75%) + vermicompost (15%) + sand (10%)

T_3: soil (50%) + cocopeat (25%) + vermicompost (15%) + sand (10%)

T_4: soil (25%) + cocopeat (50%) +vermicompost (15%) + sand (10%)

T_5: cocopeat (70%) + rice husk (10%) + vermicompost (10%) + sand (10%)

T_6: cocopeat (50%) + rice husk (25%) + vermicompost (15%) + sand (10%),

T_7: cocopeat (50%) + biochar (25%) + vermicompost (15%) + sand (10%)

T_8: cocopeat (25%) + biochar (25%) + vermicompost (25%) + sand (15%) + perlite (10%)

T_9: soil: FYM: sand (1:1:1) (Control)

T_{10}: cocopeat (50%) + vermicompost (20%) + perlite (15%) + vermiculite (15%)

Table 4.10 Nutrient uptake in different treatments

Treatments	N uptake (g plant $^{-1}$)	P uptake (g plant $^{-1}$)	K uptake (g plant $^{-1}$)
Soil based media			
T_1	3.81	0.46	4.22
T_2	3.34	0.41	3.71
T_3	3.49	0.43	3.88
T_4	3.81	0.47	4.22
T_9	3.99	0.49	4.42
Soilless media			
T_5	4.28	0.52	4.74
T_6	3.48	0.43	3.86
T_7	3.13	0.38	3.47
T_8	3.29	0.40	3.65
T_{10}	3.63	0.44	4.02
CD (0.05)	0.36	0.04	0.40

T_1: soil, vermicompost and sand in 3:2:1 ratio

T_2: soil (75%) + vermicompost (15%) + sand (10%)

T_3: soil (50%) + cocopeat (25%) + vermicompost (15%) + sand (10%)

T_4: soil (25%) + cocopeat (50%) +vermicompost (15%) + sand (10%)

T_5: cocopeat (70%) + rice husk (10%) + vermicompost (10%) + sand (10%)

T_6: cocopeat (50%) + rice husk (25%) + vermicompost (15%) + sand (10%),

T_7: cocopeat (50%) + biochar (25%) + vermicompost (15%) + sand (10%)

T_8: cocopeat (25%) + biochar (25%) + vermicompost (25%) + sand (15%) + perlite (10%)

T_9: soil: FYM: sand (1:1:1) (Control)

T_{10}: cocopeat (50%) + vermicompost (20%) + perlite (15%) + vermiculite (15%

4.5 PEST AND DISEASES

4.5.1 Major pests:

4.5.1.1 Hard scales and soft scales

Symptoms: The hemispherical shaped insects attached on the lower surfaces of leaves, petiole and tender part of the shoots and suck sap and leads to yellowing of leaves, petioles and other parts. Black fungal growth (*Capnodium* spp.) on the upper part of leaf was also observed as secondary infection.

Management: Application of Dimethoate 30% EC @ 0.5 ml/L twice at fortnightly intervals effectively controlled the infestation.

4.5.1.2 Mealy bug

Symptoms: White cottony mealybugs were gathered on the tender part of stem as well as unopened leaves and difficulty in unfurling of leaves was noticed as result of severe infestation of mealy bug.

Management: Application of *Verticillium lecanii* @ 10 g/L twice at weekly intervals or Fipronil 5 SC (5% w/w) at 2 ml /L at fortnightly interval controlled the infestation.

4.5.2 Major diseases

4.5.2.1 Diplodia leaf spot

Disease infestation was severe during April-May months. The initial symptom appeared as small water soaked lesions and later the lesions coalased on the entire part. Black coloured acervulii which are the fruiting body of the fungus was also noticed on the lesions. This symptom was severe in plants which was already infested by scales.

Management: Carbendazim 12% + Mancozeb 63% WP at 2 g/L was applied to control the disease.

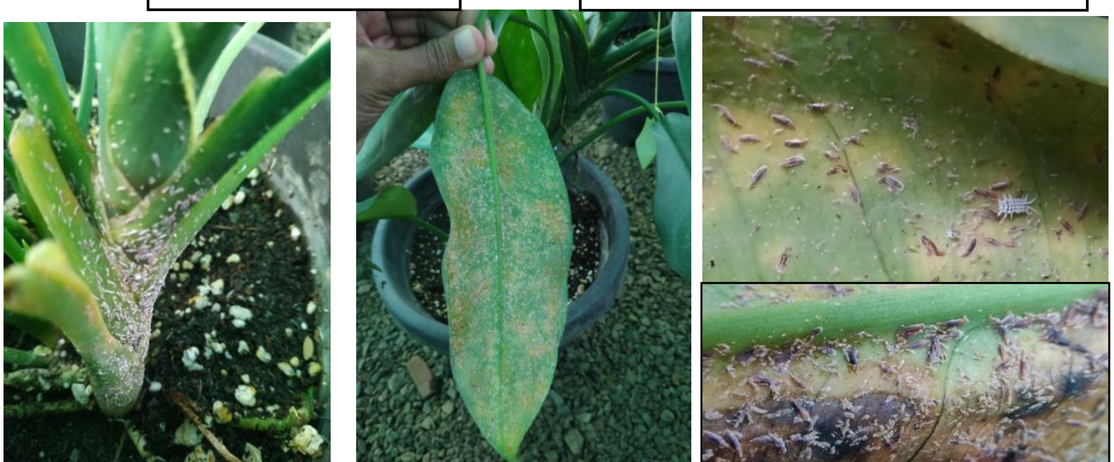
4.6 PHYSIOLOGICAL ABNORMALITIES

The plants did not show any physiological abnormalities during the course of experiment.

Plate 4.6 Incidence of insect pests

Hard scale attack

Capnodium as secondary infection

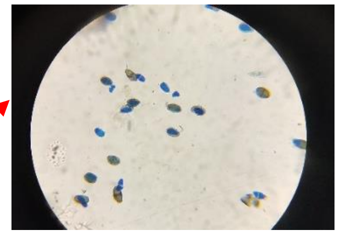


Soft scale attack

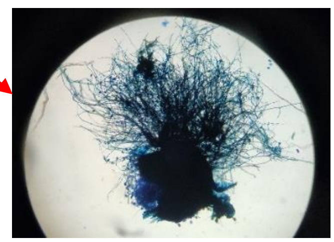
Mealy bug infestation

Plate 4.7 Incidence of diseases

Diplodia leaf blight



Fungal spore



Fruiting body of the fungus

Diplodia leaf blight - Field infection

4.5 COST OF THE GROWING MEDIA

The unit cost of the media components given in Appendix I and cost incurred for growing medium per pot are given in Table 11. The cost of the growing medium per pot was found to be the highest (Rs. 42 /- per pot) for T_{10} [cocopeat (50%) + vermicompost (20%) + perlite (15%) and vermiculite (15%)], which was a soilless medium and cost of the medium per pot was lowest (Rs. 9.62/-) in T_9 (soil, FYM and sand in 1:1:1 ratio), which was soil based.

Table 4.11 Cost of the growing media per pot

Treatments	Components	Quantity of each component per pot	Total weight of growing medium per pot (Kg)	Cost of growing media per pot (Rs.)
T_1	Soil, vermicompost and sand in 3:2:1	Soil (2.5Kg), vermicompost (1.05Kg) and sand (1.125Kg)	4.68	31.50
T_2	Soil (75%) + vermicompost (15%) + sand (10%)	Soil (3.75Kg), vermicompost (0.45Kg) and sand (0.75Kg)	4.95	28.75
T_3	Soil (50%) + cocopeat (25%) + vermicompost (15%) + sand (10%))	Soil (2.5Kg), cocopeat (0.40 Kg), vermicompost (0.45Kg) and sand (0.75Kg)	4.10	22.75
T_4	Soil (25%) +cocopeat (50%) + vermicompost (15%) + sand (10%)	Soil (1.25 Kg), cocopeat(0.80 Kg), vermicompost(0.45Kg) and sand (0.75Kg)	3.25	25.75
T_9	Soil: FYM: sand (1:1:1) (control)	Soil(1.70Kg), FYM (0.825Kg) and sand (2.48Kg)	5.01	9.62
T_5	Cocopeat (70%) + rice husk (10%) + vermicompost (10%) + sand (10%	Cocopeat (1.12Kg), rice husk (0.04Kg), vermicompost ((0.30Kg) and sand (0.75Kg)	2.21	25.55
T_6	Cocopeat (50%) + rice husk (25%) + vermicompost (15%) + sand (10%)	Cocopeat (0.80 Kg), rice husk (0.1Kg), vermicompost (0.45Kg) and sand (0.75Kg)	2.10	29.00
T_7	Cocopeat (50%) + biochar (25%) + vermicompost (15%) + sand (10%)	Cocopeat (0.80 Kg), biochar (0.175Kg), vermicompost (0.45Kg) and sand (0.75Kg)	2.17	25.88
T_8	Cocopeat (25%) + biochar (25%) + vermi compost (25%) + sand (15%) + perlite (10%)	Cocopeat (0.40Kg), biochar (0.175Kg),vermicompost (0.75Kg), sand (1.125Kg) and perlite (0.07Kg)	2.52	32.60
T_{10}	Cocopeat (50%) + vermicompost (20%) + perlite (15%) + vermiculite (15%)	Cocopeat (0.80 Kg), vermicompost (0.60 Kg), perlite (0.105Kg) and vermiculite (0.240 Kg)	1.74	42.00

Discussion

5. DISCUSSION

The results of the study entitled "Standardization of alternate media for potted ornamental foliage plants for export purpose" are discussed in this chapter.

1.1 INFLUENCE OF GROWING MEDIUM ON GROWTH CHARACTERS

A significant improvement in plant height was observed in all soil based treatments (T_1, T_2, T_3 and T_9) and in two cocopeat based treatments (T_4 and T_5) during the entire period of study (Fig.5.1). With regard to the plant spread, this parameter was consistently higher in all treatments except in T_3 [soil (50%) + cocopeat (25%) + vermicompost (15%) + sand (10%)] and T_{10} [cocopeat (50%) + vermicompost (20%) + perlite (15%) and vermiculite (15%)] during the study period (Fig.5.2). Significant variation in leaf width was also observed within the treatments. Treatments T_4 [soil (25%) + cocopeat (50%) + vermicompost (15%) + sand (10%)], T_5 [cocopeat (70%) + rice husk (10%) + vermicompost (10%) + sand (10%)] and T_6 [cocopeat (50%) + rice husk (25%) + vermicompost (15%) + sand (10%)] which are cocopeat based treatments showed more leaf width throughout the period of observation.

Addition of cocopeat to the growing medium improves the texture, water holding capacity and prevents the compaction of the medium which helps in better root growth and nutrient uptake by the plants. It also supplements organic matter to the medium [Mane and Bhosale, 2008 in *Arabidopsis thaliana*, Awang *et al.* (2010) in *Celosia cristata*, Nair and Bharathi, (2015) in chrysanthemum, Kavipriya *et al*. (2019) in *Draceana reflexa*]. Vermicompost is rich in humic acid compounds, nitrates, exchangeable phosphorus, soluble potassium, calcium and magnesium, which can be readily taken up by the plants (Krishnamoorthy and Vajranabhaiah, 1986; Shadanpour *et al.,* 2011). Supplementing the potting medium with sand as well as rice husk will increase the pore space, which facilitates drainage as well as better root penetration (Abouzari *et al*., 2012; Olosunde *et al*., 2015). Addition of farm yard manure helps to supply nutrients in available form after decomposition (Singh and Nair, 2003) in coleus, syngonium, dieffenbachia, dracaena and sansevieria, Singh *et al.* (2010) in diffenbachia, and Sarkar *et al.* (2016) in dieffenbachia and dracaena). Complementary effects of all these media components might have improved the plant height and plant spread in treatments containing these components. However pot plants should satisfy certain criteria with regard to plant height and plant spread parameters for export purpose. The recommended plant height and spread for 8 inch pot Aglaonema plant for export purpose should be within the range of 40.64 – 50.80 cm (FMA and FNGA, 1994). In the present study the medium composed of cocopeat (50%), vermicompost (20%), perlite (15%) and vermiculite (15%) (T_{10}) was found to have growth parameters *viz.*, plant height and plant spread within this range when compared to the other growing media. This medium was devoid of soil and thirty per cent of this soilless medium was constituted by inert materials *viz.*, vermiculite and perlite. pH of this medium was found to be in acidic range and EC of this medium was 2.20 dS m^{-1} which was also higher than the required EC for potted foliage plants, so that there was less nutrient uptake compared to other media. This might have cause slow growth rate of plants in this medium. Compact growth of the potted plants was also reported by Wilson *et al.* (2009) in aglaonema grown under peat, perlite and vermiculite mixture and Sardoei and Rahbarian (2014) in *Rosmarinus officinalis* grown under cocopeat, perlite mixture.

Number of leaves is one of the important growth characters which contribute to the beauty of potted plants. The treatments T_4 [soil (25%) + cocopeat (50%) + vermicompost (15%) + sand (10%)], T_1 [soil, vermicompost and sand in 3:2:1] and T_{10} [cocopeat (50%) + vermicompost (20%) + perlite (15%) + vermiculite (15%)] were superior with respect to number of leaves during the study period. Maximum number of leaves at the end of experiment could be observed in T_{10} (Fig.5.3). More number of leaves observed in T_{10} might be due to the excellent aeration provided by cocopeat, vermiculite and perlite as well as nutrients provided by vermicompost. Beneficial effect of vermicompost on number of leaves was reported by Moghadam *et al*. (2012) in lilium, Swetha *et al*. (2014) in aglaonema, Anjana *et al.* (2017) in codiaeum, Kavipriya *et al*. (2019) in *Draceana reflexa*, and Sankari *et al.* (2019) in *Asparagus sprengeri*. Effect of vermiculite amended medium on number of leaves was also reported by Sindhu *et al.* (2010) in gerbera and Thakur *et al*. (2018) in chrysanthemum.

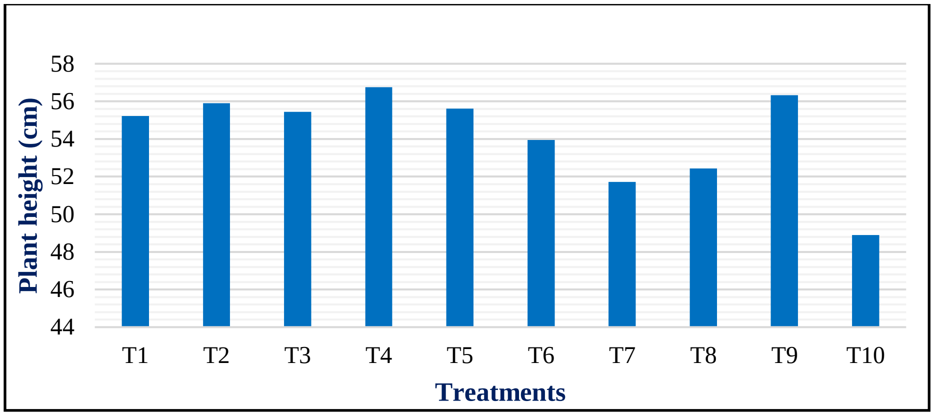


Fig.5.1. Effect of potting media on plant height (cm) of Aglaonema var. 'Silver frost' at 12 months after planting

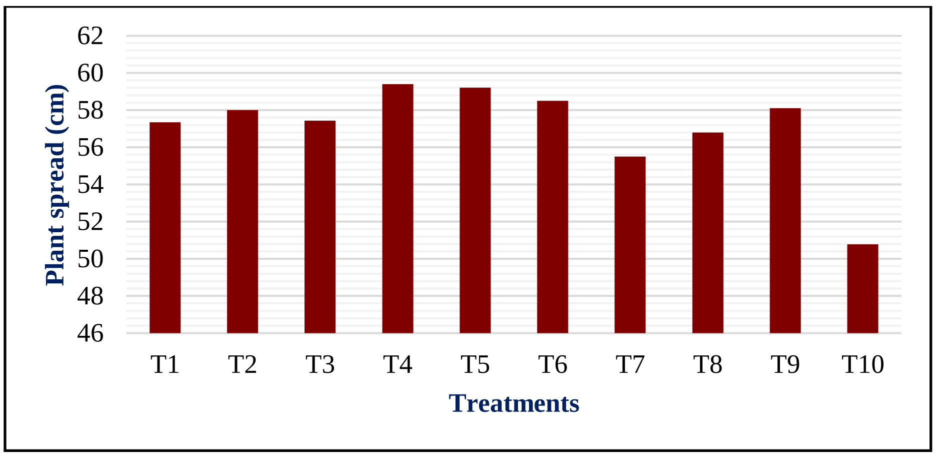


Fig.5.2. Effect of potting media on plant spread (cm) of Aglaonema var. 'Silver frost' at 12 months after planting

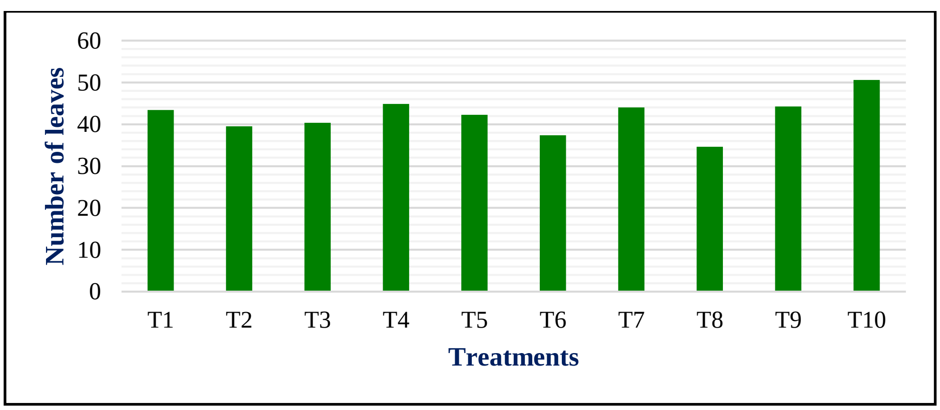


Fig.5.3. Effect of potting media on number of leaves of Aglaonema var. 'Silver frost' at 12 months after planting

It was noticed that composition of growing media significantly influenced leaf area (Fig.5.4). The treatments T_4 [soil (25%) + cocopeat (50%) +vermicompost (15%) + sand (10%)], T_{10}, [cocopeat (50%)+ vermicompost (20%)+ perlite (15%)+ vermiculite (15%)], T_1 [soil, vermicompost and sand in 3:2:1] and T_7 [cocopeat (50%) + biochar (25%) + vermicompost (15%) + sand (10%)] were found superior at 12 months after planting. Superiority of these treatments with respect to leaf area might be due to better physical properties contributed by cocopeat, vermiculite, perlite and sand and improvement in chemical properties by supplementing with biochar as well as vermicompost resulting more nutrient uptake and better plant growth. Similar findings were also reported by Chamani *et al*. (2008) in *Petunia hybrida* and Sultana *et al*. (2015) in *Zinnia elegans*.

The higher the number of leaves, the more will be the attraction to potted foliage plants. Hence, the number of days between the production of successive leaves should be minimum. Time period between the production of successive leaves was found to be minimum in T_4 [soil (25%) + cocopeat (50%) + vermicompost (15%) + sand (10%)], T_{10} [cocopeat (50%) + vermicompost (20%) + perlite (15%) + vermiculite (15%)], T_9 [soil: FYM: sand (1 : 1 : 1)], T_5 [cocopeat (70%)+ rice husk (10%) + vermicompost (10%)+ sand (10%)] and T_3 [soil (50%) + cocopeat (25%) + vermicompost (15%) + sand (10%)] (Fig.5). Improvement of physico chemical properties of these media, might have increased the nutrient uptake by the plants resulting production of more photosynthates leading to the formation of more number of leaves at frequent intervals. This result was in accordance with the findings of Kavipriya *et al.* (2019) in *Asparagus sprengeri* and Sankari *et al.* (2019) in *Draceana reflexa*.

Number of suckers decides the fullness of the pot at the base. Consistent production of suckers (6.10) throughout the period of observation was observed in T_{10} [cocopeat (50%), vermicompost (20%), perlite (15%), vermiculite (15%)] which was a soilless medium (Fig.5.6). As per the recommended grades and standards for foliage plants, the number of suckers for 8 inch pot aglaonema plant should be with the range of 6 to 12 (FMA and FNGA, 1994).T_{10} was found to satisfy this criterion. Improvement in porosity provided

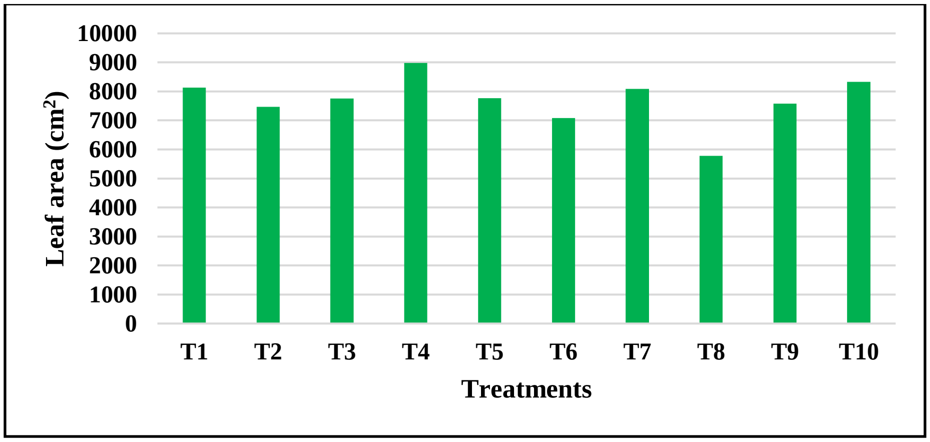


Fig.5.4. Effect of potting media on leaf area in Aglaonema var. 'Silver frost' at 12 months after planting

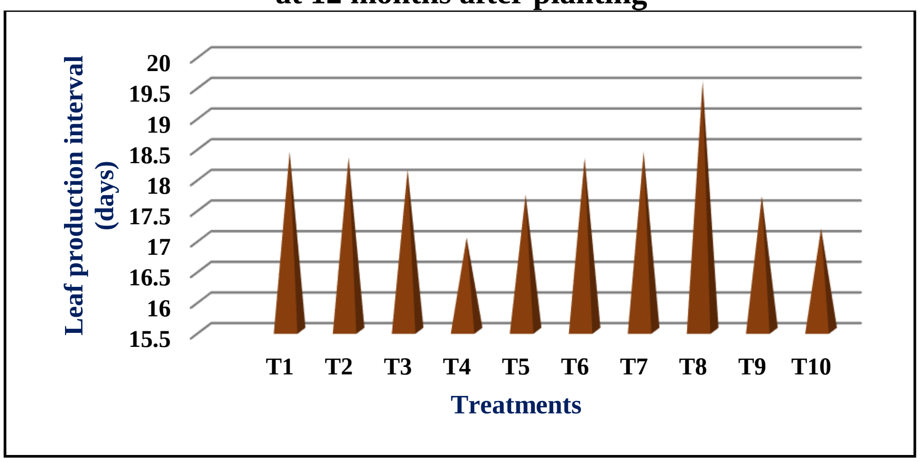


Fig.5.5. Effect of potting media on leaf production interval of Aglaonema var. 'Silver frost'

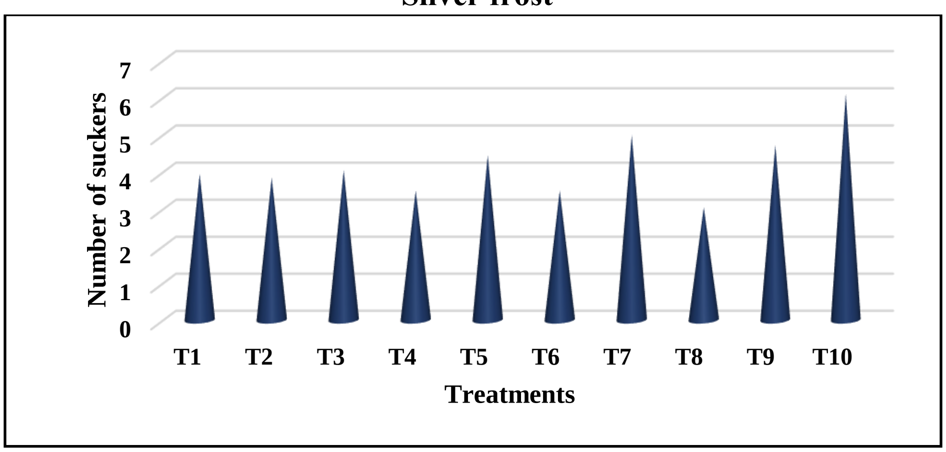


Fig.5.6. Effect of potting media on number of suckers per plant of Aglaonema var. 'Silver frost' at 12 months after planting

by the media components might have promoted the emergence of more suckers in this medium. This result was in accordance with the findings of Thakur *et al.* (2018) who reported maximum sucker production in chrysanthemum grown under cocopeat containing medium.

The lowest shoot length will provide a compact appearance to the potted plants and it is a desirable character for foliage plants as it contribute to fullness of the pot at the base. Regarding the shoot length, significant variation among the treatments was observed (Fig.5.7). The treatments T_8 [cocopeat (25%)+ biochar (25%)+ vermicompost (25%)+ sand (15%) + perlite (10%)], T_{10} [cocopeat (50%)+ vermicompost (20%)+ perlite (15%)+ vermiculite (15%)], T_7 [cocopeat (50%) + biochar (25%) + vermicompost (15%) + sand (10%)] and T_6 [cocopeat (50%) + rice husk (25%) + vermicompost (15%) + sand (10%)] showed lowest shoot length (28.69 -33.56 cm). No significant variation in shoot girth could be observed during the experiment.

The treatments *viz.*, T_1 [soil, vermicompost and sand in 3:2:1], T_9 [soil: FYM : sand (1 : 1 : 1)], T_5 [cocopeat (70%)+ rice husk (10%)+ vermicompost (10%)+ sand (10%)], T_4 [soil (25%) + cocopeat (50%) + vermicompost (15%) + sand (10%)], T_{10} [cocopeat (50%)+ vermicompost (20%)+ perlite (15%)+ vermiculite (15%)] T_8 [cocopeat (25%), biochar(25%), vermicompost (25%), sand (15%) and perlite (10%)] had more fresh weight of leaves (Fig.5.8). Dry weight of leaves (41.20 g plant^{-1}) (Fig.5.9) was found to be highest in T_5 - T_5 and T_9 also recorded maximum dry matter production. Media components *viz.*, cocopeat, FYM and vermicompost might have improved the nutrient status of the growing media resulting more nutrient uptake and production of more metabolites and thereby increasing fresh and dry weights of leaves [Moghadam *et al.* (2012) in Lilium, Swetha *et al.* (2014) in aglaonema, Anjana *et al.* (2017) in Codiaeum, Kavipriya *et al.* (2019) in *Draceana reflexa,* and Sankari *et al.* (2019) in *Asparagus sprengeri,* Singh and Nair (2003) in coleus, syngonium, dieffenbachia, dracaena and sansevieria, Singh *et al.* (2010) in diffenbachia and Sarkar *et al.* (2016) in dieffenbachia and dracaena].

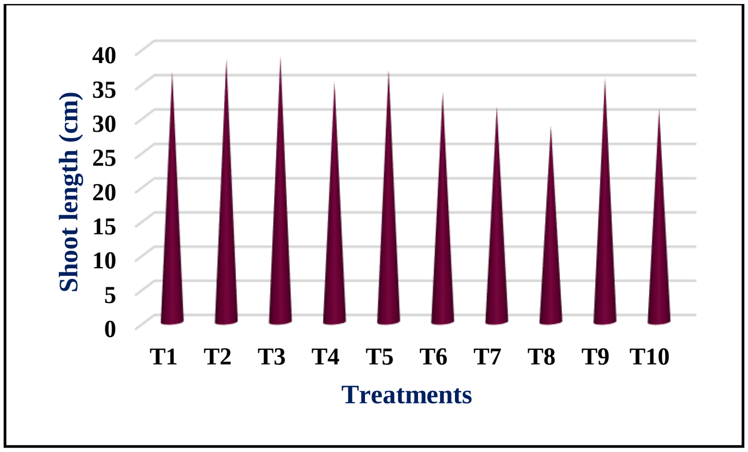


Fig. 5.7. Effect of potting media on shoot length of Aglaonema var. 'Silver frost' at 12 months after planting

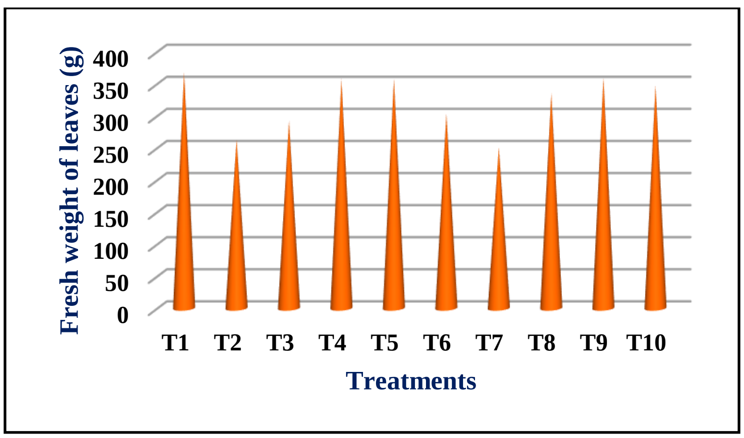


Fig.5.8. Effect of potting media on fresh weight of leaves of Aglaonema var. 'Silver frost' at 12 months after planting

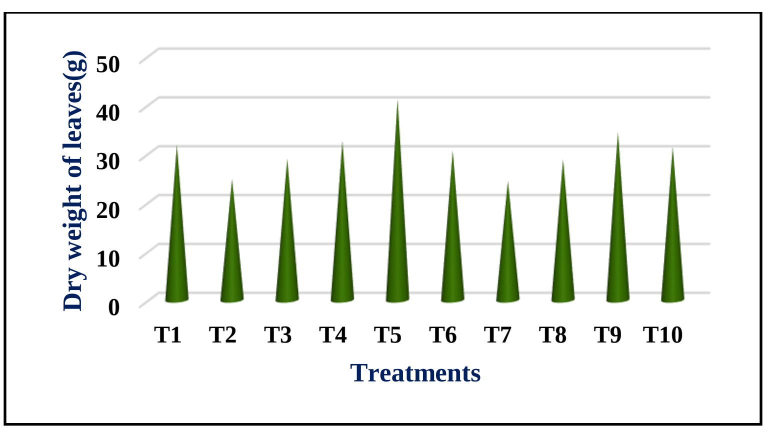


Fig.5.9. Effect of potting media on dry weight of leaves of Aglaonema var. 'Silver frost' at 12 months after planting

5. 2 INFLUENCE OF GROWING MEDIUM ON ROOT CHARACTERS

Root parameters such as number of lateral roots and root volume decide the nutrient uptake by the plants and fresh as well as dry weights are the quality parameters of roots. Significant variation due to treatments could be observed with regards to root characters. Treatments, T_5 [cocopeat (70%) + rice husk (10%) + vermicompost (10%) + sand (10%)] T_4 [soil (25%) + cocopeat (50%) +vermicompost (15%) + sand (10%)] were superior with regard to fresh weight of roots. Number of lateral roots was observed to be the highest in treatments T_9 [soil: FYM : sand (1 : 1 : 1)], T_1 [soil, vermicompost and sand in 3:2:1],T_5 [cocopeat (70%) + rice husk (10%) + vermicompost (10%)], T_4 [soil (25%) + cocopeat (50%) +vermicompost (15%) + sand (10%)] and T_2 [soil (75%) + vermicompost (15%) + sand (10%)]. Significantly higher dry weight of roots was noticed in T_9 [soil: FYM : sand (1 : 1 : 1)], T_1 [soil, vermicompost and sand in 3:2:1], T_4 [soil (25%) + cocopeat (50%) +vermicompost (15%) + sand (10%)],T_2 [soil (75%) + vermicompost (15%) + sand (10%)] and T_5 [cocopeat (70%) + rice husk (10%) + vermicompost (10%) + sand (10%)]. Treatments T_1 [soil, vermicompost and sand in 3:2:1], T_4 [soil (25%) + cocopeat (50%) +vermicompost (15%) + sand (10%)], T_5 [cocopeat (70%) + rice husk (10%) + vermicompost (10%) + sand (10%)], T_9 [soil: FYM: sand (1 : 1 : 1)] were on par with regard to root volume.

In general, treatments $T_{1,}$ $T_{4,}$ T_5 and T_9 were superior with respect to all root parameters, among which T_1 and T_9 were soil based media and T_4 and T_5 were cocopeat based media. Among soil based media, T_1 was supplemented with vermicompost and T_9 was amended with FYM. Improvement in root parameters in T_1 and T_9 could be due to beneficial effects of vermicompost as well as FYM. Vermicompost is rich in nutrients, humic acid substance and growth regulators. Supplementing with vermicompost might have enriched the medium with nutrients and growth hormones which in turn might have resulted an improvement of root parameters in plants. Easy availability of nutrients after decomposition of FYM in medium could be the reason for better root growth in treatment containing FYM. In both these treatments, addition of sand improved the porosity of the

media which facilitated better penetration of roots. Similar findings of beneficial effects of media amended with vermicompost, FYM as well as sand on plant growth were reported by Chamani *et al.* (2008) in *Petunia hybrida*, Singh *et al.* (2010) in dieffenbachia, Kayalvizhi *et al.* (2013) in *Asparagus densiflorus* 'Meyersii', Riaz *et al.* (2014) in gerbera, Sultana *et al.* (2015) in zinnia, Sarkar *et al.*(2016) in dieffenbachia and dracaena, Okunlola and Ogungbite (2016) in *Sanseveria liberica* and Abid *et al.* (2017) in *Dracaena reflexa.*
Cocopeat based media (T_4 and T_5), were supplemented with vermicompost and sand in different proportions. Rice husk was added to T_5 as an additional component. Presence of cocopeat, sand and rice husk in these media might have improved the structure, aeration and drainage of the media. Cocopeat was also found to enrich the organic matter content of the media. Supplementing the media with vermicompost might have improved the nutrient status of the media. All these factors might have contributed for enhancement of root growth and root quality parameters in T_4 and T_5. These results are in accordance with the findings of Kayalvizhi *et al.* (2013) in *Asparagus densiflorus* 'Meyersii', Swetha *et al.* (2014) in aglaonema, Sultana *et al.* (2015) in zinnia, Olosunde *et al*. (2015) in *Dracaena fragrans* Thakur *et al*. (2018) in *Chrysanthemum morifolium*, Sandeep *et al.* (2018) in *N. falcata Cordyline terminalis*, Sankari *et al.* (2019) in *Asparagus sprengeri*, Kavipriya *et al*. (2019) in *Dracaena reflexa*, and Pradhan and Mohanty (2020) in aglaonema and dieffenbachia.

Even though an improvement of root parameters were observed due to various treatments, this cannot be taken as the selection criteria for pot plants. As number of roots and root volume increases, there will be more uptake of nutrients resulting more vegetative growth, which may not contribute to compactness of potted plants.

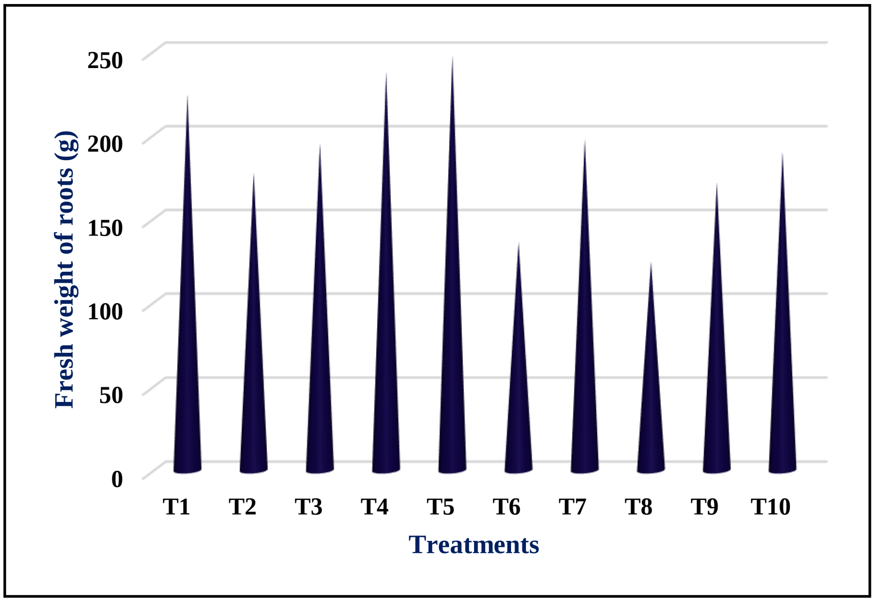


Fig.5.10. Effect of potting media on fresh weight of roots in Aglaonema var. 'Silver frost' at 12 months after planting

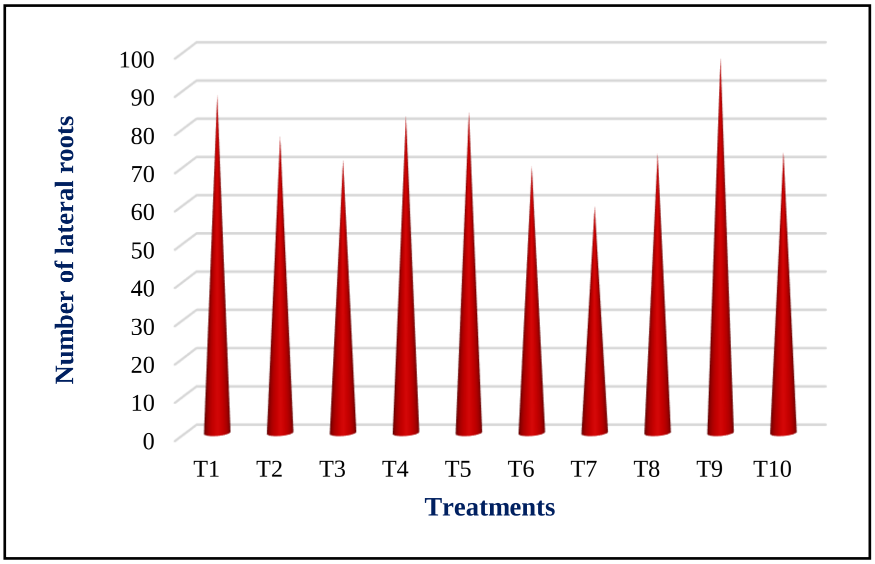


Fig.5.11. Effect of potting media on number of lateral roots of Aglaonema var. 'Silver frost' at 12 months after planting

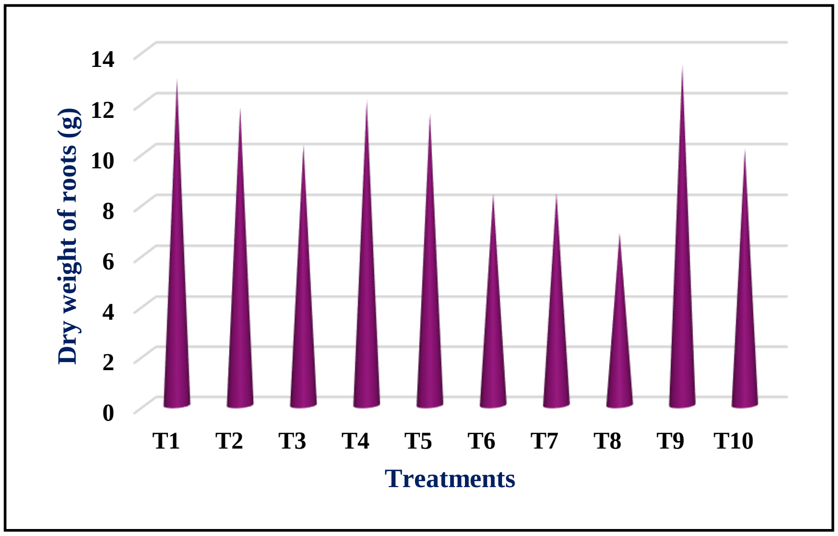


Fig.5.12. Effect of potting media on dry weight of roots of Aglaonema var. 'Silver frost' at 12 months after planting

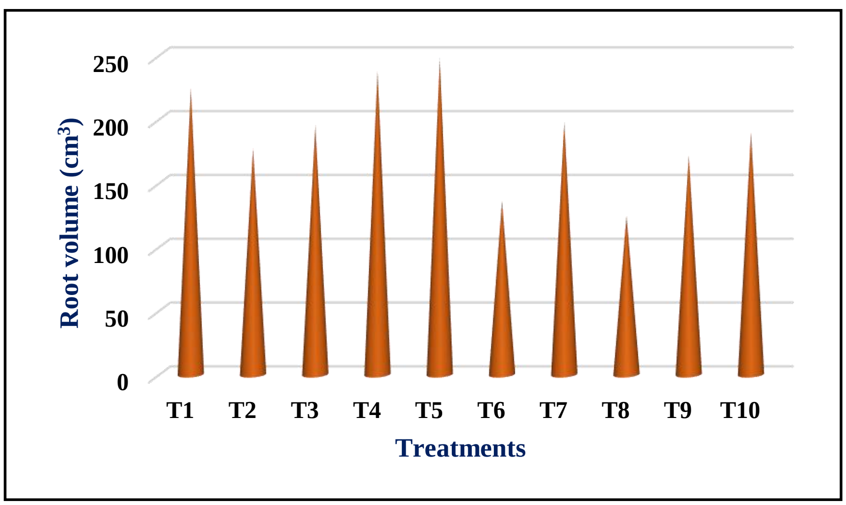


Fig.5.13. Effect of potting media on root volume of Aglaonema var. 'Silver frost' at 12 months after planting

5.3. MEDIA CHARACTERS

5.3.1. Physical properties of growing media

The lower the bulk density, the higher will be the pore space which in turn allow the medium to retain more water within the pore spaces. Highest water holding capacity (178.50%) and porosity (79.53%) and lowest bulk density was recorded in T_{10}, medium comprising of cocopeat (50%), vermicompost (20%), perlite (15%) and vermiculite (15%).

Minimum water holding capacity was noted in T_2, medium amended with soil (75%), vermicompost (15%) and sand (10%). The higher quantity of soil used in T_2 (75%) might have decreased the pore space resulting in highest bulk density leading to lowest water holding capacity in this treatment.

5.3.2. Chemical properties

a. pH

The optimum pH range for growth of potted ornamental foliage plants is within the range of 5.5 – 7.00 (Chen and McConnell, 2002). When the growing media is within the optimum range, there will be better availability of nutrients to the plants. In present study, the treatments T_1, T_2, T_3, T_4, T_5, T_6 and T_9 were in this range. In treatments T_7, T_8 and T_{10}, pH was in acidic range which might have reduced the nutrient availability to the plants leading to a reduction in growth and root parameters.

b. EC (dS m^{-1})

According to Chen and McConnell (2002), the optimum range of EC of the medium required for potted foliage plants should be within the range of 1-2.5 dS m^{-1}. The EC of media used for the study *viz.*, T_1 [soil, vermicompost and sand in 3:2:1], T_4 [soil (25%) + cocopeat (50%) +vermicompost (15%) + sand (10%)], T_5 [cocopeat (70%) + rice husk (10%) + vermicompost (10%) + sand (10%)], T_6 [cocopeat (50%) + rice husk (25%) + vermicompost (15%) + sand (10%)], T_7 [cocopeat (50%) + biochar (25%) + vermicompost (15%) + sand (10%)] and T_{10} [cocopeat (50%) + vermicompost (20%) + perlite (15%) +

vermiculite (15%)] (1.82, 1.00, 1.24, 1.32, 2.20 dS m^{-1} respectively) were under this range, before the experiment.

During the pre planting analysis of growing media, higher EC value was recorded in T_8 (2.8 dSm^{-1}) and T_{10} (2.20 dS m^{-1}). Slower growth rate was observed in plants under these treatments could be due to higher EC prevailed in the media compared to other treatments.

c. Available nitrogen

The treatment T_{10} [cocopeat (50%), vermicompost (20%), perlite (15%) and vermiculite (15%)] had more nitrogen content before (0.79%) and after (3.15%) the experiment. Higher nitrogen content in T_{10} may be due to the presence of cocopeat and vermicompost contributing to N_2 content of the medium, resulting slow nutrient uptake. However compact plant growth observed in this medium might be due to higher EC in this medium. In pre-planting analysis**,** lowest nitrogen content (0.003%) was recorded in T_3 [soil (50%) + cocopeat (25%) + vermicompost (15%) + sand (10%)], whereas in post experiment analysis, lowest nitrogen content (0.006%) was observed in T_2 [soil (75%) + vermicompost (15%) + sand (10%)]. T_3 and T_2 contain soil as the major component of the media. Proportion of components which improve the nutrient status of the media were less in these treatments. This might be the reason for lowest nitrogen content of these media.

d. Available phosphorus

T_7 [cocopeat (50%), biochar (25%), vermicompost (15%) and sand (10%)] recorded maximum phosphorus content (0.281%) as compared to other treatments and lowest was recorded in T_1 (0.002%) composed of soil, vermicompost and sand in 3:2:1, before the experiment. T_7 [cocopeat (50%) + biochar (25%) + vermicompost (15%) + sand (10%)] and T_8 [cocopeat (25%) + biochar (25%) + vermicompost (25%) + sand (15%) + perlite (10%)] recorded maximum phosphorus content (0.083%) in post experiment analysis and lowest P content was recorded in T_9 (0.001%) composed of soil: FYM: sand (1: 1: 1). Higher content of phosphorus in T_7 and T_8 treatments might be due to the cocopeat, biochar and vermicompost which might have contributed to the phosphorus content of the media. Even if phosphorus content was higher in these treatments, efficient uptake of phosphorus might not have happened due to the prevailing pH and EC of these media. This may be the reason for higher P content observed in these media even after the experiment.

e. Available potassium

Higher content of potassium was noted in T_{10} composed of cocopeat (50%), vermicompost (20%), perlite (15%) and vermiculite (15%) (7.56% and 10.8 %) during pre and post experiment analysis**,** respectively. This was attributed to the presence of media components *viz.,* cocopeat and vermicompost in large proportions. Vermiculite also might have contributed to the potassium content of the medium. This result was in line with observation of Wilson *et al.* (2009) in aglaonema. Lowest potassium concentration 0.09% was noted in T_2 composed of soil (75%), vermicompost (15%) and sand (10%), before the experiment. Lowest potassium concentration was noted at the end of experiment were in T_2 and T_3 (0.007%) composed of soil (75%) + vermicompost (15%) + sand (10%) and soil (50%) + cocopeat (25%) + vermicompost (15%) + sand (10%) respectively. Major proportion of T_2 and T_3 was soil and proportions of amendments which contribute to nutrient status of the medium were less in these treatments. Crop removal of available K might have caused the reduction of potassium content after the experiment.

5.4 COST OF THE GROWING MEDIA

In the present study, T_9 composed of soil, FYM and sand in 1:1:1 ratio was found to be the cheapest (Rs. 39.62/-) medium since the cost of components are less and also due to local availability of components. Cost of the medium per pot was highest for T_{10} composed of cocopeat (50%) + vermicompost (20%) + perlite (15%) and vermiculite (15%). However, T_{10} was soilless media composed of lightweight materials which is preferred in export market.

Summary

6. SUMMARY

The investigation entitled "standardization of alternate media for potted ornamental foliage plants for export purpose" was carried out under Department of Floriculture and landscaping, College of Horticulture, Vellanikkara, Thrissur. The experiment was laid out in completely randomized block design with ten sets of treatments and 4 replications. Treatments included ten different growing media containing soil, sand, FYM, cocopeat, vermicompost, rice husk, biochar, perlite and vermiculite in various proportions *viz.*, T_1 : soil, vermicompost and sand in 3:2:1, T_2 : soil (75%) + vermicompost (15%) + sand (10%), T_3: soil (50%) + cocopeat (25%) + vermicompost (15%) + sand (10%), T_4 : soil (25%) + cocopeat (50%) +vermicompost (15%) + sand (10%) , T_5 : cocopeat (70%) + rice husk (10%) + vermicompost (10%) + sand (10%), T_6 : cocopeat (50%) + rice husk (25%) + vermicompost (15%) + sand (10%), T_7 : cocopeat (50%) + biochar (25%) +vermicompost (15%) + sand (10%), T_8 : cocopeat (25%) + biochar (25%) + vermicompost (25%) + sand (15%) + perlite (10%), T_9 : soil: FYM : sand (1:1:1) (Control) and T_{10} : cocopeat (50%) + vermicompost (20%) + perlite (15%) + vermiculite (15%). Popular herbaceous foliage plant *Aglaonema commutatum* var. 'silver frost' was used for the study. The salient findings of experiment are summarized here.

Significant effect of treatments on growth characters could be observed throughout the period of observation. With regard to plant height, treatments T_1, T_2, T_3, T_4, T_5 and T_9 were found be superior, where T_4 and T_5 were cocopeat based media and T_1, T_2, T_3 and T_9 being ordinary potting mixture.

Regarding plant spread, this parameter was consistently higher in all treatments except in T_3, T_7 and T_{10} during the study period. Among the treatments T_1, T_2 and T_9 were soil based media and rest of the treatments were cocopeat based supplemented with vermicompost, sand, rice husk, biochar and perlite.

The treatment T_4 [soil (25%) + cocopeat (50%) + vermicompost (15%) + sand (10%)], T_1 [soil, vermicompost and sand in 3:2:1] and T_{10} [cocopeat (50%) + vermicompost

(20%) + perlite (15%) + vermiculite (15%)] consistently superior with regard to number of leaves during entire period of study and T_{10} recorded more number of leaves at the end of experiment. Significant variation in leaf length and petiole length was observed only up to three months after planting and did not vary significantly during remaining period of observation.

Treatments T_4, composed of soil (25%), cocopeat (50%), vermicompost (15%) and sand (10%) and T_5, consisting of cocopeat (70%) + rice husk (10%) + vermicompost (10%) + sand (10%) which were cocopeat based treatments showed more leaf width throughout the period of observation.

Composition of growing media significantly influenced the leaf area. T_4 [soil (25%) + cocopeat (50%) +vermicompost (15%) + sand (10%), T_1 [soil, vermicompost and sand in 3:2:1] and T_7 [cocopeat (50%) + biochar (25%) + vermicompost (15%) + sand (10%)] and T_{10} [cocopeat (50%) + vermicompost (20%) + perlite (15%) + vermiculite (15%)] showed consistently better performance throughout the period of observation with regard to leaf area.

The minimum interval between the production of successive leaves was noted in T_4, medium composed of soil (25%), cocopeat (50%), vermicompost (15%) + sand (10%), T_{10}, comprising cocopeat (50%), vermicompost (20%), perlite (15%) and vermiculite (15%), T_5, consisting of cocopeat (70%) + rice husk (10%) + vermicompost (10%) + sand (10%) and T_3 [soil (50%) + cocopeat (25%) + vermicompost (15%) + sand (10%)] and more time for production of leaves was taken by T_8 composed of cocopeat (25%) + biochar (25%) + vermicompost (25%) + sand (15%) + perlite (10%).

Early emergence of first sucker (94.79 days – 124.33 days) was observed in T_8, T_4 and T_1 whereas T_2 which was amended with soil (75%), vermicompost (15%) and sand (10%) took more time for emergence of first sucker. T_{10}, comprising cocopeat (50%), vermicompost (20%), perlite (15%) and vermiculite (15%) found to be superior with regard to sucker production. There was no significant variation between treatments with respect to leaf longevity during the period of observation.

The lowest shoot length will provide a compact appearance to the potted plants.

Regarding the shoot length, the parameter has shown significant variation among the treatments. T_8 [cocopeat (25%), biochar (25%), vermicompost (25%), sand (15%) and perlite (10%)], T_{10} [cocopeat (50%), vermicompost (20%), perlite (15%) and vermiculite (15%)] and, T_7 [cocopeat (50%) + biochar (25%) + vermicompost (15%) + sand (10%)] and T_6 [cocopeat (50%) + rice husk (25%) + vermicompost (15%) + sand (10%)] showed lowest shoot length. No significant variation in shoot girth could be observed during the experiment.

Fresh weight of leaves was found to be highest (335.75-367.50g) in medium comprising soil, vermicompost and sand in 3:2:1(T_1), T_9 [soil: FYM: sand (1: 1: 1)], T_5 [cocopeat (70%) + rice husk (10%) + vermicompost (10%) + sand (10%)], T_4 [soil (25%) + cocopeat (50%) +vermicompost (15%) + sand (10%] and T_{10} [cocopeat (50%) + vermicompost (20%) + perlite (15%) + vermiculite (15%)]. T_5 amended with cocopeat (70%), rice husk (10%), vermicompost (10%), sand (10%)) was found to be superior with regard to dry weight of leaves. Lowest fresh (24.40g) and dry weight (250.83g) of leaves was observed in T_7 composed of cocopeat (50%) + biochar (25%) + vermicompost (15%) + sand (10%).

Treatments including T_1 [soil, vermicompost and sand in 3:2:1), T_4 (soil (25%) + cocopeat (50%) +vermicompost (15%) + sand (10%)] and T_5 [cocopeat (70%) + rice husk (10%) + vermicompost (10%) + sand (10%)] found superior with regard to fresh weight of roots. Number of lateral roots was observed to be highest in T_9 [soil: FYM : sand (1 : 1 : 1)], T_1 [soil, vermicompost and sand in 3:2:1],T_5 [cocopeat (70%) + rice husk (10%) + vermicompost (10%)], T_4 [soil (25%) + cocopeat (50%) +vermicompost (15%) + sand (10%)] and T_2 [soil (75%) + vermicompost (15%) + sand (10%)]. Significantly higher dry weight of roots was noticed in T_9 [soil: FYM : sand (1 : 1 : 1)],T_1 [soil, vermicompost and sand in 3:2:1], T_4 [soil (25%) + cocopeat (50%) +vermicompost (15%) + sand (10%)], T_2 [soil (75%) + vermicompost (15%) + sand (10%)] and T_5 [cocopeat (70%) + rice husk (10%) + vermicompost (10%) + sand (10%). Treatments T_1 [soil, vermicompost and sand in 3:2:1], T_4 [soil (25%) + cocopeat (50%) +vermicompost (15%) + sand (10%)], T_5 [cocopeat (70%) + rice husk (10%) + vermicompost (10%) + sand (10%)] and T_9 [soil:

FYM : sand (1 : 1 : 1)] were on par with regard to root volume.

Analysis of growing media after the experiment for different physical and chemical properties revealed that treatment T_{10} [cocopeat (50%), vermicompost (20%), perlite (15%) and vermiculite (15%)] was having highest water holding capacity as well as porosity and low bulk density which made it a suitable media for export of potted ornamental foliage plants. With regard to chemical properties, pH value towards neutral range was observed in T_9 whereas value was acidic range in $T_{10.}$ T_1 [soil, vermicompost and sand in 3:2:1], T_4 [soil (25%) + cocopeat (50%) +vermicompost (15%) + sand (10%)], T_5 [cocopeat (70%) + rice husk (10%) + vermicompost (10%) + sand (10%)], T_6 [cocopeat (50%) + rice husk (25%) + vermi compost (15%) + sand (10%)], T_7 [cocopeat (50%) + biochar (25%) + vermicompost (15%) + sand (10%)] and T_{10} [cocopeat (50%) + vermicompost (20%) + perlite (15%) + vermiculite (15%)] were within the range of 1.00– 2.5 dS m^{-1} which is the preferred range of EC for potted ornamental foliage plants (Chen and McConnell, 2002). The treatment T_{10} have the highest content of nitrogen, potassium and the treatment T_7 was superior with respect phosphorus content.

Salient findings of experiment

As per the recommended grades and standards for potted foliage plants (FMA and FNGA, 1994), *Aglaonema commutatum* in 8 inch pot should have a height and spread of 12-16’’ (40.64 cm to 50.80 cm) and number of lateral shoots 6-12. There should be more number of leaves. In the present study, the medium consisted of cocopeat (50%) + vermicompost (20%) + perlite (15%)+ vermiculite (15%) was found to satisfy all the quality parameters specified for export purpose. In addition, the medium has an additional advantage of being the lightest which is also preferred in export market. Hence this medium can be recommended as an alternate medium for export of potted plants.

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Appendix

APPENDIX-I

Meteorological data during the period of observation from June, 2019 to June, 2020

Monthly data (2019-2020)						
Month	**Temperature (^0C)**		**RH (%)**			**Rainfall (mm)**
	Max.	**Min.**	**I**	**II**	**Mean**	
June-19	32.2	23.5	93	73	83	324.40
July	30.4	22.8	95	76	85	654.40
August	29.5	21.9	96	82	89	977.50
September	31.2	22	95	75	85	419.00
October	32.4	21.4	91	68	79	418.40
November	32.9	21.7	83	60	71	205.00
December	32.3	22.1	73	52	63	4.40
January-20	34.1	22.4	78	43	60	0
February	35.5	23.2	71	37	54	0
March	36.4	24.4	85	46	65	33.40
April	36.4	24.7	86	55	71	44.70
May	35.0	25.2	90	63	77	59.60
June, 20	31.1	23.7	94	75	85	427.20

APPENDIX - II

Cost of growing media components used for the study

Component	**Unit cost (Kg)**
Soil	2.00
Sand	3.00
FYM	1.50
Vermicompost	20.00
Cocopeat	15.00
vermiculite	40.00
Perlite	80.00
Rice husk	5.00
Biochar	15.00

STANDARDIZATION OF ALTERNATE MEDIA FOR POTTED ORNAMENTAL FOLIAGE PLANTS FOR EXPORT PURPOSE

By

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(2018 – 12 – 011)

ABSTRACT OF THE THESIS

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ABSTRACT

The investigation entitled "standardization of alternate media for potted ornamental foliage plants for export purpose" was carried out in Department of Floriculture and Landscaping, College of Horticulture, Vellanikkara from June, 2019 to June, 2020. The objectives of the study were to standardize alternate media for potted ornamental foliage plants for export purpose and to work out the economics. The experiment was laid out in completely randomized block design with ten treatments and four replications. Treatments included ten different growing media containing soil, sand, FYM, cocopeat, vermicompost, rice husk, biochar, perlite and vermiculite in various proportions *viz.,* T_1 : soil, vermicompost and sand in 3:2:1, T_2 : soil (75%) + vermicompost (15%) + sand (10%), T_3: soil (50%) + cocopeat (25%) + vermicompost (15%) + sand (10%), T_4 : soil (25%) + cocopeat (50%) + vermicompost (15%) + sand (10%), T_5 : cocopeat (70%) + rice husk (10%) + vermicompost (10%) + sand (10%), T_6 : cocopeat (50%) + rice husk (25%) + vermicompost (15%) + sand (10%), T_7 : cocopeat (50%) + biochar (25%) + vermicompost (15%) + sand (10%), T_8 : cocopeat (25%) + biochar (25%) + vermicompost (25%) + sand (15%) + perlite (10%), T_9 : soil: FYM : sand (1:1:1) (Control) and T_{10} : cocopeat (50%) + vermicompost (20%) + perlite (15%) + vermiculite (15%). Popular herbaceous foliage plant *Aglaonema commutatum* var. 'silver frost' was used for the study.

Significant improvement in growth parameters *viz.,* plant height and plant spread was observed in all soil based media (T_1, T_2, T_3 and T_9) as well as in two cocopeat based media (T_4 and T_5) during the study period. However, the treatment T_{10} [cocopeat (50%) + vermicompost (20%) + perlite (15%) + vermiculite (15%)] was found to satisfy the height (48.89 cm) and plant spread (50.78cm) as per the recommended grades and standards for potted aglaonema (FMA and FNGA, 1994). Even though significant improvement with respect to number of leaves was observed in various treatments during the period of experiment, T_{10} was found to have consistent performance confirming to the standards of

potted plants. The treatments T_4, T_5 and T_6 which were cocopeat based treatments showed more leaf width throughout the period of observation (7.89-7.29 cm). Composition of growing media significantly influenced the leaf area. T_1, T_7, T_{10} and T_4 were found to have maximum leaf area (8091.26 - 8982.67 cm^2) at the end of experiment. As the foliage enhances the beauty of potted plants, production of leaves at frequent intervals is a desirable character. In the present study, minimum interval for the production of successive leaves was observed in treatments T_4, T_{10}, T_9, T_5 and T_3, whereas T_8 was found to have more time interval between the production of leaves. Early emergence of first sucker (94.79 days) was observed in T_8 [cocopeat (25%) + biochar (25%)+ vermicompost (25%)+ sand (15%) + perlite (10%)], whereas T_2 [soil (75%)+ vermicompost (15%) + sand (10%)] took more time for emergence of first sucker (155.33 days). Number of suckers decides the fullness of the pot at the base and the medium composed of cocopeat (50%), vermicompost (20%), perlite (15%) and vermiculite (15%) (T_{10}) was superior with regard to this parameter (6.10).

The lowest shoot length will provide a compact appearance to the potted plants. The treatments T_8 [cocopeat (25%), biochar (25%), vermicompost (25%), sand (15%) and perlite (10%)], T_{10} [cocopeat (50%)+ vermicompost (20%)+ perlite (15%)+ vermiculite (15%)], T_7 [cocopeat (50%)+ biochar (25%)+ vermicompost (15%)+ sand (10%)] and T_6 [cocopeat (50%)+ rice husk (25%)+ vermicompost (15%)+ sand (10%)] showed lowest shoot length. Fresh weight of leaves is an indication of quality of foliage and this parameter was found to be highest in media T_1, T_9, T_4, T_8 and T_{10}. T_5 was superior with regard to dry weight of leaves. With regard to root parameters, T_4 and T_5 were superior in terms of fresh weight of roots. Number of lateral roots was observed to be highest in T_9, T_1, T_5, T_4 and T_2.

Even though improvement in growth characters and root parameters was observed due to various treatments, potted ornamental foliage plants should satisfy certain quality criteria for export purpose.

As per the recommended grades and standards for potted aglaonema for export, it should possess height and spread within the range of 40.64 cm to 50.80 cm and there should be 6-12 suckers per pot. The medium should be light in weight and it should have more water holding capacity so as to avoid irrigation at frequent intervals. In the present study, the medium composed of cocopeat (50%), vermicompost (20%), 6perlite (15%), vermiculite (15%) (T_{10}) was found to possess all these characteristics and also it was superior with respect to number of leaves as well as number of suckers, which are the desirable characters for potted foliage plants for interiorscaping. In addition to this, the medium was found to have high porosity, low bulk density and high water holding capacity which helps to reduce irrigation requirement of potted plants. Hence this medium can be recommended as a medium for export purpose of potted ornamental foliage plants.