STANDARDIZATION OF SOILLESS MEDIUM AND FOLIAR NUTRIENTS FOR POTTED ORNAMENTAL FOLIAGE PLANTS

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THESIS

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COLLEGE OF AGRICULTURE
VELLANIKKARA, THRISSUR-680656
KERALA, INDIA

2021

DECLARATION

I hereby declare that this thesis entitled **"Standardization of soilless medium and foliar nutrients for potted ornamental foliage plants"** is a bonafide record of research work done by me during the course of research and the thesis has not previously formed the basis for the award of any degree, diploma, fellowship or other similar title, of any other University or Society.

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Date: 24-11-2021

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CERTIFICATE

Certified that this thesis entitled **"Standardization of soilless medium and foliar nutrients for potted ornamental foliage plants"** is a record of research work done independently by **Ms. Chaitra K. (2019-12-004)** 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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DEDICATED TO MY PARENTS, GUIDE & TEACHERS

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LIST OF ABBREVIATION AND SYMBOLS USED

Symbols	Abbreviation
^0C	Degree Celsius
cc	Cubic centimetre
cm	Centimetre
CRD	Completely randomized design
cv.	Cultivar
et al.	And others
FYM	Farmyard manure
g	Gram
L	Litre
ml	Milli litre
MAP	Months after planting
NS	Non-significant
No.	Number
%	Percentage
Rs.	Rupees
SE(m)	Standard error of means
v/v	Volume by volume
var.	Variety

INTRODUCTION

1. INTRODUCTION

Floriculture is an aesthetic branch of horticulture that has been emerged as a potential money-earning industry throughout the world. Floriculture comprises of commercial production of flowers, potted plants, seeds, bulbs and other planting materials as well as their trade. Foliage plants are one of the essential components of the floriculture industry and are commonly used as potted plants and for cut foliage. Nowadays rapid urbanization has resulted in the replacement of the scenic beauty of nature by high sky buildings/skyscrapers and a reduction in green space. Interior scaping is the practice of introducing some green into an interior environment by means of potted plants. The significance of these potted plants is expanding due to the lack of open spaces, forcing people to rely on potted plants to beautify their homes and workplaces. Hence recently demand for potted ornamental foliage plants has gone up drastically for interior scaping as they enhance the aesthetic view of the indoors along with which it also provides a valuable weapon in the fight against the rising level of indoor air pollution and absorb gaseous air pollutants, microbes, dust particles and purify the indoor air.

Philodendron xanadu is a popular foliage plant that needs little attention and is frequently used in arrangements, bouquets and stage decorations. It is widely grown in tropical, subtropical and warm temperate climates as a landscape plant. It is a shade-loving crop that's great for interior scaping. Kerala has been designated as one of the best places for growing cut foliage plants, because of its favourable climatic conditions.

One of the most important components of the cultivation of potted ornamental foliage plants is the choice of growing substrate or medium. The substance that offers anchoring to the plants by holding the root system is known as medium or substrate. It also delivers the critical nutrients that the plants require for metabolism, growth and development. The substrate may be a single medium or a mix of two or more media. Generally, soil is not preferred as a growing medium for potted plants since they make them heavy and bulky for transport and handling. Also, factors such as the presence of disease-causing organisms and nematodes, unfavourable soil reactions, compaction and poor drainage will lead to poor growth and appearance of ornamental plants (Sengupta and Banerjee, 2012).

The growing medium must be affordable and easy to obtain in the local market and guarantee product quality. Soilless media are popular among most producers due to their consistency, great aeration, reproducibility and low bulk density which reduces shipping and handling costs for both the medium and the finished plants. Soilless culture systems refer to methods of growing plants that do not require the use of soil in situ or soilless culture is a method of growing plants in media that helps to alleviate soil-related issues in traditional crop cultivation (Murumkar *et al*., 2012).

Many organic nutrient solutions are used as foliar sprays as a source of nutrients to plants. Out of these, the use of natural seaweed extracts is reported as a promising substitute for foliar chemical fertilizer formulations. Hence there is a need to test the efficacy of such organic formulations in comparison with commonly used chemical fertilizers as a nutrient source to foliage plants for their quick growth.

Under this context, the study was undertaken to standardize soilless medium and foliar nutrients for potted ornamental foliage plants.

REVIEW OF LITERATURE

2. REVIEW OF LITERATURE

In recent years, the demand for potted ornamental foliage plants has gone up drastically for interior scaping and instant gardens. One of the most important components of the cultivation of potted ornamental foliage plants is the choice of growing substrate or medium. Growing media are organic or inorganic substances, which anchor the plant's root system. It provides the plant nutrients required for metabolism, growth and development. The medium used must be free from disease pathogens, weeds, pests and nematodes with an adequate water holding capacity and drainage. Foliar nutrients have distinct benefits over soil-based nutrients since they are absorbed directly by leaves, resulting in a specific and rapid response. Cited here are the literature pertaining to the effect of different growing media components and foliar nutrients on the growth of potted ornamental plants.

2.1. EFFECT OF GROWING MEDIA COMPONENTS ON ORNAMENTAL PLANTS

2.1.1. Cocopeat

Cocopeat is the agro-waste or agricultural by-product of the coconut processing industry, characterized by reduced bulk density, high porosity, high water holding capacity as well as higher availability of nitrogen to plants. It has the ability to retain and release nutrients to plants over an extended period of time.

Saravanan (2001) observed an improvement in plant height, number of roots per plant, earliest in flowering, number of spikes per plant and spike length in *Dendrobium* cv. Sonia-17 grown in coconut dust medium.

Sreerama *et al.* (2002) reported that under cocopeat media, the highest rooting and root length was recorded for the carnation cultivar 'Malaga'.

Ritu and Grewal (2002) investigated the usage of cocopeat medium for *Aglaonema commutatum* and inferred that superior growth in terms of general appearance and vegetative characters might be due to the medium's high nutritional status and better water holding capacity.

Khayyat *et al.* (2007) observed more freshness, shoot length, shoot fresh and dry weights, root fresh and dry weights and root number in *Epipremnum aureum* Lindl. and Andre 'Golden Pothos' grown in medium containing cocopeat only, showing the superiority of cocopeat over other pot mixes on pothos.

According to Treder (2008), *Lilium* cv. Star Gazer grown in cocopeat medium had early flowering, highest fresh and dry flower weights of the blossoms and leaves, longer flower buds and healthy root structure.

Basheer and Thekkayam (2012) evaluated different growing media for young anthurium plants and observed the maximum plant height, leaf area, petiole length, fresh and dry weight of leaves, highest N and K content and shortest phyllachron in plants grown in medium containing sand and coir pith.

Nair and Bharathi (2015) reported potting medium containing cocopeat, sand, FYM and vermicompost in 2:1:0.5:0.5 v/v as the best medium for producing more number of flowers and extending the flowering time in chrysanthemum cv. Sadhbhavana and recommended it as a substitute for traditional potting medium for pot mom production.

2.1.2. Coco chips

Coco chips, also known as chipped coconut husks are utilized as a growing media component in pot plant production. Coco chips are made from coconut husks that have been chopped into small pieces. Coco chips are added to potting soil or mixed in various proportions with other components to regulate aeration and maintain the ideal air-to-moisture ratio for better root growth.

Muraleedharan and Karuppaiah (2015) investigated the effect of growing media on anthurium (*Anthurium andreanum*) cv. Tropical. Maximum plant height, plant spread, number of flowers per plant, flower stalk length, spathe length, and spathe breadth was observed in a growing medium containing coir pith and coconut husk.

Kapane *et al.* (2015) investigated the effects of various growing media on anthurium plants and observed improvement in vegetative parameters *viz.,* plant height, spread and leaf area as well as flowering parameters *viz.*, days to first flower initiation, no. of flowers per plant, maximum spathe size, stalk length and flower longevity in plants grown under the medium containing coconut husk pieces.

Sumathi *et al.* (2018) reported a significant improvement in all vegetative and flowering parameters of *Anthurium andreanum* var. Tropical, when grown in a medium containing coconut husk + charcoal in 3:1 proportion.

According to Hariyanto *et al.* (2019), growing media influence the growth of *Dendrobium sylvanum* and observed that media containing a combination of bagasse and coconut husk increased the root length, leaf width, leaf length, and stem diameter.

Sanghamitra *et al.* (2019) assessed the effects of the different potting media on the vegetative and flowering parameters in *Dendrobium* cv. Sonia 17. Of all treatments, coconut husk chips + brick pieces + charcoal + gravel (2:1:1:1) produced the best performance for all vegetative growth parameters, *viz*., plant height, number of leaves/plant, number of shoots/plant, shoot girth, leaf length and breadth. Flowering parameters *viz*., spike length, spike girth, spike weight, number of flowers per spike, flower diameter and number of spikes per plant was also observed in this medium.

2.1.3. Vermicompost

Vermicompost is a nonthermophilic and stable product created by the interactions of earthworms and microorganisms which has a high potential as a soil amendment (Arancon *et al.* 2008). This compost is an odourless, clean, organic material that contains sufficient amounts of NPK and several micronutrients for plant growth (Kaushal and Kumari 2020). It aids in improving the form, texture, aeration and water retention capacity of growing media. Beneficial microorganisms abound in vermicompost and it also contains plant growth regulators such as auxin and gibberellins. It also improves the efficacy of fertilizers that have been added to the soil (Ganesh and Jawaharlal, 2019).

Barreto and Jagtap (2002), observed that pots with cocopeat and vermicompost (1:1, v/v) produced the best flower quality in terms of head and disc diameter, number of ray florets and stalk length in gerbera cv. Sangria.

According to Parmar (2006), the application of vermicompost at 500 g per plant improved flower diameter and the number of petals per flower in rose cv. Gladiator.

Arancon *et al.* (2008) reported that the application of vermicompost improved plant germination, growth and flowering of petunia grown in pots.

Thangam *et al.* (2009) evaluated different growing media *viz*., sand, FYM, vermicompost, rice husk as well as coco peat and reported high-quality flowers in gerbera grown in medium containing vermicompost.

Sangwan *et al.* (2010) observed that adding vermicompost to potting media in appropriate amounts had synergistic benefits on plant development and blooming, including number of buds, number of flowers per plant, shoot biomass, root biomass, plant height and flower diameter in marigold.

Swetha *et al.* (2014) investigated the effect of potting media on the growth and quality of *Aglaonema* cv. Ernesto's Favourite and observed maximum plant height, number of leaves, leaf length, leaf width, leaf area, plant growth index, fresh weight of root, dry weight of root, visual plant grade, colour grade, root grade and NPK content in leaf under the treatment containing cocopeat + sand + vermicompost in 2:1:1 (v/v) combination.

Sisodia and Singh (2015) reported early spike emergence, floret colour show, first floret opening and increased diameter of first, third and fifth florets in gladiolus grown in medium containing vermicompost.

Juveriya and Ahmmed (2016) observed more number of shoots and an improvement in the length of shoot of *Codiaeum variegatum* grown in soil-based medium containing vermicompost.

An improvement in growth and yield in terms of number of leaves, number of suckers and flowering characters such as days to first flowering, stalk length, stalk diameter, flower diameter, flower weight, number of flowers, period of flower retention and vase life were reported in gerbera when grown in growing medium containing coir pith, garden soil and vermicompost in 1:1:1 proportion (Arunesh *et al*., 2020).

Monika *et al.* (2021) investigated the influence of different potting mixtures on the growth and blooming of chrysanthemum cv. Haldighati and noted the highest number of major and sub-branches per plant, number of ray florets per flower, length and width of ray florets under the treatment containing vermicompost, FYM and garden soil.

2.1.4. Vermiculite

Vermiculite is a naturally occurring micaceous mineral that expands when heated. It is made up of hydrated magnesium, aluminum iron silicate and water. Vermiculite is an excellent soil conditioner and a suitable hydroponic growing medium that has high cation exchange and buffering properties. It also has the ability to supply potassium and magnesium. For potted plants, it is used in conjunction with perlite.

Maximum dry weight of *Impatiens wallerana* was observed in growing medium containing carex peat (70%) + perlite (20%) + vermiculite (10%), whereas maximum dry weight in *Petunia* × *hybrida* was observed in growing medium containing carex peat (40%) + river waste (40%) + perlite (10%) + vermiculite (10%) (Chavez *et al*., 2008)**.**

According to Sindhu *et al*. (2010), gerbera performs better in a soilless medium composed of cocopeat, vermiculite and perlite (4:1:1).

The effect of growing media compositions containing cocopeat, FYM and vermiculite in various ratios on potted *Chrysanthemum morifolium* Ramat cv. Kikiobiory (standard) for quality flower production was evaluated and it was concluded that flower quality parameters such as flower diameter and flowering duration were highest in media containing vermiculite and FYM in 2:1 proportion (Thakur and Grewal, 2019).

Rashidha *et al.* (2021) investigated the performance of aglaonema in various potting media and reported that media containing cocopeat (50%), vermicompost (20%), perlite (15%) and vermiculite (15%) as superior in terms of leaf number and suckers and also satisfied the recommended height and plant spread for potted aglaonema.

2.1.5. Perlite

Perlite is a silicon-rich amorphous volcanic rock. Perlite acts as an insulator, reducing extreme temperature fluctuations in the medium. It is a clean, sterile, odourless and free of weeds and diseases. It improves aeration and drainage, make plants easily accessible for moisture and nutrients with neutral pH of 6.5 to 7.5 (Kaushal and Kumari, 2020).

Khalaj *et al.* (2011) investigated the impact of various substrates on the growth and yield of gerbera and found that media containing perlite (25%), peat (70%) and expanded clay mix (5%) produced significantly the highest no. of flowers per plant and other quality characteristics, implying that it is best suited for growing gerbera.

Kakoei and Salehi (2013) compared the growth of *Spathiphyllum wallisii* Regel plants grown in various pot mixtures and found that the media containing perlite produced the best results in terms of leaf area, leaf number, shoot fresh and dry weights, root fresh and dry weights, root length and root volume.

Bidarnamani and Zarei (2014) reported that media containing perlite and leaf compost as well as perlite and mushroom compost were ideal for improving plant height, leaf number and chlorophyll content in pothos.

Growing the magnolia seedlings in a mixture of peat moss, sand and perlite resulted in the tallest plants, thickest stems, largest leaves, longest roots and the maximum fresh weight of leaves, stems and roots (El-Quasni *et al*., 2014).

Jabbar *et al.* (2018) studied the effect of cocopeat and perlite medium with three ratios (1:1, 3:1, and 1:3 v/v) in two gladiolus cv. Strong and White revealed that highest vegetative, flowering and biochemical parameters were highest in medium containing cocopeat: perlite in 1:3 proportion.

Mohamed (2018) conducted pot experimental trial in *Dypsis cabadae* and reported tallest plants, highest fresh and dry weights of leaves, stem length, root length, total chlorophyll content, total NPK and total carbohydrates content as well as the leaf auxin and gibberellins content under the treatment containing compost, peat moss and perlite in 1:1:1 proportion.

Kakhki *et al.* (2020) investigated the effects of different growing media and nitrogen fertilizer (urea) on some morphological traits of *Spathiphyllum* and observed that the growing medium containing perlite 30%, cocopeat 50% and peat moss 20% + 2 g/L urea fertilizer had the highest shoot fresh and dry weights, root fresh and dry weights, length of petiole and leaf number.

Singh *et al.* (2020) investigated the effect of various potting media on the survival percentage of bougainvillea rooted cuttings and found that media containing sand, cocopeat, perlite (1:1:1) was superior with respect to parameters such as rooting of cuttings, days to the first sprout, no. of vegetative buds/plant, survival percentage of cutting, length of longest shoot, fresh weight of shoots/plant, dry weight of shoots/plant, length of longest root/plant, fresh weight of roots/plant and dry weight of roots/plant.

Highest stem diameter, plant spread, fresh weight, leaf biomass, no. of suckers per plant, flower diameter and minimum days to the first colour shown were observed in pot mum chrysanthemum when grown in a medium containing perlite, FYM and garden soil in 2:1:1 proportion (Monika *et al*., 2021).

2.1.6. Neem cake

Neem cake is the residual meal of neem seed obtained through the cold-pressed extraction process of extracting neem oil from neem kernels. When combined with nitrogen fertilizers, it inhibits the conversion of nitrogenous compounds to nitrogen gas, allowing plants to use nitrogen for longer periods (Juveriya and Ahmmed, 2016). Neem cake improves the overall appearance of leaves by extending their life, improving their development, flowering and root strength. It is entirely organic that increases the productivity and fertility of the soil.

Jothi *et al*. (2004) investigated the influence of soil amendments on the development of *Pratylenchus delatteri* and the growth of crossandra cv. Local and their findings revealed that neem cake outperformed the others in terms of nematode control and yield.

Singh (2006) investigated the effect of substrate mixtures on anthurium (*Anthurium andreanum*) growth and flower production in a protected structure and observed that medium containing coco fibre and neem cake in equal proportion produced the best results in terms of flower stalk length (cm) and vase life (days).

In Anthurium, an organic manure combination of leaf compost, neem cake, bone meal, poultry manure and wood ash (2:2:2:1:1 v/v) was given to potting media at bimonthly intervals had positive effects (Basheer and Thekkayam, 2012).

Karim *et al.* (2017) reported that a combination of neem cake and seaweed extract improved leaf length, spike weight and vase life in tuberose cv. Prajwal.

2.2. EFFECT OF FOLIAR NUTRIENTS ON ORNAMENTAL PLANTS

2.2.1. NPK 19:19:19

It is a water-soluble fertilizer that contains 19% nitrogen, 19% phosphorus, and 19% potassium and it provides equal amounts of nitrogen, phosphorus and potassium to the soil. As a foliar spray, it aids in the improvement of growth and yield of the plants.

EL Sayed *et al*. (2009) reported that spraying of NPK at 1 g alone or in combination with trace elements (Fe, Mn and Zn) at monthly intervals enhanced plant height, stem diameter, number of leaves per plant, leaf area, fresh and dry weights of leaves in *Dracaena marginata* ‘Bicolor’.

Monthly application of NPK (19:19:19) at 5 g/plant was found to be very effective for enhancing vegetative growth, flower quality and bulb production in *Hippeastrum vittatum* (El-Naggar and El-Nasharty, 2009).

Kumar *et al.* (2019) revealed that spraying NPK-19:19:19 at 5 g/L twice a week was found to be the best in terms of vegetative development and blooming of anthurium var. Xavia.

2.2.1. Seaweed extract

Seaweed extracts, now widely recognized as 'plant biostimulants' are extracts prepared from marine macroalgae that are green, brown or red. Brown seaweed extracts are widely utilized in horticulture, primarily to promote plants growth and improve crop tolerance against abiotic stresses including salinity, extreme temperatures, nutrient deficiencies and drought. Complex polysaccharides, fatty acids, vitamins, phytohormones and mineral nutrients are the chemical constituents of seaweed extract. The presence of organic and inorganic components in seaweed fertilizer promotes plant growth by increasing nutrient uptake and aiding in the assimilation of the plant's carbohydrate and protein contents, thus increasing plant output.

Seaweed manure has been shown to eliminate 'black spots' on roses as well as increase crop resistance to pests and diseases caused by aphids, red spider mites, powdery mildew and the fungi that cause seedling damping (Chapman and Chapman, 1980).

Sridhar and Rengasamy (2010) found that the application of 1.0 per cent seaweed liquid fertilizer improved growth characteristics, height and the number of branches in marigold (*Tagetes erecta*).

Aziz *et al.* (2011) investigated the effect of spraying seaweed extracts (*Ascophyllum nodosum*) on the growth, flowering and chemical constituents of *Amaranthus tricolour* and found that spraying with seaweed extract resulted in more length and diameter of the stem, root length, number of leaves, fresh and dry weights of leaves, stems and roots.

In a pot experiment with bedding plants, seaweed extract of *Ascophyllum nodosum* was found to produce positive effects on plant growth and development of petunia, pansy and cosmos (Battacharyya *et al*., 2015).

Al-Hamzawi (2019) carried out a study on *Dianthus chinesis* L. as well as *Gazania splender* L. to investigate the impact of spraying seaweed extract and micronutrients and concluded that with increasing concentrations of seaweed extract, there was a significant increase in leaf number in gazania and the application of the maximum concentration improved chlorophyll content, no. of flowers per plant, carbohydrate content and flower stalk length of both the plants.

MATERIALS AND METHODS

3. MATERIALS AND METHODS

The present experiment titled "Standardization of soilless medium and foliar nutrients for potted ornamental foliage plants" was carried out at the Department of Floriculture and Landscape Architecture at the College of Agriculture, Vellanikkara from December 2020 to May 2021. The materials used in the study as well as the methods followed are discussed in this chapter.

3.1. LOCATION OF EXPERIMENT

The experiment field is located at an elevation of 22.25 m above mean sea level (MSL) at a latitude of 10^{o} 31' N and longitude of 76^{o} 13' E.

3.2. CLIMATE

The region is having a warm humid tropical climate. The meteorological data collected during the observation period is included in Appendix 15.

3.3. MATERIALS

3.3.1. Planting material

The experiment was carried out using one-year-old plants of *Philodendron xanadu*, a popular ornamental foliage plant.

3.3.2. Growing structure

The experiment was conducted in a protected structure of dimension of 20 m × 5 m (length × breadth) cladded with 200-micron UV stabilized film and sides were covered with 50 per cent shade net.

3.3.3. Container

The plants were raised in 8-inch sized plastic pots

3.3.4. Growing media

Pots were filled with various proportions of potting media components *viz.*, cocopeat, coco chips, vermicompost, perlite, vermiculite and neem cake on volume-by-volume basis (v/v) as per treatments.

The media combinations are:

M_1 : cocopeat (50%) + vermicompost (30%) + perlite (10%) + vermiculite (10%)

M_2 : cocopeat (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%)

M_3 : coco chips (50%) + vermicompost (30%) + Perlite (10%) + vermiculite (10%)

M_4 : coco chips (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%)

M_5 : cocopeat (60%) + vermicompost (20%) + perlite (20%)

3.3.5. Foliar nutrients

Two different foliar applied nutrient formulations *viz*., NPK-19:19:19 at 2 g/L (N_1) and seaweed extract (IFFCO – Sagarika) at 10 ml/L (N_2) were applied as foliar sprays at fortnightly intervals.

3.4. TREATMENTS AND DESIGN OF EXPERIMENT

Design of experiment: CRD (factorial)

No. of treatments: 10 (5×2)

No. of replications: 3

No. of plants per replication: 5

3.4.1. Treatments

The treatments consist of five growing media and two foliar nutrients with 10 different treatment combinations and they are:

T_1: M_1 x N_1	T_6: M_1 x N_2
T_2: M_2 x N_1	T_7: M_2 x N_2
T_3: M_3 x N_1	T_8: M_3 x N_2
T_4: M_4 x N_1	T_9: M_4 x N_2
T_5: M_5 x N_1	T_{10}: M_5 x N_2

T_1	M_1 x N_1	cocopeat (50%) + vermicompost (30%) + perlite (10%) +vermiculite (10%) and NPK-19:19:19 at 2 g/L
T_2	M_2 x N_1	cocopeat (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%) and NPK-19:19:19 at 2 g/L
T_3	M_3 x N_1	coco chips (50%) + vermicompost (30%) + perlite (10%) + vermiculite (10%) and NPK-19:19:19 at 2 g/L
T_4	M_4 x N_1	coco chips (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%) and NPK-19:19:19 at 2 g/L
T_5	M_5 x N_1	cocopeat (60%) + vermicompost (20%) + perlite (20%) and NPK-19:19:19 at 2 g/L
T_6	M_1 x N_2	cocopeat (50%) + vermicompost (30%) + perlite (10%) + vermiculite (10%) and seaweed extract at 10 ml/L
T_7	M_2 x N_2	cocopeat (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%) and seaweed extract at 10 ml/L
T_8	M_3 x N_2	coco chips (50%) + vermicompost (30%) + perlite (10%) + vermiculite (10%) and seaweed extract at 10 ml/L
T_9	M_4 x N_2	coco chips (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%) and seaweed extract at 10 ml/L
T_{10}	M_5 x N_2	cocopeat (60%) + vermicompost (20%) + perlite (20%) and seaweed extract at 10 ml/L

3.5 MANAGEMENT PRACTICES

Uniform management practices were followed for all treatments throughout the study. Irrigation was applied on alternate days at the rate of 0.5 litre (Dec-Feb) and 1 litre (Mar-May) per pot. Proper plant protection measures were done as and when needed.

3.6. OBSERVATIONS

Three best plants per replication of each treatment were selected for recording observations and observations are as follows:

3.6.1. Vegetative parameters

I. Observations recorded at monthly intervals.

a. Plant height (cm)

The plant height was measured from the base to the growing tip of the uppermost leaf and expressed in centimetres.

b. Plant spread (cm)

The plant spread in the North-South and East-West directions were measured and the average was expressed in centimetres.

c. Number of leaves

The total number of leaves on each plant was counted and recorded.

d. Leaf length (cm)

The length of three recently developed and fully matured leaves was measured from the base of the leaf to the tip, and the average was taken and expressed in centimetres.

e. Leaf width (cm)

The width of three recently developed and fully matured leaves was measured and the average was taken and expressed in centimetres.

f. Petiole length (cm)

The length of the petiole of three recently developed and fully matured leaves was measured and the average was taken and expressed in centimetres.

g. Leaf longevity (days)

The duration that a leaf remained physiologically active in the plant after fully unfolding was noted and expressed in days.

h. Leaf production interval (days)

The time interval between subsequent leaf production was observed and recorded in days.

i. Number of suckers / plant

The number of suckers per plant that emerged during the period of study was noted.

j. Leaf area (cm^2)

The leaf area of the plant was calculated using the formula 0.53 × length × breadth of the leaf where 0.53 is a constant (where constant is calculated using regression method).

k. Days taken for emergence of first sucker

During the period of experiment, days taken for emergence of first sucker were noted.

II. Observations recorded at 6 MAP.

l. Shoot girth (cm)

The diameter of the shoot was measured and expressed in centimetres.

m. Shoot length (cm)

Length from the plant base to the first whorl of leaves was measured and recorded in centimetres.

n. Fresh and dry weights of the leaves / plant (g)

The fresh and dry weights of the leaves per plant were measured and expressed in grams.

3.6.2. Root parameters

Observations on root parameters were recorded after uprooting the plants at the end of the study (6 MAP).

a. Fresh weight of the roots (g)

The fresh weight of the washed and cleaned roots was measured and expressed in grams.

b. Root length (cm)

The longest root length was measured and expressed in centimetres.

c. Number of lateral roots

The total number of lateral roots per plant was counted and recorded.

d. Dry weight of the roots (g)

The weight of the roots was measured after they were dried in the oven at 40 ^{0}C to 60 ^{0}C and expressed in grams.

e. Root volume (cm^3)

The water displacement method was used to calculate root volume. The root volume is the amount of water displaced by the root and expressed in cm^3.

3.6.3. Media analysis

3.6.3.1. Physical properties

Before the experiment, the physical properties of the growing media were estimated.

a. Bulk density (g/cm^3)

Bulk density (ρb) is a measure of the oven-dry mass per unit volume of bulk media which was assessed by the Keen-Raczkowski box method (Piper, 1942).

b. Porosity (%)

Porosity is the percentage of pore space or voids in the media and it was measured by using the formula (Piper, 1942).

$$\text{Porosity} = 1 - \frac{(\text{Bulk density})}{(\text{Particle density})} \times 100$$

c. Water holding capacity (%)

The maximum amount of water that media can hold under normal conditions is referred to as water holding capacity and it was measured using the Keen-Raczkowski box method (Piper, 1942).

3.6.3.2. Chemical properties

The chemical properties of the growing media were estimated before and after the experiment.

a. pH

pH of a media solution is a measure of the relative concentration of hydroxide ion (OH^-) and hydrogen ion (H^+) and it was measured using pH meter (Jackson, 1973).

b. EC (dS/m)

Electrical conductivity is used to determine the total dissolved salts (free ions) in the media solutions. The electrical conductivity of dissolved ions, which conducts the electrical current through the water, is used to detect soluble salts (Jackson, 1973).

c. Available N, P and K (%)

Available N, P, and K content of growing media were estimated using the following methods.

Table 1. Methods followed for nutrient analysis of growing media

Sl. No.	Parameters	Procedure	Reference
1	Nitrogen	Alkaline permanganate method	Subbiah and Asija, 1956
2	Phosphorous	Bray No.1 method using spectrophotometer	Bray and Kurtz, 1945
3	Potassium	Neutral normal ammonium acetate extract using flame photometer	Jackson, 1973

3.6.4. Other observations

a. Plant nutrient content

At the end of the experimental period, the nutrient content of the plants was analyzed. To determine this parameter, leaf samples from each treatment were dried in shade for a few days and then in an electric hot air oven at 40 ^{0}C to 60 ^{0}C. After drying, samples were crushed into a fine powder and sieved. The appropriate amount of dried samples were weighed and analyzed, by the following methods.

Table 2. Methods followed for plant nutrient analysis.

Sl. No.	Parameters	Procedure	Reference
1	Nitrogen	Kjeldahl method	Jackson, 1973
2	Phosphorous	Vanadomolybdate method using spectrophotometer	
3	Potassium	Flame photometer method	

b. Plant nutrient uptake

Nutrient uptake by plants in each treatment was measured using the following formula and expressed as gram per plant.

Nutrient uptake (g/plant) =

$$\frac{(\%\text{ of nutrient content in plant sample} \times \text{Dry matter production})}{100}$$

c. Total chlorophyll content

The concentration of chlorophyll in leaves is an essential characteristic that is often studied as an indicator of chloroplast content, photosynthetic mechanism, and plant metabolism (Kamble *et al.* 2015). Chlorophyll content was measured using a spectrophotometer and absorbance was measured at 646.6 nm and 663.6 nm using distilled water as blank (Porra, 2002).

$$\text{Total chlorophyll content (mg/g)} = \frac{17.76\ (A_{646.6}) + 7.34\ (A_{663.6}) \times 10\text{ ml acetone}}{100\text{ mg leaf tissue}}$$

d. Pest and disease incidence

The presence of pests and diseases was observed during the experimental period.

e. Physiological abnormalities

Changes in the physical appearance of plants were observed.

f. Micronutrient deficiencies

Plants were observed for deficiency of micronutrients during the study period.

g. Cost of growing media

The cost of growing media was estimated by multiplying the quantity of each component per pot by the unit cost.

3.7. STATISTICAL ANALYSIS

The data were statistically analyzed using OP-STAT (HAU, Hisar).

Plate 1. Materials used for the experiment

Philodendron xanadu	**One-year-old suckers**

Cocopeat

Coco chips

Vermicompost

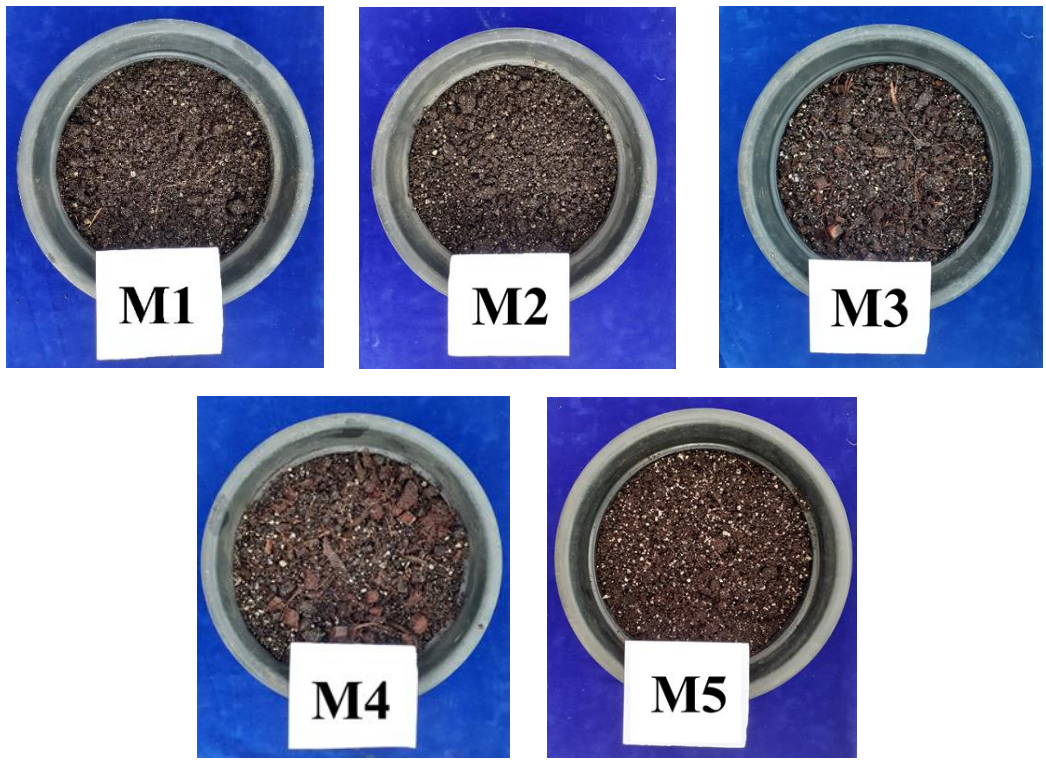
Neem cake

Perlite

Vermiculite

Components used for the preparation of growing media

Plate 2. Materials used for the experiment



Different types of growing media used in the experiment

NPK-19:19:19

Seaweed extract (IFFCO – Sagarika)

Foliar nutrients

Plate 3. General overview of the field

RESULTS

4. RESULTS

The study entitled "Standardization of soilless medium and foliar nutrients for potted ornamental foliage plants" was conducted at the Department of Floriculture and Landscape Architecture, College of Agriculture, Vellanikkara during 2020-21. The results of the study are presented in this chapter.

4.1. VEGETATIVE PARAMETERS

These parameters were observed at monthly intervals and the values are given in Appendix – 1 to 14. The results for parameters *viz.*, plant height, plant spread, number of leaves, leaf length, leaf width, petiole length, leaf area, leaf longevity, leaf production interval, shoot girth, shoot length, fresh and dry weights of the leaves are interpreted based on the observations at six months after planting which is usually the minimum period required for sufficient growth of the plant (Table 3, 4, 5 and 6).

a. Plant height (cm)

Significant variation due to treatments on plant height was observed during the study. With regard to influence of growing media on plant height, treatments M_4 [coco chips (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%)], M_2 [cocopeat (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%)] and M_1 [cocopeat (50%) + vermicompost (30%) + perlite (10%) + vermiculite (10%)] were on par and statistically superior (37.72 cm, 37.67 cm and 36.16 cm respectively). Lowest plant height (29.22 cm) was observed in M_5 [cocopeat (60%) + vermicompost (20%) + perlite (20%)].

Regarding the influence of foliar nutrients on plant height, greatest plant height (35.27 cm) was observed under N_1 (NPK-19:19:19 at 2 g/L) whereas plant height was lowest (33.47 cm) under N_2 (seaweed extract at 10 ml/L).

M x N interaction had significant influence on plant height. The treatment combinations of T_4 - M_4 x N_1 [coco chips (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%) and NPK-19:19:19 at 2 g/L], T_2 - M_2 x N_1

[cocopeat (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%) and NPK-19:19:19 at 2 g/L] and T_1 - M_1 x N_1 [cocopeat (50%) + vermicompost (30%) + perlite (10%) + vermiculite (10%) and NPK-19:19:19 at 2 g/L] were on par and recorded greatest plant height (39.78 cm, 38.78 cm and 37.33 cm respectively) whereas lowest plant height (27.89 cm) was observed under T_5 - M_5 x N_1 [cocopeat (60%) + vermicompost (20%) + perlite (20%) and NPK-19:19:19 at 2 g/L] (Plate 4).

b. Plant spread

Plant spread was found to be significantly influenced by growing media. Greatest plant spread was observed under the growing media M_4 [coco chips (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%)] and M_2 [cocopeat (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%)] which recorded plant spread of 118.11 cm and 116.28 cm respectively. Plant spread was lowest (105.16 cm) in the medium containing cocopeat (60%) + vermicompost (20%) + perlite (20%) [M_5].

Effect of foliar nutrients and M x N interaction were not significant with respect to plant spread during the study period.

c. Number of leaves

Number of leaves varied significantly among the growing media during the study period. Greatest number of leaves 34.11 and 34.05 were observed under M_2 [cocopeat (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%)] and M_4 [coco chips (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%)] respectively, whereas M_5 [cocopeat (60%) + vermicompost (20%) + perlite (20%)] was found to produce the lowest number of leaves (21.89).

No significant influence of foliar nutrients on number of leaves could be observed during the period of observation.

With regard to M × N interaction, treatment combinations of T_2 - M_2 x N_1 [cocopeat (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%) and NPK-19:19:19 at 2 g/L], T_4 - M_4 x N_1 [coco chips (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%) and NPK-19:19:19 at 2 g/L], T_9 - M_4 x N_2 [coco chips (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%) and seaweed extract at 10 ml/L] and T_1 - M_1 x N_1 [cocopeat (50%) + vermicompost (30%) + perlite (10%) + vermiculite (10%) and NPK-19:19:19 at 2 g/L] were on par and statistically superior (36.44, 35.00, 33.11 and 32.67 respectively) and lowest number of leaves (18.22) was observed under T_5 - M_5 x N_1 [cocopeat (60%) + vermicompost (20%) + perlite (20%) and NPK-19:19:19 at 2 g/L] (Plate 4).

d. Leaf Length

There was significant variation in leaf length due to growing media. M_2 [cocopeat (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%)] and M_4 [coco chips (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%)] were on par and statistically superior with respect to this parameter (12.64 cm and 11.93 cm respectively). Lowest leaf length (10.75 cm) was recorded under M_5 [cocopeat (60%) + vermicompost (20%) + perlite (20%)].

Foliar nutrients and M x N interaction had no significant influence on leaf length during the study period (Plate 5).

e. Leaf width

Significant variation on leaf width due to growing media was observed during the period of experiment. M_2 [cocopeat (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%)] and M_4 [coco chips (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%)] were on par and recorded maximum leaf width during the period of observation (5.81 cm and 5.59 cm respectively) whereas lowest leaf width (4.76 cm) was observed under growing media containing cocopeat (60%) + vermicompost (20%) + perlite (20%) [M_5].

Leaf width was not significantly influenced by foliar nutrients as well as M x N interaction (Plate 5).

f. Petiole length

Growing media had significant influence on petiole length. M_4 [coco chips (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%)], M_2 [cocopeat (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%)], M_3 [coco chips (50%) + vermicompost (30%) + perlite (10%) + vermiculite (10%)] and M_1 [cocopeat (50%) + vermicompost (30%) + perlite (10%) + vermiculite (10%)] were on par and statistically superior with respect to this parameter (19.54 cm, 19.20 cm, 18.67 cm and 18.63 cm respectively). Lowest petiole length of 17.64 cm was observed under M_5 [cocopeat (60%) + vermicompost (20%) + perlite (20%)]

There was no significant influence of foliar nutrients as well as M x N interaction on petiole length during the study.

g. Leaf longevity (days)

The growing media had a significant influence on leaf longevity. M_2 [cocopeat (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%)] and M_4 [coco chips (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%)] had the longest leaf longevity (169.8 days), whereas M_5 [cocopeat (60%) + vermicompost (20%) + perlite (20%)] had the least leaf longevity during the period of study (159 days).

Foliar nutrients as well as M x N interaction had no significant influence on leaf longevity during the period of study.

h. Leaf production interval (days)

The results revealed that growing media had significant influence on leaf production interval. Shortest interval for the production of successive leaves was observed in M_4 [coco chips (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%)] (7.16 days) and M_2 [cocopeat (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%)] (7.35 days) whereas leaf production interval (11.72 days) was long in M_5 [cocopeat (60%) + vermicompost (20%) + perlite (20%)].

Foliar nutrients N_1 (NPK-19:19:19 at 2 g/L) and N_2 (seaweed extract at 10 ml/L) had no significant impact on the leaf production interval.

M x N interaction had significant effect on leaf production interval. Shortest leaf production interval was observed in treatment combination of T_2- M_2 x N_1 [cocopeat (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%) and NPK-19:19:19 at 2 g/L] with 6.98 days. Longest leaf production interval was recorded in T_5 - M_5 x N_1 [cocopeat (60%) + vermicompost (20%) + perlite (20%) and NPK-19:19:19 at 2 g/L] with 12.45 days (Plate 6).

i. Number of suckers/plant

Philodendron xanadu is a shy suckering species. Hence there was no production of suckers during the study period.

j. Leaf area (cm^2)

Significant difference among growing media with regard to leaf area could be observed during the study period and greatest leaf area of 1130.16 cm^2 and 1206.11 cm^2 were recorded in M_2 [cocopeat (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%)] and M_4 [coco chips (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%)]. Lowest leaf area (597.74 cm^2) was observed in M_5 [cocopeat (60%) + vermicompost (20%) + perlite (20%)].

Foliar nutrients had no significant effect on leaf area during the study period.

With regard to M x N interaction effect on leaf area, more leaf area (1457.49 cm^2) was observed under treatment combination of T_2- M_2 x N_1 [cocopeat (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%) and NPK-19:19:19 at 2 g/L] and leaf area was lowest (477.45 cm^2) under T_5 - M_5 x N_1 [cocopeat (60%) + vermicompost (20%) + perlite (20%) and NPK-19:19:19 at 2 g/L] (Plate 5).

k. Days taken for emergence of first sucker

This parameter could not be noted as there was no production of suckers during the study period.

l. Shoot girth (cm)

Growing media had significant influence on shoot girth. M_4 [coco chips (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%)] and M_2 [cocopeat (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%)] were on par and statistically superior having a shoot girth of 3.27 cm and 3.15 cm respectively and lowest shoot girth (2.70cm) was observed under M_5 [cocopeat (60%) + vermicompost (20%) + perlite (20%)].

There was no significant influence of foliar nutrients and M x N interaction on this parameter during the study period.

m. Shoot length (cm)

Growing media had a significant effect on the shoot length throughout the study period. M_4 [coco chips (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%)], M_2 [cocopeat (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%)] and M_1 [cocopeat (50%) + vermicompost (30%) + perlite (10%) + vermiculite (10%)] were on par and recorded highest shoot length (7.52 cm, 7.25 cm and 7.12 cm respectively). The shortest length of shoot (6.39 cm) was observed under growing medium containing cocopeat (60%) + vermicompost (20%) + perlite (20%) [M_5].

There was no significant influence of foliar nutrients on shoot length during the period of observation.

The M x N interaction had significant effect on shoot length. Treatment combinations of T_4 - M_4 x N_1 [coco chips (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%) and NPK-19:19:19 at 2 g/L] and T_7 - M_2 x N_2 [cocopeat (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%) and seaweed extract at 10 ml/L] were on par and statistically superior having shoot lengths of 7.97 cm and 7.45 cm respectively whereas T_5 - M_5 x N_1 [cocopeat (60%) + vermicompost (20%) + perlite (20%) and NPK-19:19:19 at 2 g/L] recorded the lowest shoot length (6.10 cm).

n. The fresh weight of the leaves / plant (g)

The growing media had significant impact on the fresh weight of the leaves. M_4 [coco chips (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%)] was found to have the highest fresh weight of leaves (152.42 g) while M_5 [cocopeat (60%) + vermicompost (20%) + perlite (20%)] recorded the lowest value with respect to this parameter (88.50 g).

Foliar nutrients and M x N interaction were found to have no significant effect on the fresh weight of the leaves during the observation period.

o. The dry weight of the leaves / plant (g)

The growing media influenced the dry weight of the leaves significantly. M_4 [coco chips (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%)] and M_2 [cocopeat (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%)] were on par and recorded highest dry weight of the leaves (37.89 g and 32.09 g respectively), whereas M_5 [cocopeat (60%) + vermicompost (20%) + perlite (20%)] (24.24 g) had the lowest dry weight of the leaves.

It was noticed that foliar nutrients and M x N interaction had no significant impact on the dry weight of the leaves during the observation period.

4.2. ROOT PARAMETERS

a. Fresh weight of the roots (g)

With regard to fresh weight of the roots, the growing media and foliar nutrients had no significant influence during the study period (Table 7).

It was found that the M x N interaction had a significant impact on the fresh weight of the roots. The treatment combinations of T_8 – M_3 x N_2 [coco chips (50%) + vermicompost (30%) + perlite (10%) + vermiculite (10%) and seaweed extract at 10 ml/L], T_9 - M_4 x N_2 [coco chips (50%) + vermicompost (20%) + neem cake (10%) +

perlite (10%) + vermiculite (10%) and seaweed extract at 10 ml/L], T_2- M_2 x N_1 [cocopeat (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%) and NPK-19:19:19 at 2 g/L], T_4 - M_4 x N_1 [coco chips (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%) and NPK-19:19:19 at 2 g/L] and T_{10}- M_5 x N_2 [cocopeat (60%) + vermicompost (20%) + perlite (20%) and seaweed extract at 10 ml/L] were on par and recorded highest fresh weight of roots (75.50 g, 67.83 g, 60.00 g, 58.17 g and 57.00 g respectively). Lowest fresh weight of the roots (40.00 g) was noticed under the treatment combination of T_7 - M_2 x N_2 [cocopeat (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%) and seaweed extract at 10 ml/L] (Table 8).

b. Dry weight of the roots (g)

The dry weight of the roots was not influenced by the growing media and foliar nutrients (Table 7).

With regard to the effect of M x N interaction on dry weight of roots, all the treatment combinations except T_1- M_1 x N_1 [cocopeat (50%) + vermicompost (30%) + perlite (10%) + vermiculite (10%) and NPK-19:19:19 at 2 g/L], T_3- M_3 x N_1 [coco chips (50%) + vermicompost (30%) + perlite (10%) + vermiculite (10%) and NPK-19:19:19 at 2 g/L] and T_7 - M_2 x N_2 [cocopeat (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%) and seaweed extract at 10 ml/L] were on par and recorded highest dry weight of roots and lowest dry weight (4.53 g) was recorded under T_7 - M_2 x N_2 (Table 8).

c. Root length (cm)

From the results it could be observed that growing media had significant influence on length of roots. Plants with longest roots were observed under M_2 [cocopeat (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%)], M_5 [cocopeat (60%) + vermicompost (20%) + perlite (20%)] and M_4 [coco chips (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%)] (62.75 cm, 59.33 cm and 55.67 cm respectively). Shortest root length (45.75 cm) was noticed under M_1 [cocopeat (50%) + vermicompost (30%) + perlite (10%) + vermiculite (10%)] (Table 7).

Significant influence of foliar nutrients on root length was observed during the experiment. Longest root (57.77 cm) was noticed with the application of N_2 (seaweed extract at 10 ml/L) whereas shortest root length (50.17 cm) was observed with the application of N_1 (NPK-19:19:19 at 2 g/L) (Table 7).

It was evident that M x N interaction had significant effect on root length. Longest roots were observed under treatment combinations of T_{10}- M_5 x N_2 [cocopeat (60%) + vermicompost (20%) + perlite (20%) and seaweed extract at 10 ml/L], T_2- M_2 x N_1 [cocopeat (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%) and NPK-19:19:19 at 2 g/L] and T_9 - M_4 x N_2 [coco chips (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%) and seaweed extract at 10 ml/L] (72.83cm, 70.00 cm and 64.33 cm respectively). Root length was shortest (43.50 cm) under treatment combination of T_1- M_1 x N_1 [cocopeat (50%) + vermicompost (30%) + perlite (10%) + vermiculite (10%) and NPK-19:19:19 at 2 g/L] (Table 8 and Plate 7).

d. Number of lateral roots

Growing media had significant impact on number of lateral roots. M_4 [coco chips (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%)] and M_2 [cocopeat (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%)] were found to have highest number of lateral roots (69.17 and 64.75 respectively) and lowest number of lateral roots (51.83) was observed in M_5 [cocopeat (60%) + vermicompost (20%) + perlite (20%)] (Table 7).

Foliar nutrients as well as M x N interaction was found to have no significant influence on number of lateral roots during the period of observation (Table 7 and Table 8).

e. Root volume (cm^3)

Growing media had significant influence on root volume during the study period. Greatest root volume was observed under M_4 [coco chips (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%)] and M_1 [cocopeat (50%) + vermicompost (30%) + perlite (10%) + vermiculite (10%)]

(187.50 cm^3 and 173.33 cm^3 respectively) whereas lowest root volume (160.41 cm^3) was noticed under M_2 [cocopeat (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%)] (Table 7).

There was no significant variation on root volume due to foliar nutrients as well as M x N interaction (Table 7 and Table 8).

Table 3. Effect of growing media and foliar nutrients on vegetative parameters of *Philodendron xanadu* (6 MAP)

Treatments		Plant height (cm)	Plant spread (cm)	No of leaves	Leaf length (cm)	Leaf width (cm)	Petiole length (cm)	Leaf area (cm^2)	leaf longevity (days)	Leaf production interval (days)
GROWING MEDIA	M_1	36.16	110.615	30.22	11.60	5.29	18.63	981.98	163.8	8.06
	M_2	37.67	116.28	34.11	12.64	5.81	19.21	1330.16	169.8	7.35
	M_3	31.06	107.72	26.72	11.27	5.08	18.67	810.40	161.4	8.22
	M_4	37.72	118.11	34.05	11.93	5.59	19.55	1206.11	169.8	7.16
	M_5	29.22	105.16	21.89	10.75	4.76	17.64	597.74	159	11.72
CD (0.05)		2.19	6.62	2.91	0.73	0.50	1.14	145.43	4.44	0.65
SE(m)		0.74	2.23	0.98	0.25	0.17	0.38	48.95	1.49	0.22
FOLIAR NUTRIENTS	N_1	35.27	112.04	29.64	11.63	5.28	18.73	996.65	165.36	8.53
	N_2	33.47	111.11	29.16	11.65	5.34	18.74	973.91	164.16	8.48
CD (0.05)		1.39	NS	NS	NS	NS	NS	NS	NS	NS
SE(m)		0.47	1.41	0.62	0.16	0.11	0.24	30.96	0.94	0.14

Growing media	M_1: cocopeat (50%) + vermicompost (30%) + perlite (10%) + vermiculite (10%) M_2: cocopeat (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%) M_3: coco chips (50%) + vermicompost (30%) + perlite (10%) + vermiculite (10%) M_4: coco chips (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%) M_5: cocopeat (60%) + vermicompost (20%) + perlite (20%)
Foliar nutrients	N_1: NPK-19:19:19 at 2 g/L N_2: sea weed extract at 10 ml/L

Table 4. Effect of M x N interaction on vegetative parameters of *Philodendron xanadu* (6 MAP)

Treatments		Plant height (cm)	Plant spread (cm)	No of leaves	Leaf length (cm)	Leaf width (cm)	Petiole length (cm)	Leaf area (cm^2)	leaf longevity (days)	Leaf production interval (days)
T_1	**M_1 x N_1**	37.33	111.67	32.67	11.57	5.26	18.62	1049.49	163.20	7.63
T_2	**M_2 x N_1**	38.78	117.78	36.44	12.86	5.87	19.36	1457.49	172.80	6.98
T_3	**M_3 x N_1**	32.56	108.44	25.89	11.28	5.04	18.61	776.48	160.80	8.40
T_4	**M_4 x N_1**	39.78	120.44	35.00	11.86	5.56	19.70	1222.35	171.60	7.16
T_5	**M_5 x N_1**	27.89	101.89	18.22	10.59	4.67	17.38	477.45	158.40	12.45
T_6	**M_1 x N_2**	35.00	109.56	27.78	11.64	5.33	18.65	914.48	164.40	8.49
T_7	**M_2 x N_2**	36.56	114.78	31.78	12.43	5.75	19.04	1202.83	166.80	7.71
T_8	**M_3 x N_2**	29.56	107.00	27.56	11.26	5.13	18.74	844.32	162.00	8.03
T_9	**M_4 x N_2**	35.67	115.78	33.11	12.01	5.63	19.39	1189.88	168.00	7.16
T_{10}	**M_5 x N_2**	30.56	108.44	25.56	10.92	4.85	17.89	718.03	159.60	10.99
CD (0.05)		3.10	NS	4.12	NS	NS	NS	205.67	NS	0.92
SE(m)		1.04	3.15	1.39	0.35	0.24	0.55	69.23	2.11	0.31

Growing media	M_1: cocopeat (50%) + vermicompost (30%) + perlite (10%) + vermiculite (10%) M_2: cocopeat (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%) M_3: coco chips (50%) + vermicompost (30%) + perlite (10%) + vermiculite (10%) M_4: coco chips (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%) M_5: cocopeat (60%) + vermicompost (20%) + perlite (20%)
Foliar nutrients	N_1: NPK-19:19:19 at 2 g/L N_2: sea weed extract at 10 ml/L

Table 5. Effect of growing media and foliar nutrients on shoot girth, shoot length, fresh and dry weight of leaves of *Philodendron xanadu*

Treatments		Shoot girth (cm)	Shoot length (cm)	Fresh weight of leaves/plant (g)	Dry weight of leaves/plant (g)
GROWING MEDIA	**M_1**	3.01	7.12	106.08	28.96
	M_2	3.15	7.25	125.83	32.09
	M_3	2.96	6.98	102.17	26.12
	M_4	3.27	7.52	152.42	37.89
	M_5	2.70	6.39	88.50	24.24
CD (0.05)		0.21	0.41	15.60	7.37
SE(m)		0.07	0.14	5.25	2.48
FOLIAR NUTRIENTS	**N_1**	2.99	6.97	117.67	30.09
	N_2	3.04	7.14	112.33	29.64
CD (0.05)		NS	NS	NS	NS
SE(m)		0.05	0.09	3.32	1.57

Growing media	M_1: cocopeat (50%) + vermicompost (30%) + perlite (10%) + vermiculite (10%) M_2: cocopeat (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%) M_3: coco chips (50%) + vermicompost (30%) + perlite (10%) + vermiculite (10%) M_4: coco chips (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%) M_5: cocopeat (60%) + vermicompost (20%) + perlite (20%)
Foliar nutrients	N_1: NPK-19:19:19 at 2 g/L N_2: sea weed extract at 10 ml/L

Table 6. Effect of M x N interaction on shoot girth, shoot length, fresh and dry weight of leaves of *Philodendron xanadu*

Treatments		Shoot girth (cm)	Shoot length (cm)	Fresh weight of leaves/plant (g)	Dry weight of leaves/plant (g)
T_1	M_1 x N_1	3.00	7.00	111.50	29.04
T_2	M_2 x N_1	3.10	7.05	133.00	33.39
T_3	M_3 x N_1	2.97	6.73	105.17	25.65
T_4	M_4 x N_1	3.28	7.97	155.17	38.91
T_5	M_5 x N_1	2.60	6.10	83.50	23.43
T_6	M_1 x N_2	3.02	7.25	100.67	28.89
T_7	M_2 x N_2	3.20	7.45	118.67	30.80
T_8	M_3 x N_2	2.95	7.23	99.17	26.59
T_9	M_4 x N_2	3.25	7.07	149.67	36.87
T_{10}	M_5 x N_2	2.80	6.68	93.50	25.06
CD (0.05)		NS	0.58	NS	NS
SE(m)		0.10	0.19	7.43	3.51

Growing media	M_1: cocopeat (50%) + vermicompost (30%) + perlite (10%) + vermiculite (10%) M_2: cocopeat (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%) M_3: coco chips (50%) + vermicompost (30%) + perlite (10%) + vermiculite (10%) M_4: coco chips (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%) M_5: cocopeat (60%) + vermicompost (20%) + perlite (20%)
Foliar nutrients	N_1: NPK-19:19:19 at 2 g/L N_2: sea weed extract at 10 ml/L

Table 7. Effect of growing media and foliar nutrients on root parameters of *Philodendron xanadu*

Treatments		Fresh weight of the roots (g)	Dry weight of the roots (g)	Root length (cm)	No of lateral roots	Root volume (cm^3)
GROWING MEDIA	M_1	49.41	5.21	45.75	53.75	173.33
	M_2	50.00	6.60	62.75	64.75	160.41
	M_3	60.91	6.76	46.33	55.42	163.75
	M_4	63.00	6.84	55.67	69.17	187.50
	M_5	54.08	5.85	59.33	51.83	162.50
CD (0.05)		NS	NS	9.62	8.21	15.09
SE(m)		4.43	0.76	3.24	2.76	5.08
FOLIAR NUTRIENTS	N_1	51.73	6.07	50.17	59.17	165.00
	N_2	59.23	6.44	57.77	58.80	174.00
CD (0.05)		NS	NS	6.08	NS	NS
SE(m)		2.80	0.48	2.05	1.75	3.21

Growing media	M_1: cocopeat (50%) + vermicompost (30%) + perlite (10%) + vermiculite (10%) M_2: cocopeat (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%) M_3: coco chips (50%) + vermicompost (30%) + perlite (10%) + vermiculite (10%) M_4: coco chips (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%) M_5: cocopeat (60%) + vermicompost (20%) + perlite (20%)
Foliar nutrients	N_1: NPK-19:19:19 at 2 g/L N_2: sea weed extract at 10 ml/L

Table 8. Effect of M x N interaction on root parameters of *Philodendron xanadu*

Treatments		Fresh weight of the roots (g)	Dry weight of the roots (g)	Root length (cm)	No of lateral roots	Root volume (cm^3)
T_1	**M_1 x N_1**	43.00	4.56	43.50	49.83	165.83
T_2	**M_2 x N_1**	60.00	8.68	70.00	70.83	168.33
T_3	**M_3 x N_1**	46.33	5.11	44.50	57.00	160.00
T_4	**M_4 x N_1**	58.17	6.45	47.00	67.17	172.50
T_5	**M_5 x N_1**	51.17	5.54	45.83	51.00	158.33
T_6	**M_1 x N_2**	55.83	5.86	48.00	57.67	180.83
T_7	**M_2 x N_2**	40.00	4.53	55.50	58.67	152.50
T_8	**M_3 x N_2**	75.50	8.41	48.17	53.83	167.50
T_9	**M_4 x N_2**	67.83	7.23	64.33	71.17	202.50
T_{10}	**M_5 x N_2**	57.00	6.17	72.83	52.67	166.67
CD (0.05)		18.59	3.20	13.59	NS	NS
SE(m)		6.26	1.08	4.58	3.91	7.18

Growing media	M_1: cocopeat (50%) + vermicompost (30%) + perlite (10%) + vermiculite (10%) M_2: cocopeat (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%) M_3: coco chips (50%) + vermicompost (30%) + perlite (10%) + vermiculite (10%) M_4: coco chips (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%) M_5: cocopeat (60%) + vermicompost (20%) + perlite (20%)
Foliar nutrients	N_1: NPK-19:19:19 at 2 g/L N_2: sea weed extract at 10 ml/L

4.3. MEDIA ANALYSIS

4.3.1. Physical properties

Data on the physical properties of media is furnished in Table 9.

a. Bulk density (g/cm^3)

In this experiment, the lowest bulk density (0.12 g/cm^3) was observed in M_4 [coco chips (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%)], whereas the highest bulk density (0.19 g/cm^3) was observed in M_1 [cocopeat (50%) + vermicompost (30%) + perlite (10%) + vermiculite (10%)].

b. Porosity (%)

M_4 [coco chips (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%)] had the highest porosity (92%), whereas M_5 [cocopeat (60%) + vermicompost (20%) + perlite (20%)] was found to have lowest porosity (89%).

c. Water holding capacity (%)

M_5 [cocopeat (60%) + vermicompost (20%) + perlite (20%)] was found to have the highest water holding capacity (311%), whereas M_1 [cocopeat (50%) + vermicompost (30%) + perlite (10%) + vermiculite (10%)] had the lowest water holding capacity (222%).

Table 9. Physical properties of growing media

Growing media	Bulk density (g/cm^3)	Porosity (%)	Water holding capacity (%)
M_1	0.19	91	222
M_2	0.17	89	271
M_3	0.13	91	238
M_4	0.12	92	251
M_5	0.16	88	311

M_1: cocopeat (50%) + vermicompost (30%) + perlite (10%) + vermiculite (10%)

M_2: cocopeat (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%)

M_3: coco chips (50%) + vermicompost (30%) + perlite (10%) + vermiculite (10%)

M_4: coco chips (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%)

M_5: cocopeat (60%) + vermicompost (20%) + perlite (20%)

4.3.2. Chemical properties

Data on the chemical properties of media before and after the experiment is furnished in Table 10.

a. pH

Highest pH was observed in M_4 [coco chips (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%)] before and after the experiment (7.15 and 7.22 respectively). Lowest pH was observed in M_1[cocopeat (50%) + vermicompost (30%) + perlite (10%) + vermiculite (10%)] before and after the experiment (6.75 and 6.86 respectively). In all media, there was a slight increase in the pH at the end of observation period.

b. EC (dS/m)

Media differed substantially with respect to EC before and after the experiment. M_4 [coco chips (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%)] was observed to have the highest EC before and after the experiment (0.88 dS/m and 0.71 dS/m respectively). EC was lowest under M_5 [cocopeat (60%) + vermicompost (20%) + perlite (20%)] before and after the experiment (0.79 dS/m and 0.52 dS/m respectively). In all growing media, EC was in a favourable range before and after the experiment. In general, a reduction in EC was observed in all media after the experiment.

c. Available N, P, and K (%)

I. Available N (%)

Before the experiment highest available nitrogen content (0.34%) was noticed in M_2 [cocopeat (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%)]. Highest available nitrogen content was noticed in M_1 [cocopeat (50%) + vermicompost (30%) + perlite (10%) + vermiculite (10%)] and M_3 [coco chips (50%) + vermicompost (30%) + perlite (10%) + vermiculite (10%)] (0.32%) after the experiment. Lowest available nitrogen content was observed in M_5 [cocopeat (60%) +

vermicompost (20%) + perlite (20%)] before the experiment whereas after the in M_4 [coco chips (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%)] (0.26% and 0.17% respectively).

II. Available P (%)

M_4 [coco chips (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%)] had the greatest available phosphorous content both before and after the experiment (0.037% and 0.039% respectively). M_5 [cocopeat (60%) + vermicompost (20%) + perlite (20%)] recorded the lowest available phosphorous content both before and after the experiment (0.033% and 0.035% respectively).

III. Available K (%)

Growing medium M_4 [coco chips (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%)] had the highest available potassium content before the experiment and M_3 [coco chips (50%) + vermicompost (30%) + perlite (10%) + vermiculite (10%)] had the highest available potassium content after the experiment (0.34% and 0.16% respectively). Lowest available potassium content was noticed in M_3 [coco chips (50%) + vermicompost (30%) + perlite (10%) + vermiculite (10%)] before the experiment whereas after the experiment, lowest available potassium content was noticed in M_1 [cocopeat (50%) + vermicompost (30%) + perlite (10%) + vermiculite (10%)] (0.22% and 0.07% respectively).

Table 10. Chemical properties of growing media

Growing media	pH		EC (dS/m)	
	Before	After	Before	After
M_1	6.75	6.86	0.84	0.58
M_2	6.82	6.91	0.81	0.63
M_3	6.92	7.10	0.86	0.66
M_4	7.15	7.22	0.88	0.71
M_5	6.85	6.98	0.79	0.52

Growing media	N (%)		P (%)		K (%)	
	Before	After	Before	After	Before	After
M_1	0.29	0.32	0.036	0.038	0.28	0.07
M_2	0.34	0.20	0.035	0.037	0.23	0.13
M_3	0.31	0.32	0.034	0.036	0.22	0.16
M_4	0.28	0.17	0.037	0.039	0.34	0.12
M_5	0.26	0.22	0.033	0.035	0.27	0.15

M_1: cocopeat (50%) + vermicompost (30%) + perlite (10%) + vermiculite (10%)

M_2: cocopeat (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%)

M_3: coco chips (50%) + vermicompost (30%) + perlite (10%) + vermiculite (10%)

M_4: coco chips (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%)

M_5: cocopeat (60%) + vermicompost (20%) + perlite (20%)

4.4. OTHER OBSERVATIONS

4.4.1. Plant nutrient content

Growing media had a significant impact on plant nutrient content. M_2 [cocopeat (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%)] and M_1 [cocopeat (50%) + vermicompost (30%) + perlite (10%) + vermiculite (10%)] were on par and statistically superior with respect to nitrogen and potassium content whereas highest phosphorus content was observed in M_2. Lowest nitrogen and potassium content (1.73% and 2.31% respectively) was observed under M_5 [cocopeat (60%) + vermicompost (20%) + perlite (20%)] whereas lowest phosphorus content (0.25%) was observed under M_3 [coco chips (50%) + vermicompost (30%) + perlite (10%) + vermiculite (10%)] and M_5 (Table 11).

The highest nitrogen content (2.13%) was recorded with the application of N_1 (NPK-19:19:19 at 2 g/L) and the lowest nitrogen content (1.96%) was noticed with the application of N_2 (seaweed extract at 10 ml/L) whereas phosphorus and potassium content were not significantly influenced with foliar nutrients (Table 11).

Treatment combinations of T_2- M_2 x N_1 [cocopeat (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%) and NPK-19:19:19 at 2 g/L] and T_1- M_1 x N_1 [cocopeat (50%) + vermicompost (30%) + perlite (10%) + vermiculite (10%) and NPK-19:19:19 at 2 g/L] were on par and statistically superior with respect to nitrogen content (2.54% and 2.43% respectively). Treatment combinations of T_2- M_2 x N_1, T_4 - M_4 x N_1 [coco chips (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%) and NPK-19:19:19 at 2 g/L] and T_6 - M_1 x N_2 [cocopeat (50%) + vermicompost (30%) + perlite (10%) + vermiculite (10%) and seaweed extract at 10 ml/L] were on par and statistically superior with respect to phosphorus content (0.33%, 0.30% and 0.29% respectively), while treatment combinations of T_2- M_2 x N_1, T_6 - M_1 x N_2 and T_7 - M_2 x N_2 [cocopeat (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%) and seaweed extract at 10 ml/L] were on par and statistically superior with respect to potassium content (3.74%, 3.64% and 3.24% respectively).

Lowest nitrogen, phosphorus and potassium content was recorded in T_8 - M_3 x N_2 [coco chips (50%) + vermicompost (30%) + perlite (10%) + vermiculite (10%) and seaweed extract at 10 ml/L] (1.70%), T_9 - M_4 x N_2 [coco chips (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%) and seaweed extract at 10 ml/L] (0.23%) and T_{10}- M_5 x N_2 [cocopeat (60%) + vermicompost (20%) + perlite (20%) and seaweed extract at 10 ml/L] (2.18%) respectively (Table 12).

4.4.2. Plant nutrient uptake

Plant nutrient uptake was influenced significantly by the growing media. M_2 [cocopeat (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%)], M_4 [coco chips (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%)] and M_1 [cocopeat (50%) + vermicompost (30%) + perlite (10%) + vermiculite (10%)] were on par and statistically superior with respect to nitrogen and phosphorus uptake while M_2 and M_1 were on par and statistically superior with respect to potassium uptake. Lowest nitrogen and potassium uptake (0.42 g/plant and 0.56 g/plant respectively) was observed under M_5 [cocopeat (60%) + vermicompost (20%) + perlite (20%)] whereas lowest phosphorus uptake (0.06 g/plant) was observed under M_3 [coco chips (50%) + vermicompost (30%) + perlite (10%) + vermiculite (10%)] and M_5 (Table 11).

No significant variation due to foliar nutrients and M x N interaction could be observed on plant nutrient uptake (Table 11 and Table 12).

4.4.3. Total chlorophyll content

The total chlorophyll content was significantly influenced by the growing media. M_4 [coco chips (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%)] had the highest total chlorophyll content (1.05 mg/g), whereas M_5 [cocopeat (60%) + vermicompost (20%) + perlite (20%)] had the lowest total chlorophyll content (0.68 mg/g) (Table 11).

Foliar nutrients had no significant influence on total chlorophyll content (Table 11).

Total chlorophyll content was significantly influenced by the M x N interaction. The treatment combinations of T_9 - M_4 x N_2 [coco chips (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%) and seaweed extract at 10 ml/L] and T_4 - M_4 x N_1 [coco chips (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%) and NPK-19:19:19 at 2 g/L] recorded highest total chlorophyll content (1.07 mg/g and 1.03 mg/g respectively), while T_5 - M_5 x N_1 [cocopeat (60%) + vermicompost (20%) + perlite (20%) and NPK-19:19:19 at 2 g/L] recorded the lowest total chlorophyll content (0.49 mg/g) (Table 12).

4.4.4. Pest and disease incidence

4.4.4.1. *Pest incidence*

a. Sucking pests

I. Mealybugs

Mealybugs are small sap-sucking insects with a white cottony growth that have been spotted on newly emerging leaves. They harm their hosts by sucking the sap from them. Mealybug incidence was noticed from February to April. As a result of mealybug infestation, leaves became yellowish and finally fallen from the plant (Plate 8).

II. Aphids

Aphids are persistent pests that inflict harm to host plants by sucking up plant sap and injecting poisonous salivary secretions during feeding. Aphids attack was noticed during January to February. Aphids feeding resulted in stunted growth and deformed leaves (Plate 8).

Control measures: The application of Imidacloprid (Confider) at 0.3 to 0.5 ml/L effectively reduced the infestation and further spread of sucking pests.

b. Leaf eating caterpillar

Symptoms of leaf eating caterpillar have appeared as holes on the newly emerging leaves (Plate 8).

Control measures: Removal of affected leaves and mechanical destruction of caterpillars effectively controlled the pest incidence.

c. Slugs

Slugs are damaging garden pests, which feed on succulent foliage and symptoms appeared as irregular feed marks on the leaves (Plate 8).

Control measures: Hand-picking and mechanical destruction were done to control this pest.

4.4.4.2. *Disease incidence*

a. Sclerotium rot

Sclerotium is a common soil-borne fungus that infects lower shoots and roots. Sclerotium was observed by the presence of sclerotium spores produced near the media. The stem became soft and the plant wilted and died suddenly. Decay was occurred suddenly, resulting in total collapse of the plant (Plate 9).

Control measures: Drenching of media with Bavistin + Mancozeb (Saaf) at 2 g/L followed by application of *Tricoderma viridae* after 10 days at 10 g/plant, effectively controlled the disease.

4.4.5. Physiological abnormalities

No physiological abnormalities was noticed during the period of the experiment.

4.4.6. Micronutrient deficiencies

No micronutrient deficiency was noticed during the period of the experiment.

4.4.7. Cost of growing media

The cost of each component used in growing media and cost of growing media/pot are given in Table 13. and Table 14. respectively. Highest cost (34.10 Rs.) was incurred for M_2 [cocopeat (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%)] whereas minimum cost (27.60 Rs.) was incurred for M_3 [coco chips (50%) + vermicompost (30%) + perlite (10%) + vermiculite (10%)].

Table 11. Effect of growing media and foliar nutrients on plant nutrient content, plant nutrient uptake and total chlorophyll content of *Philodendron xanadu*

Treatments		Plant nutrient content			Plant nutrient uptake			Total chlorophyll (mg /g)
		N (%)	P (%)	K (%)	N (g/plant)	P (g/plant)	K (g/plant)	
GROWING MEDIA	M_1	2.32	0.27	3.24	0.67	0.08	0.93	0.71
	M_2	2.41	0.31	3.49	0.77	0.09	1.12	0.82
	M_3	1.94	0.25	2.53	0.50	0.06	0.66	0.73
	M_4	1.83	0.26	2.71	0.69	0.10	0.84	1.05
	M_5	1.73	0.25	2.31	0.42	0.06	0.56	0.68
CD (0.05)		0.14	0.03	0.41	0.15	0.02	0.22	0.15
		0.05	0.01	0.14	0.05	0.01	0.07	0.05
FOLIAR NUTRIENTS	N_1	2.13	0.27	2.77	0.64	0.08	0.84	0.79
	N_2	1.96	0.26	2.94	0.58	0.07	0.80	0.81
CD (0.05)		0.09	NS	NS	NS	NS	NS	NS
SE(m)		0.03	0.01	0.09	0.03	0.004	0.05	0.03

Growing media	M_1: cocopeat (50%) + vermicompost (30%) + perlite (10%) + vermiculite (10%) M_2: cocopeat (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%) M_3: coco chips (50%) + vermicompost (30%) + perlite (10%) + vermiculite (10%) M_4: coco chips (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%) M_5: cocopeat (60%) + vermicompost (20%) + perlite (20%)
Foliar nutrients	N_1: NPK-19:19:19 at 2 g/L N_2: sea weed extract at 10 ml/L

Table 12. Effect of M x N interaction on plant nutrient content, plant nutrient uptake and total chlorophyll content of *Philodendron xanadu*

Treatments		Plant nutrient content N (%)	Plant nutrient content P (%)	Plant nutrient content K (%)	Plant nutrient uptake N (g/plant)	Plant nutrient uptake P (g/plant)	Plant nutrient uptake K (g/plant)	Total chlorophyll (mg /g)
T_1	M_1 x N_1	2.43	0.25	2.83	0.70	0.07	0.82	0.81
T_2	M_2 x N_1	2.54	0.33	3.74	0.85	0.11	1.25	0.85
T_3	M_3 x N_1	2.18	0.24	2.39	0.56	0.06	0.61	0.75
T_4	M_4 x N_1	1.81	0.30	2.47	0.70	0.12	0.96	1.03
T_5	M_5 x N_1	1.71	0.25	2.43	0.40	0.06	0.57	0.49
T_6	M_1 x N_2	2.22	0.29	3.64	0.64	0.08	1.04	0.62
T_7	M_2 x N_2	2.29	0.28	3.24	0.70	0.09	0.99	0.80
T_8	M_3 x N_2	1.70	0.26	2.67	0.45	0.07	0.71	0.71
T_9	M_4 x N_2	1.85	0.23	2.95	0.68	0.08	0.72	1.07
T_{10}	M_5 x N_2	1.74	0.25	2.18	0.44	0.06	0.55	0.86
CD (0.05)		0.20	0.04	0.58	NS	NS	NS	0.21
SE(m)		0.07	0.01	0.19	0.07	0.01	0.11	0.07

Growing media	M_1: cocopeat (50%) + vermicompost (30%) + perlite (10%) + vermiculite (10%) M_2: cocopeat (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%) M_3: coco chips (50%) + vermicompost (30%) + perlite (10%) + vermiculite (10%) M_4: coco chips (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%) M_5: cocopeat (60%) + vermicompost (20%) + perlite (20%)
Foliar nutrients	N_1: NPK-19:19:19 at 2 g/L N_2: sea weed extract at 10 ml/L

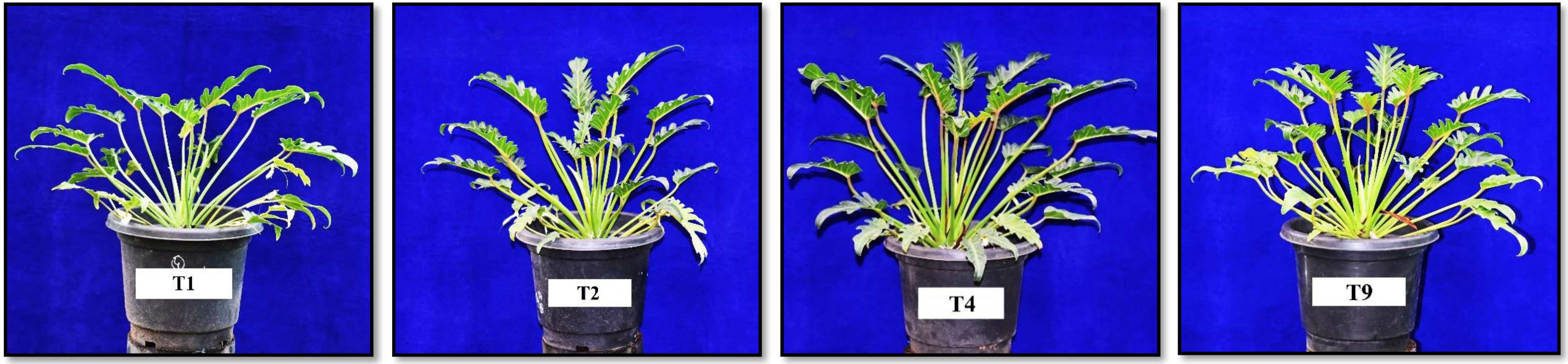
Table 13. Cost of growing media components

	Growing media components					
	Cocopeat	**Coco chips**	**Vermicompost**	**Perlite**	**Vermiculite**	**Neem cake**
Cost/Kg (Rs.)	10	20	10	70	35	30

Table 14. Cost of growing media

Growing media	Components	Quantity of each component/ pot	Weight of growing media/pot (Kg.)	Cost of growing media/pot (Rs.)
M_1	cocopeat (50%) + vermicompost (30%) + perlite (10%) + vermiculite (10%)	cocopeat (0.80 Kg), vermicompost (0.90 Kg) , perlite (0.10 Kg) and vermiculite (0.16 Kg)	1.96	29.60
M_2	cocopeat (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%)	cocopeat (0.80 Kg), vermicompost (0.60 Kg), neem cake (0.25 Kg), perlite (0.10 Kg), vermiculite (0.16 Kg)	1.91	34.10
M_3	coco chips (50%) + vermicompost (30%) + perlite (10%) + vermiculite (10%)	coco chips (0.3 Kg), vermicompost (0.90 Kg), perlite (0.10 Kg), vermiculite (0.16 Kg)	1.46	27.60
M_4	coco chips (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%)	coco chips (0.3 Kg), vermicompost (0.60 Kg), neem cake (0.25 Kg), perlite (0.10 Kg), vermiculite (0.16 Kg)	1.41	32.10
M_5	cocopeat (60%) + vermicompost (20%) + perlite (20%)	cocopeat (0.96 Kg), vermicompost (0.60 Kg), perlite (0.20 Kg)	1.76	29.60

Plate 4. Effect of growing media and foliar nutrients on plant height and number of leaves of *Philodendron xanadu*



T_1: M_1 x N_1- cocopeat (50%) + vermicompost (30%) + perlite (10%) + vermiculite (10%) and 19:19:19 at 2 g/L
T_2: M_2 x N_1 - cocopeat (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%) and 19:19:19 at 2 g/L
T_4: M_4 x N_1 - coco chips (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%) and 19:19:19 at 2 g/L
T_9: M_4 x N_2 - coco chips (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%) and seaweed extract at 10 ml/L

Plate 5. Effect of growing media and foliar nutrients on leaf length, leaf width and leaf area of *Philodendron xanadu*

T_2: M_2 x N_1 - cocopeat (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%) and 19:19:19 at 2 g/L
T_4: M_4 x N_1 - coco chips (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%) and 19:19:19 at 2 g/L
T_5: M_5 x N_1 - cocopeat (60%) + vermicompost (20%) + perlite (20%) and 19:19:19 at 2g/L

Plate 6. Leaf production interval stages of *Philodendron xanadu*

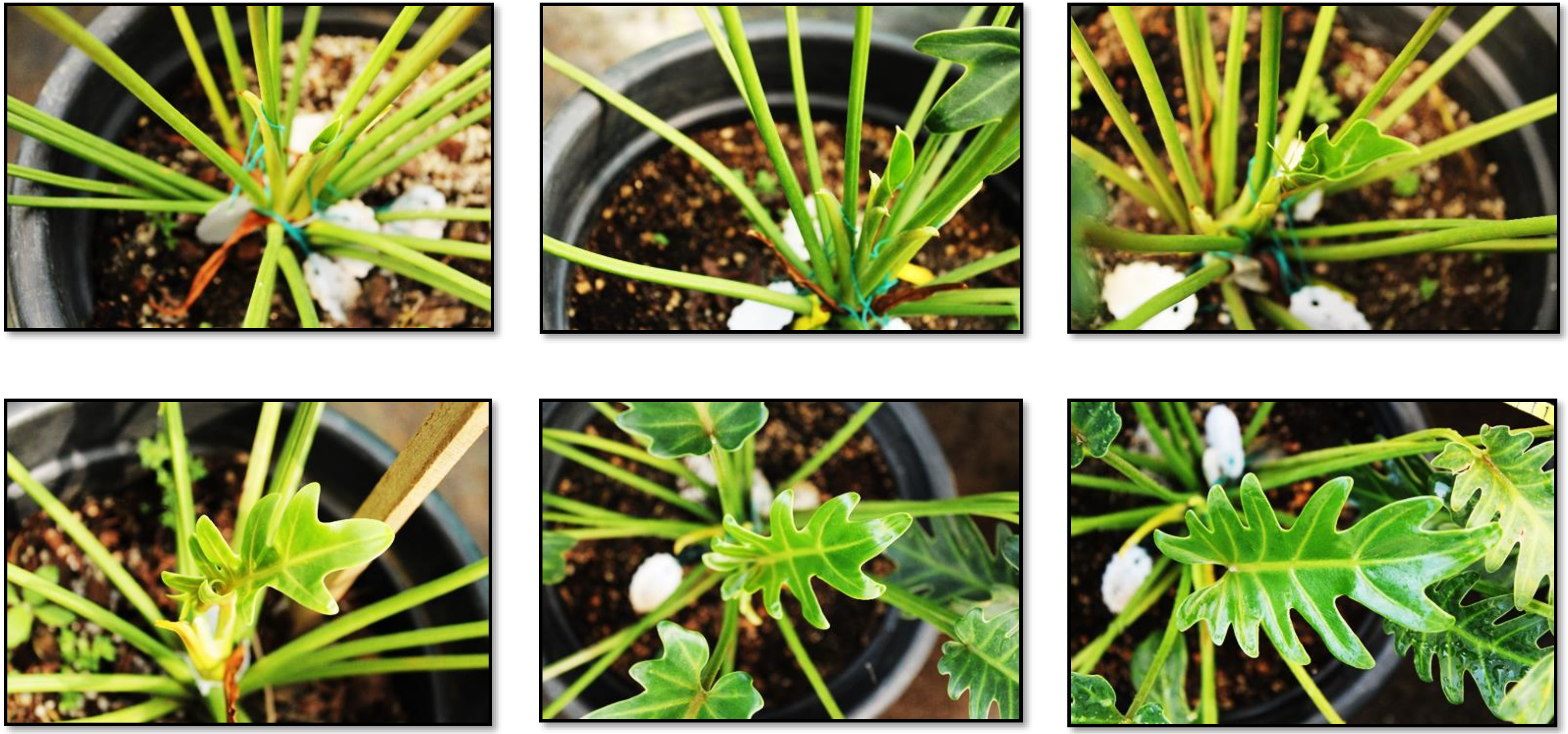


Plate 7. Effect of growing media and foliar nutrients on leaf length, leaf width and leaf area of *Philodendron xanadu*

T_2: M_2 x N_1 - cocopeat (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%) and 19:19:19 at 2 g/L
T_4: M_4 x N_1 - coco chips (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%) and 19:19:19 at 2 g/L
T_5: M_5 x N_1 - cocopeat (60%) + vermicompost (20%) + perlite (20%) and 19:19:19 at 2g/L

Plate 8. Pest incidence

Mealy bugs

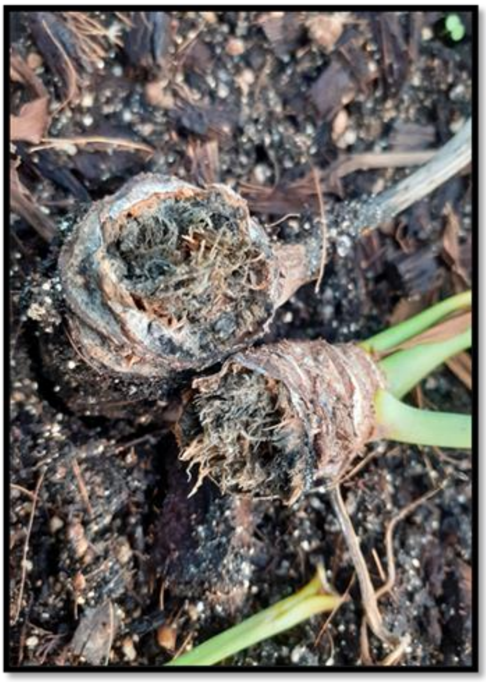
Aphids

Leaf eating caterpillar symptoms

Slugs

Plate 9. Disease incidence

Sclerotium spores



Sclerotium rot

Drenching of Saaf at 2 g/L

Application of *Tricoderma viridae* at 10 g/plant

Plate 10. Effect of growing media and foliar nutrients on the overall performance of *Philodendron xanadu* after the experiment

DISCUSSION

5. DISCUSSION

An investigation entitled "Standardization of soilless medium and foliar nutrients for potted ornamental foliage plants" was conducted at the Department of Floriculture and Landscape Architecture, College of Agriculture, Vellanikkara, Thrissur, Kerala during 2020-21. The results of the study are discussed in this chapter.

5.1. EFFECT OF GROWING MEDIA

5.1.1. Vegetative parameters

Plant height and plant spread are important parameters with respect to the attractiveness of the potted ornamental foliage plants. The number of leaves and leaf area determine the fullness of the pot. Leaf production interval decides the number of leaves and directly influences the beauty of potted plants. The parameters leaf length and leaf width also influence the presentability of potted ornamental foliage plants, as they contribute to leaf area.

From the results, it could be concluded that there was a significant variation with respect to all vegetative parameters due to the growing media. M_2 [cocopeat (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%)] and M_4 [coco chips (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%)] were on par and statistically superior with respect to plant height, plant spread, leaf length, leaf width, petiole length, leaf longevity, leaf production interval, leaf area, shoot girth, shoot length and dry weight of the leaves. The fresh weight of the leaves decides the turgidity and freshness of the leaves, which is an important quality criterion of potted ornamental foliage plants. In the present study, M_4 was recorded with the highest fresh weight of the leaves.

In general, it could be observed that plants grown in media M_2 and M_4 had all the quality criteria for potted ornamental foliage plants, with respect to vegetative parameters. The major components of these media were cocopeat in M_2 and coco chips in M_4 which constituted 50% of the growing media composition. In addition to this, both of these media consisted of components such as vermicompost, neem cake, vermiculite and perlite. The better performance of plants in these media may be due to the beneficial effects of media components.

Cocopeat as a growing media component improves the aeration, water holding capacity, facilitates root growth and thereby better nutrient uptake by the plants. The presence of nitrogen, calcium and magnesium as well as high content of phosphorus and potassium were reported in cocopeat (Gohil *et al*., 2018). Apart from this, it is also resistant to bacterial and fungal growth. The benefits of using cocopeat as an appropriate medium component for growing plants have been noted by several researchers including Khayyat *et al*. (2007) in *Epipremnum aureum*, Swetha *et al*. (2014) in *Aglaonema* cv. Ernesto's, Sankari *et al*. (2019) in *Asparagus spengeri*, Pradhan and Mohanty (2020) in aglaonema and dieffenbachia, Rashidha *et al.* (2021) in aglaonema.

Coco chips provide excellent aeration to the growing media and act as a reservoir of nutrients as it contains macro and micronutrients and slowly releases nutrients to the growing medium. It also provides anchorage to the roots. The beneficial effects of coco chips as a growing media component had been reported by Savithri and Khan, (1994); Muraleedharan and Karuppaiah (2015), Kapane *et al.* (2015) and Sumathi *et al*. (2018) in anthuriums; Hariyanto *et al.* (2019) and Sanghamitra *et al.* (2019) in orchids.

The use of vermicompost in growing media improves the overall growth and development of the plants as it influences vegetative growth and root development. Vermicompost had higher and more soluble levels of nutrients such as nitrogen, phosphorous, potassium, calcium and magnesium. It enhances the physical structure of the media and nourishes the media with microorganisms. An improvement in growth due to vermicompost in potted ornamentals had been reported by Kayalvizhi *et al.* (2013) in *Asparagus densiflorus*, Fatmi and Singh (2017) in *Codiaeum*, Sandeep *et al.* (2018) in *Nephrolepis*.

Neem cake was one of the growing media components both in M_2 and M_4 that showed superior performance of the potted plants in this study. Neem cake is organic in nature and is rich in NPK. Neem cake being an organic manure might have nourished the plants continuously that resulted better growth. In addition to this, the increased chlorophyll content of leaves in both the media enriched with neem cake might have resulted in enhanced photosynthesis and plant growth. Amendment with organic supplements such as neem cake has a favourable impact on the physical, chemical and biological properties of the media (Abawi and Thurston, 1994). Neem cake not only enhanced plant growth and yield, but it improved the general appearance of foliage [Juveriya and Ahmmed (2016) in *Codiaeum variegatum*]. Apart from the beneficial effects of neem cake on plant growth, yield and media characters, it is also reported to have insecticidal and fungicidal properties (Khan and Saxena, 1997). Nematicidal properties of neem cake were reported by Jothi *et al*. (2004) in crossandra. It was reported that organic acids, phenols, tannins and hydrogen sulphide released during the decomposition of neem cake suppress the nematodes, as well as disease-causing microorganisms and nitrogenous compounds formed during decomposition promote plant growth (Rodriguez-Kabana, 1986). Improvement of plant growth and yield by the addition of neem cake into the growing medium was reported by Singh (2006) in *Anthurium andreanum* and Karim *et al.* (2017) in tuberose.

In the present study, perlite was also used as a media component in M_2 and M_4. Perlite is highly porous, lightweight and is characterized by high porosity, neutral pH and high permeability. Ten times water retention capacity than its dry weight was reported in perlite (Khosh Khui *et al*., 2006). Even though perlite is having less nutrient content, in combination with other media components, it was found to improve the physical properties of the media and thereby better plant growth. The beneficial effect of perlite as a growing media component had been reported in various ornamentals *viz.*, gerbera (Khalaj *et al.*, 2011), spathiphyllum (Kakhki *et al.* 2020; Kakoei and Salehi 2013), pothos (Bidarnamani and Zarei, 2014), gladiolus (Jabbar *et al.*, 2018), areca palm (Mohamed, 2018) and aglaonema (Rashidha *et al.*, 2021).

Vermiculite was also one of the growing media components in M_2 and M_4. It is hydrated aluminum iron magnesium silicate having low bulk density and high-water holding capacity. The presence of small amount of potassium and magnesium was reported in vermiculite (Landis *et al*., 2014). Vermiculite as a component of growing media enhances media properties such as aeration as well as water-holding capacity and thereby better penetration of roots and nutrient uptake by the plants. The influence of vermiculite on the growth and yield of potted ornamentals was reported by Sindhu *et al*. (2010) in gerbera, Thakur and Grewal (2019) in chrysanthemum and Rashidha *et al.* (2021) in aglaonema.

Beneficial effects of media components *viz*., coco chips, cocopeat, vermicompost, neem cake, vermiculite and perlite might have caused favourable effects in terms of plant growth and presentability of potted plants in media M_2 and M_4. Apart from these, M_2 and M_4 were found to have properties such as bulk density, porosity and pH in favourable range. The nutrient contents of these media were also high when compared to other media combinations. These media were found to have high NPK content before the experiment. Plant nutrient status (NPK) was significantly high in M_2 and total chlorophyll content was recorded as high in both M_2 and M_4.

5.1.2. Root parameters

The nutrient uptake by plants is determined by root characteristics such as the number of lateral roots, root volume as well as fresh and dry weight of the roots.

During the experiment, significant influence of growing media was observed only on root length, number of laterals and root volume. Greatest number of lateral roots as well as longest roots were observed in M_2 [cocopeat (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%)] and M_4 [coco chips (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%)]. Along with this media, M_5 [cocopeat (60%) + vermicompost (20%) + perlite (20%)] also had longest roots whereas maximum root volume was observed in M_1 [cocopeat (50%) + vermicompost (30%) + perlite (10%) + vermiculite (10%)] and M_4. With respect to fresh and dry weights of the roots, no significant difference was noticed due to the growing media.

5.2. EFFECT OF FOLIAR NUTRIENTS

5.2.1. Vegetative parameters

Application of foliar nutrients *viz*., N_1 (NPK-19:19:19 at 2 g/L) and N_2 (seaweed extract at 10 ml/L) were found to be non-significant with respect to vegetative parameters *viz*., plant spread, number of leaves, leaf length, leaf width, petiole length, leaf longevity, leaf production interval, leaf area, shoot girth, shoot length, fresh and dry weight of the leaves. Significant variation was noticed only with respect to plant height in which N_1 (NPK-19:19:19 at 2 g/L) was found to be superior.

In the present study, both NPK-19:19:19 and seaweed extract were applied as a foliar spray. NPK-19:19:19 supplies the major nutrients such as nitrogen, phosphorus and potassium in equal proportion, which is inorganic in nature. Foliar application of NPK-19:19:19 facilitates easy availability of nutrients and thereby increased synthesis of metabolites for plant growth. These findings can be ascribed to the effect of nitrogen at certain concentrations on plant growth, resulting in the production of new cells and increased growth and development of the plant. These findings are in accordance with the findings of EL Sayed *et al*. (2009) in *Dracaena marginata* 'Bicolor', El-Naggar and El-Nasharty (2009) in *Hippeastrum vittatum,* Kumar *et al.* (2019) in *Anthurium* Var. Xavia.

Seaweed extract is an organic source of nutrient and bio stimulant which contains sufficient amount of potassium, nitrogen, growth-promoting hormones and micronutrients. The application of seaweed extracts helps in improving the quality, nutrient content, overall growth and development of the plant. Similar findings were also reported by Sridhar and Rengasamy (2010) in *Tagetes erecta*, Aziz *et al.* (2011) in *Amaranthus tricolour,* Battacharyya *et al*. (2015) in petunia, pansy and cosmos, Al-Hamzawi (2019) in *Dianthus chinensis* and *Gazania splender.*

5.2.2. Root parameters

Foliar application of nutrients had no significant influence on the fresh weight and dry weights of the roots, no. of lateral roots and root volume during the experimental period. However foliar nutrients were found to have a significant impact on root length. Application of N_2 (seaweed extract at 10 ml/L) recorded the highest root length.

5.3. EFFECT OF M X N INTERACTION

M x N interaction had significant influence on plant height, no. of leaves, leaf production interval, shoot length, fresh and dry weights of roots and root length. Interaction effect of both growing media and foliar nutrients with respect to majority of these parameters were evident in T_2 - M_2 x N_1 [cocopeat (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%) and NPK-19:19:19 at 2 g/L] and T_4 - M_4 x N_1 [coco chips (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%) and NPK-19:19:19 at 2 g/L]. Other media combinations that performed better were T_7- M_2 x N_2 [cocopeat (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%) and seaweed extract at 10 ml/L] and T_9 - M_4 x N_2 [coco chips (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%) and seaweed extract at 10 ml/L]. This again highlights the beneficial effect of neem cake in the growing medium for enhancing growth of potted foliage ornamentals. Moreover, NPK-19:19:19 and seaweed extract were given as foliar spray which resulted in easy absorption of nutrients and thereby faster synthesis of carbohydrates and translocation of nutrients to roots leading to better development of plants and root system.

5.4. MEDIA ANALYSIS

5.4.1. Physical properties

Physical properties of the media are important with respect to plant growth as they decide the growth of the root system. In the present study, highest water holding capacity was observed in M_5 [cocopeat (60%) + vermicompost (20%) + perlite (20%)] followed by M_2 [cocopeat (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%)] and lowest water holding capacity was noticed in M_1 [cocopeat (50%) + vermicompost (30%) + perlite (10%) + vermiculite (10%)]. This may be due to the maximum proportion of cocopeat in a medium. Hume (1949) reported a 40% improvement in the water holding capacity after adding 2% cocopeat to sandy soil. In accordance with Awang *et al.* (2009) in *Celosia cristata* and Dubey *et al.* (2013), in *Petunia* × *hybrida.* Variation in bulk density is likely to be attributed to differences in the material's particle-size distribution (Richards and Beardsell, 1986). During the study, growing medium containing coco chips (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%) [M_4] had the lowest bulk density and highest porosity. This medium M_4 containing lightweight coco chips adds great porosity, resulting in the lowest bulk density.

5.4.2. Chemical properties

a. pH

According to the Chen and McConell (2002), the optimal pH range for the development of potted foliage plants is 5.5-7. When the pH of growing media is within this optimal range, the plants will have improved nutrient availability. Plants grown in cocopeat as a component of growing media had pH less than 7 while the highest pH was observed in coco chips containing media M_4 [coco chips (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%)] both before and after the experiment (7.15 and 7.22 respectively). In all media, there was a slight increase in the pH at the end of the observation period. The low pH of cocopeat-based media may be due to the low pH (5.6-6.0) of cocopeat (Coir board, 2016).

b. EC

In all growing media, EC was in a favourable range before and after the experiment. The low EC level in all media combinations may be due to the presence of inert substances such as perlite and vermiculite. Other components, cocopeat and vermicompost are in composite form in which there might have a reduction in EC due to composting.

c. Available N, P and K (%)

Media M_2 [cocopeat (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%)] was found to have highest available N content and M_4 [coco chips (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%)] had highest available P and K content before the experiment. The presence of organic amendments such as neem cake and vermicompost might have improved the nutrient status of these media. Coco chips and cocopeat are also reported to have major and secondary nutrients which also might have improved the nutrient status of these media.

5.5. OTHER OBSERVATIONS

5.5.1. Plant nutrient content and uptake

Medium M_2, as well as M_1 in combination with N_1, were superior with respect to nitrogen content whereas M_2 and M_4 in combination with N_1 had the highest phosphorus content. With regard to potassium content, media M_2 in combination with both N_1 as well as N_2 and M_1 in combination with N_2 was found to be superior.

Regarding nutrient uptake, growing media had a significant influence with respect to this parameter. No significant variation could be observed in terms of foliar nutrients and M x N interaction. M_1, M_2 and M_4 were on par with respect to nitrogen and phosphorus uptake and M_1 and M_2 were on par with respect to potassium uptake.

Improvement in root parameters of these media due to favourable physical and chemical properties of growing media components might have caused increased nutrient uptake and translocations from roots to vegetative parts. This might have caused an important of nutrients status of plants in these treatments. Similar findings were also reported by Awang *et al.* (2009) in *Celosia cristata*, Basheer and Thekkayam (2012) in anthurium, Swetha *et al*. (2014) in aglaonema, Juveriya and Ahmmed (2016) in *Codiaeum variegatum.*

5.5.2. Total chlorophyll content

With regard to media, M_4 [coco chips (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%)] resulted with highest total chlorophyll content, whereas treatment combinations of T_9 - M_4 x N_2 [coco chips (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%) and seaweed extract at 10 ml/L] and T_4 - M_4 x N_1 [coco chips (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%) and NPK-19:19:19 at 2 g/L] recorded highest total chlorophyll content. It has been noted that both foliar nutrients along with M_4 were very effective for improving chlorophyll content. This may be due to the better synthesis of chlorophyll pigments due to the influence of media components and foliar nutrients. Similar findings were reported by Bidarnamani and Zarei (2014) in pothos, while application of seaweed extract resulted in improved chlorophyll content as per results of Al-Hamzawi (2019) in *Dianthus chinesis* L. and *Gazania splender* L.

In the present study, medium with high proportion of cocopeat and perlite (M_5) was noted with lowest total chlorophyll content. This is in accordance with Bidarnamani and Zarei (2014) who reported less level of chlorophyll content in *Scindapsus aureum* (pothos) grown in medium containing perlite and cocopeat.

5.5.3. Cost of growing media

The growing medium M_4 consisting of coco chips (0.3 Kg), vermicompost (0.60 Kg), neem cake (0.25 Kg), perlite (0.10 Kg) and vermiculite (0.16 Kg) was found to have lowest weight compared to other media and found to be the cheapest medium in this research as the components used was having low cost.

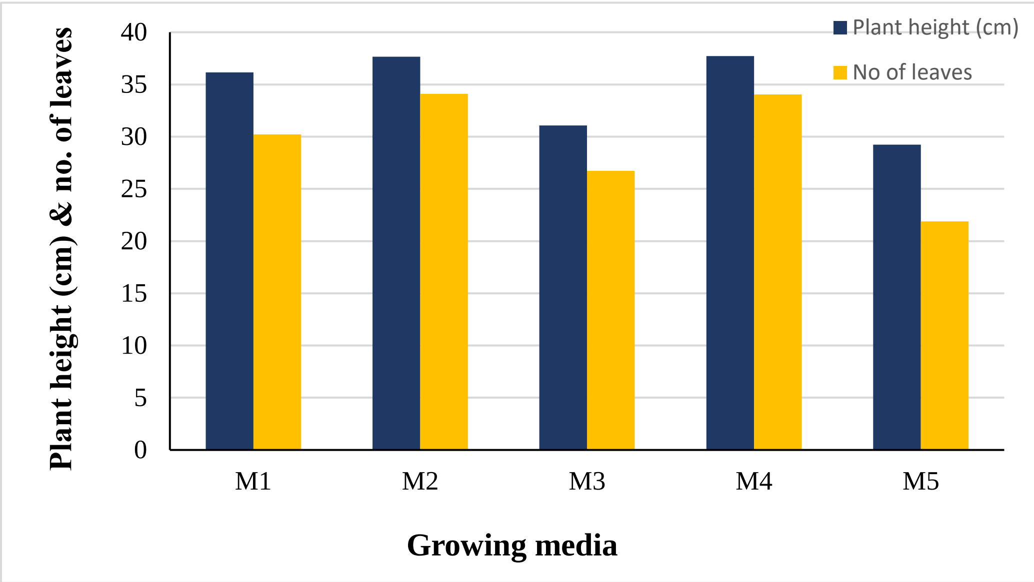


Figure 1. Effect of growing media on plant height and no. of leaves

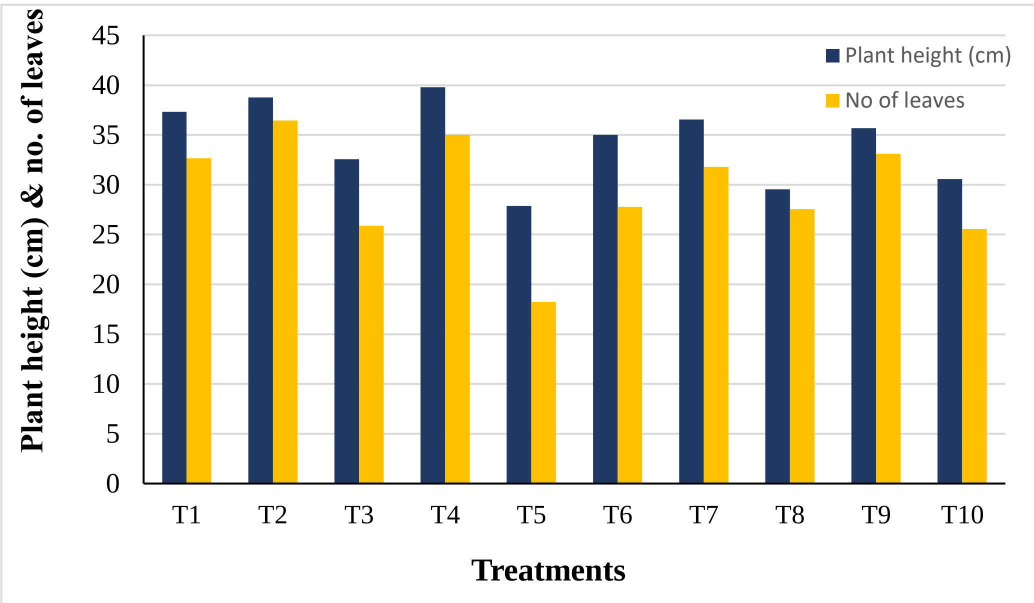


Figure 2. Effect of M x N interaction on plant height and no. of leaves

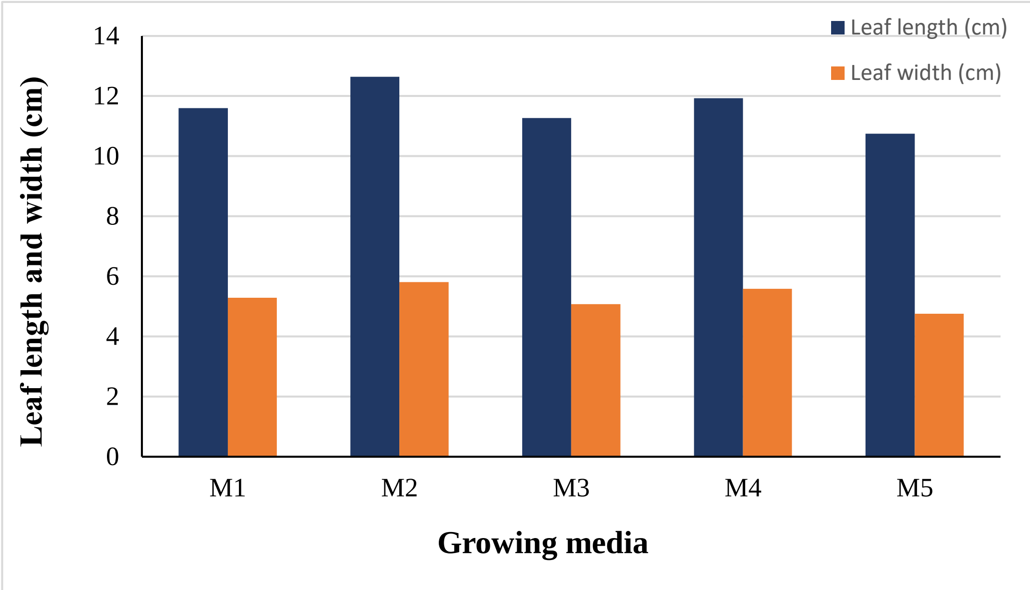


Figure 3. Effect of growing media on leaf length and leaf width

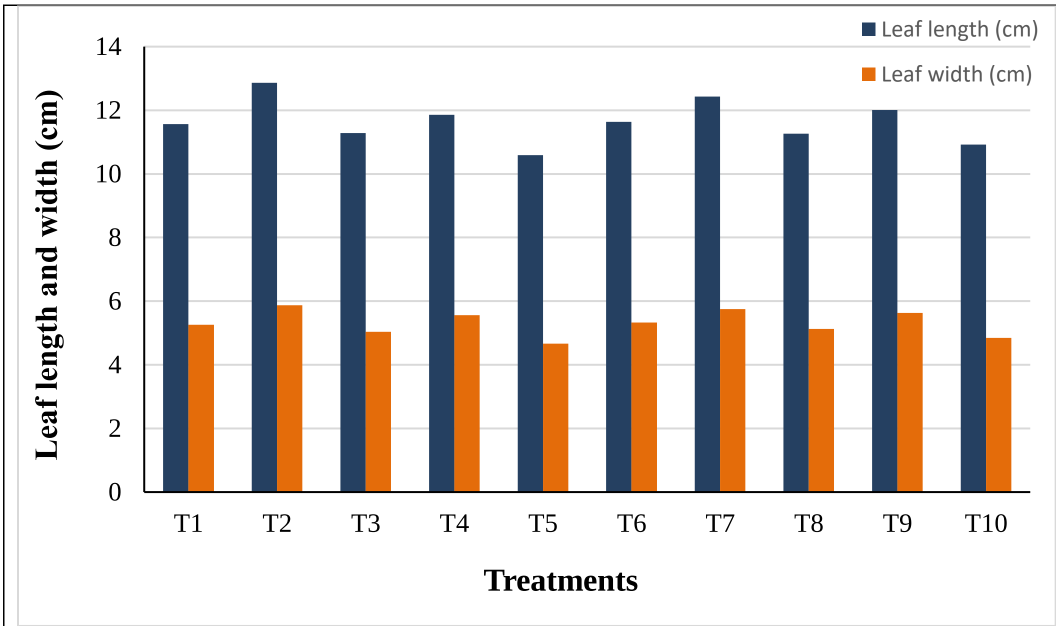


Figure 4. Effect of M x N interaction on leaf length and leaf width

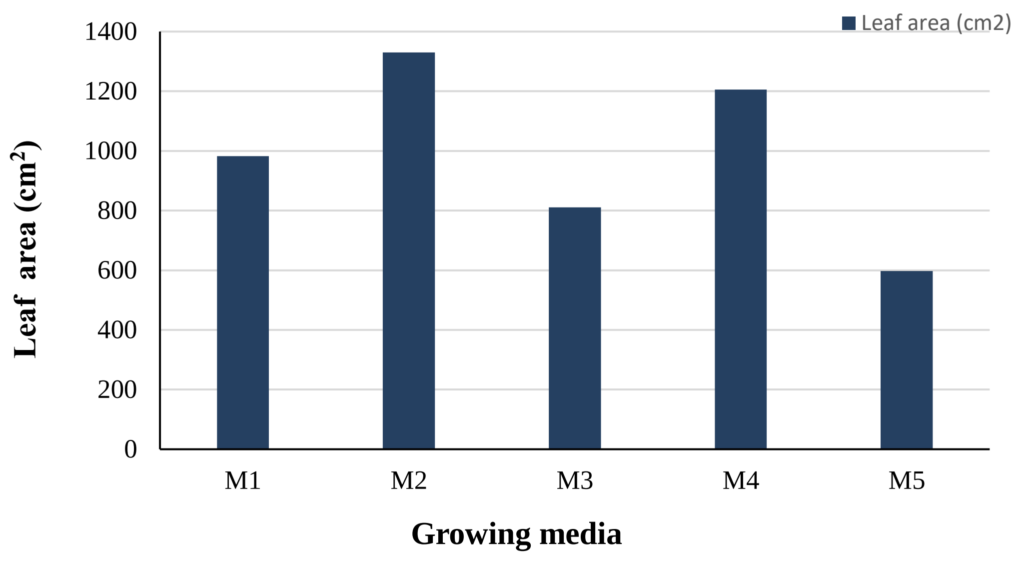


Figure 5. Effect of growing media on leaf area

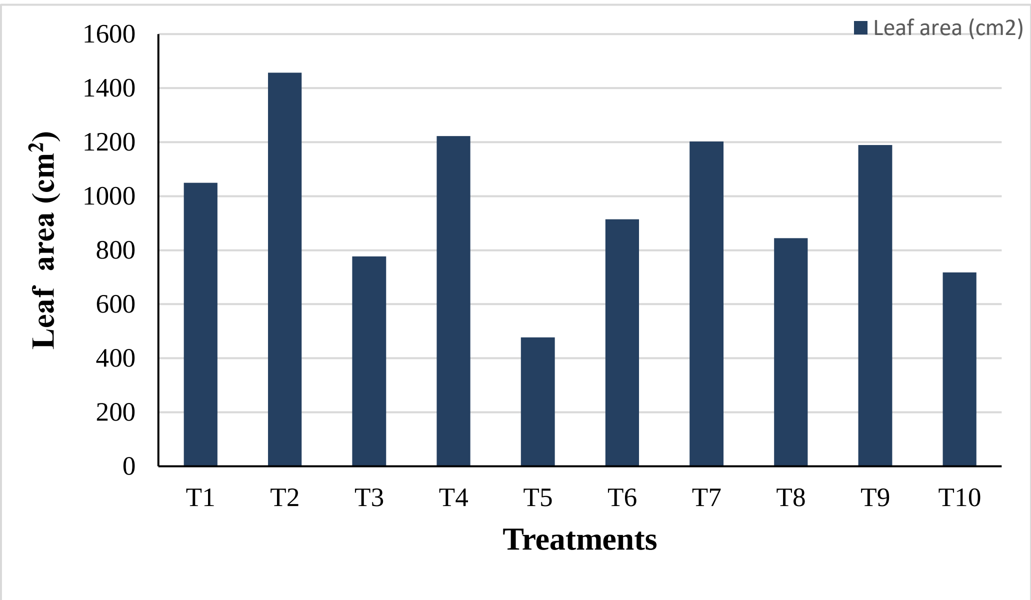


Figure 6. Effect of M x N interaction on leaf area

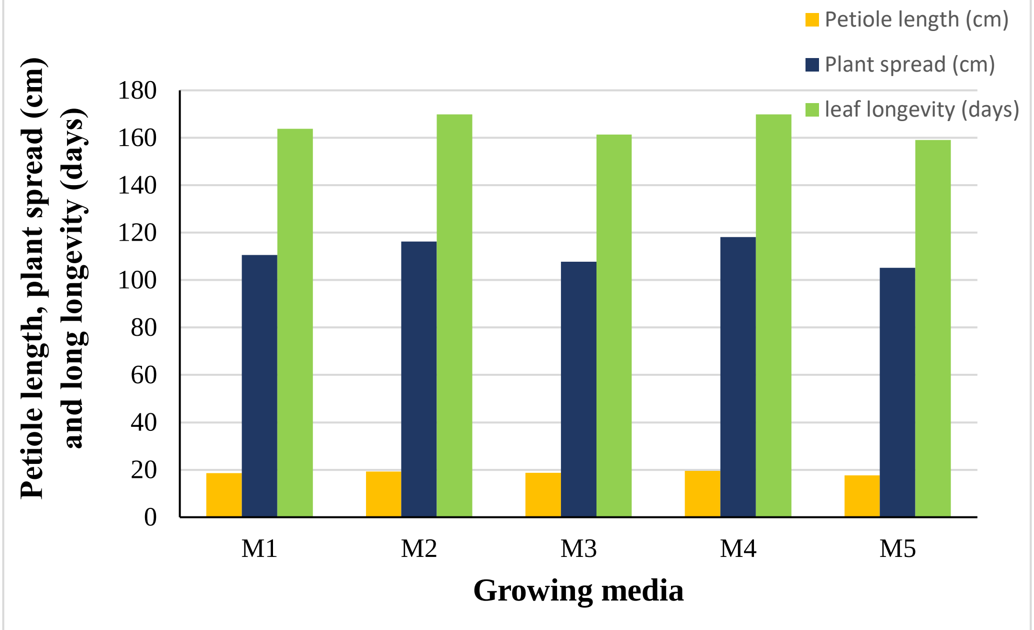


Figure 7. Effect of growing media on petiole length, plant spread and leaf longevity

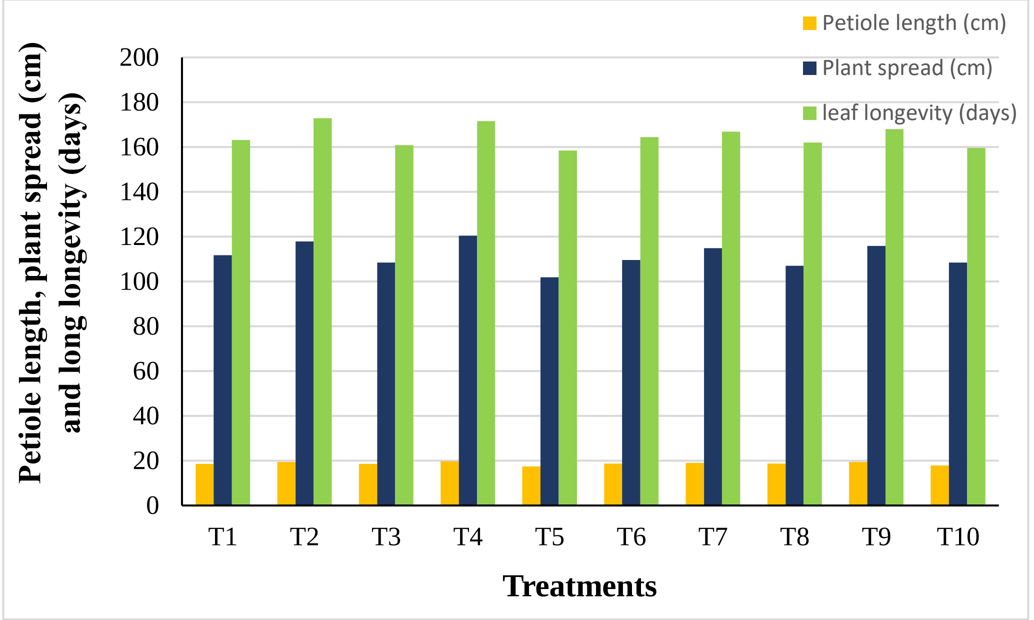


Figure 8. Effect of M x N interaction on petiole length, plant spread and leaf longevity

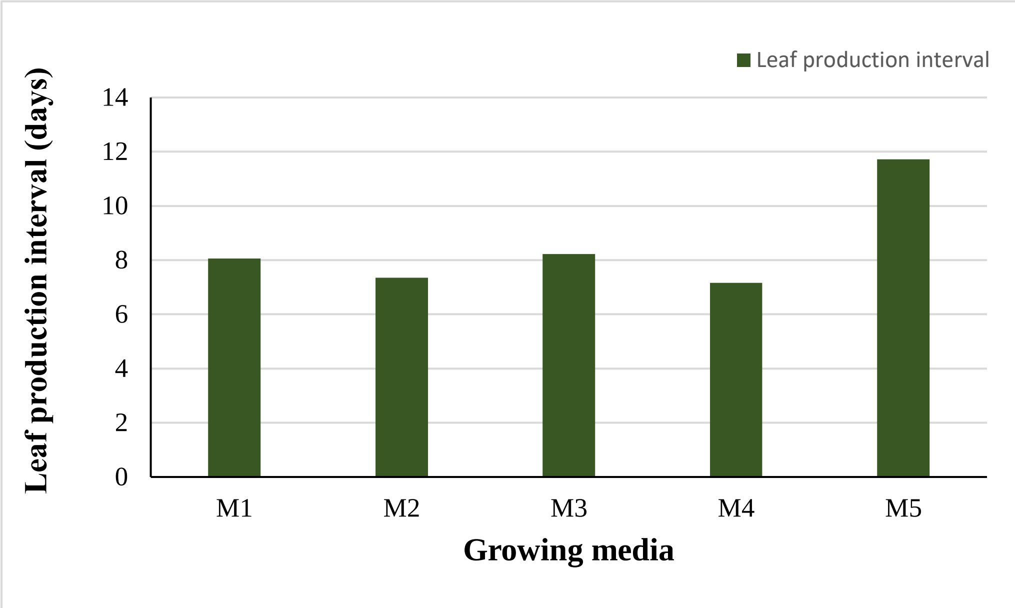


Figure 9. Effect of growing media on leaf production interval

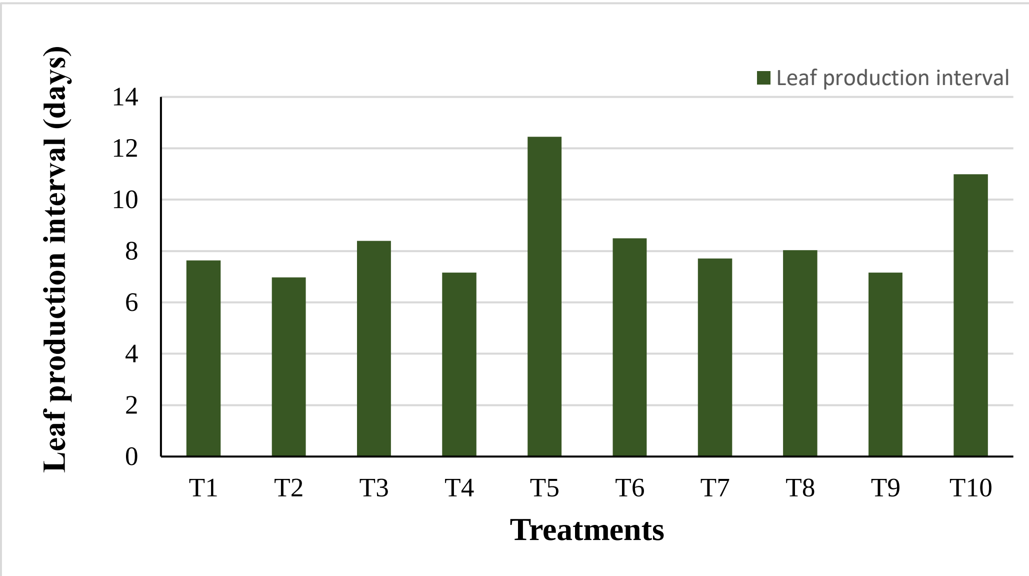


Figure 10. Effect of M x N interaction on leaf production interval

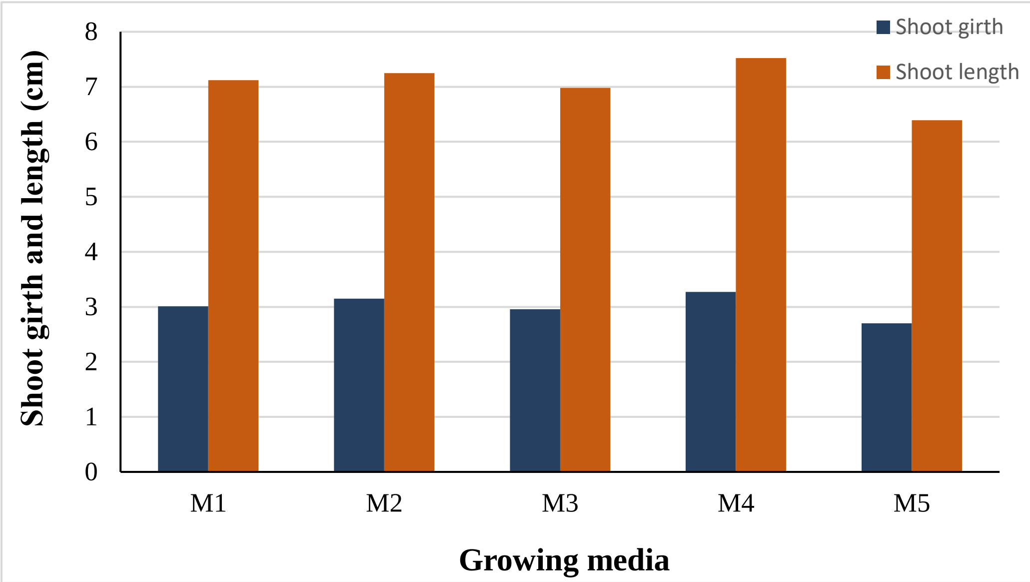


Figure 11. Effect of growing media on shoot girth and shoot length

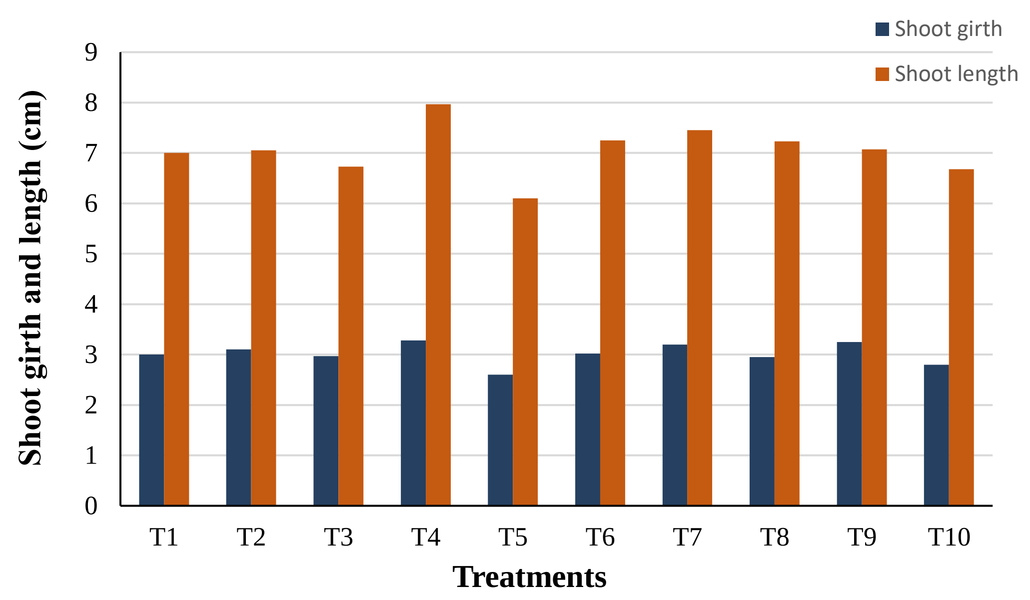


Figure 12. Effect of M x N interaction on shoot girth and shoot length

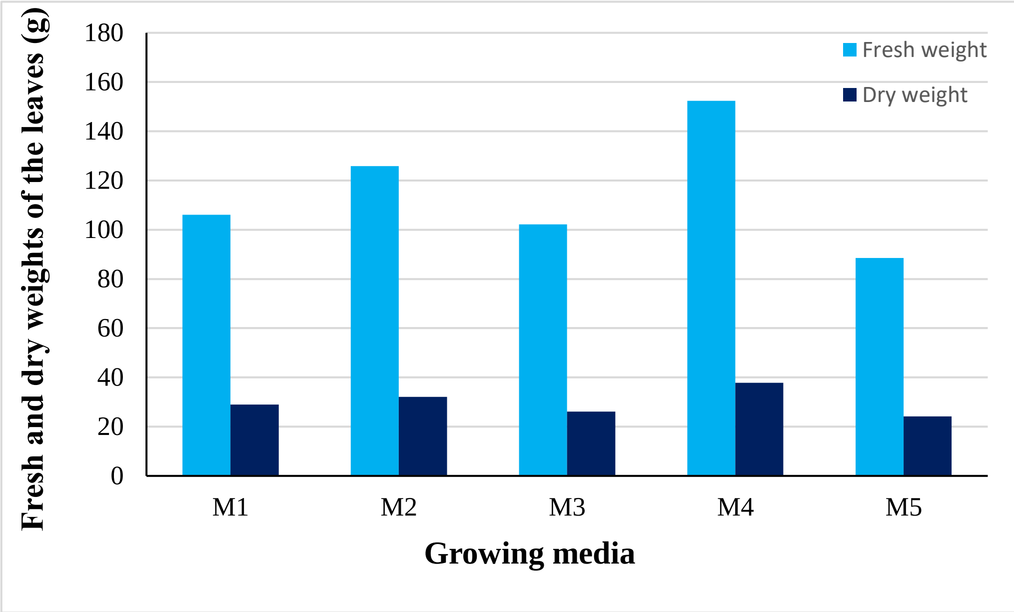


Figure 13. Effect of growing media on fresh and dry weights of the leaves

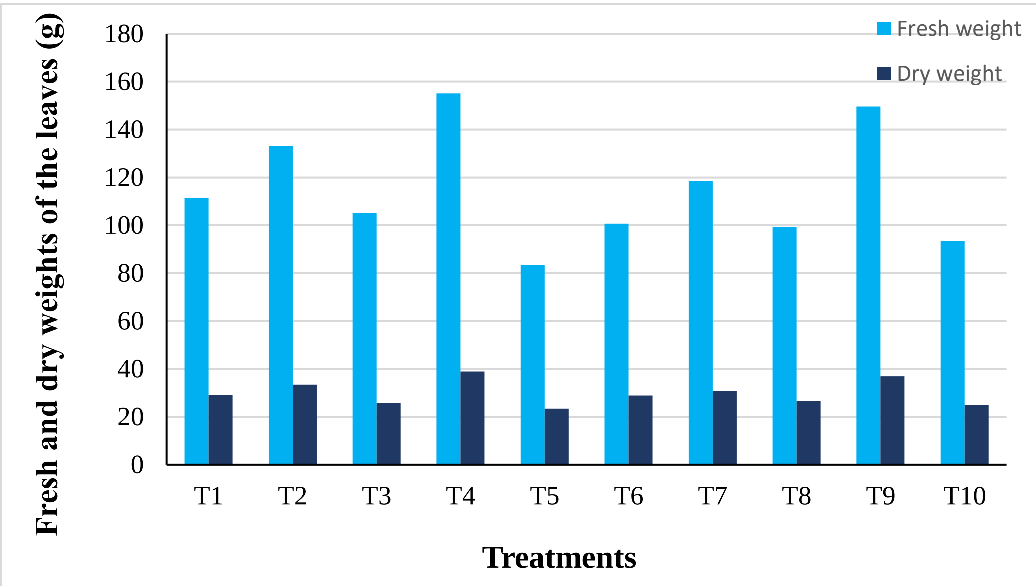


Figure 14. Effect of M x N interaction on fresh and dry weights of the leaves

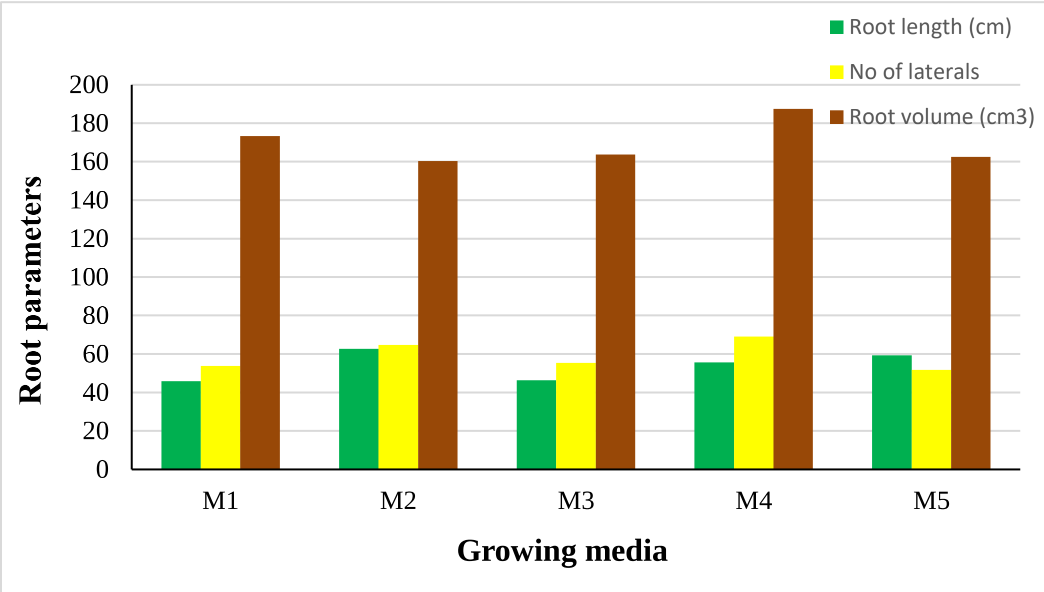


Figure 15. Effect of growing media on root length, number of laterals and root volume

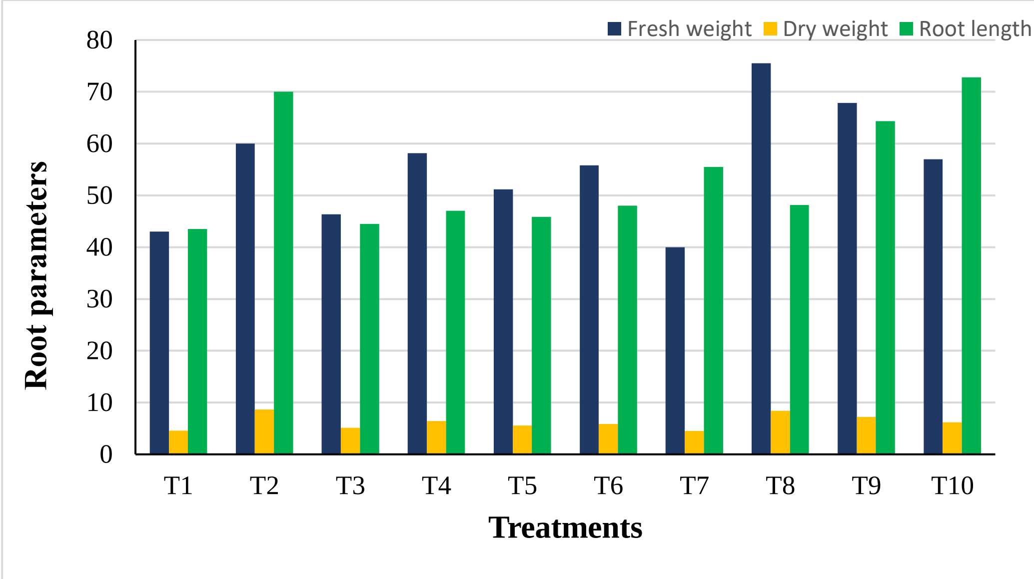


Figure 16. Effect of M x N interaction on fresh weights of the roots, dry weights of the roots and root length

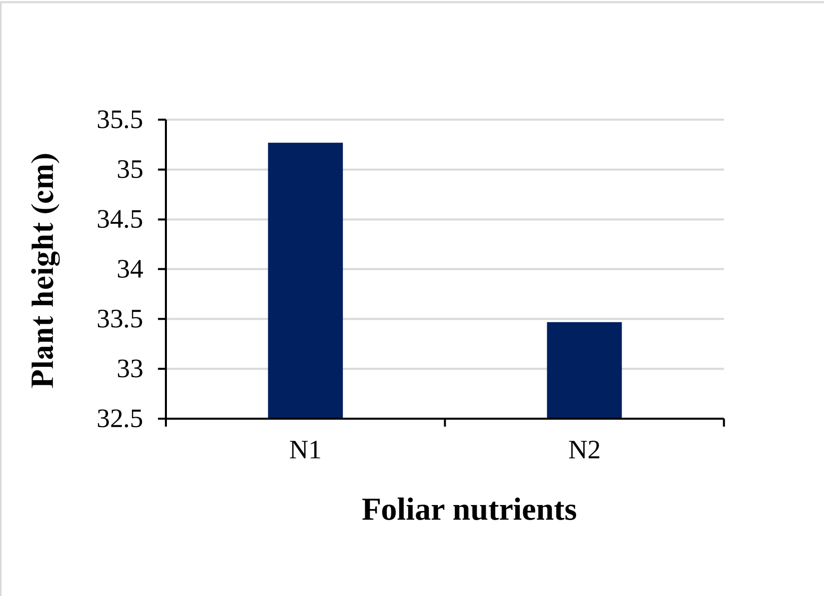


Figure 17. Effect of foliar nutrients on plant height

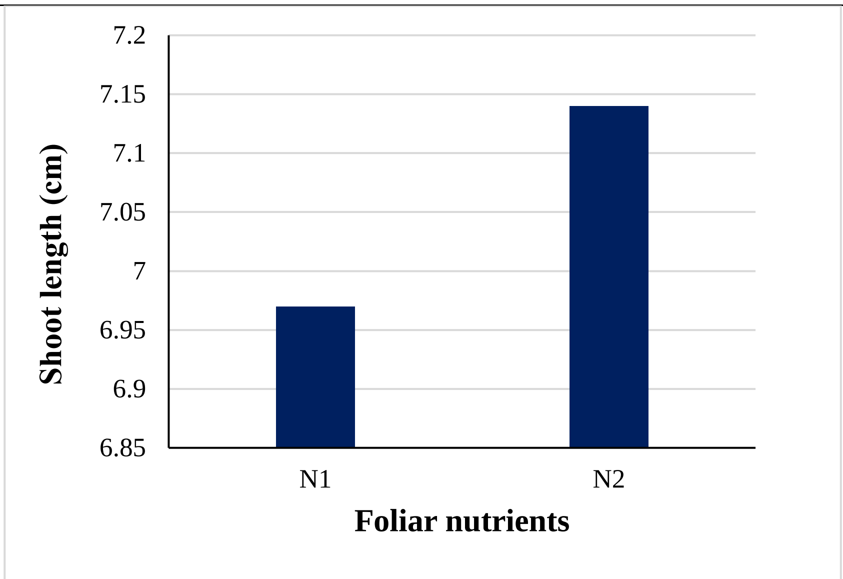


Figure 18. Effect of foliar nutrients on shoot length

SUMMARY

6. SUMMARY

The present study entitled "Standardization of soilless medium and foliar nutrients for potted ornamental foliage plants" was conducted at the Department of Floriculture and Landscape Architecture at the College of Agriculture, Vellanikkara, Thrissur, Kerala during 2020-21.

The experiment was laid out in a completely randomized design (factorial) using 5 growing media *viz*., M_1: cocopeat (50%) + vermicompost (30%) + perlite (10%) + vermiculite (10%), M_2: cocopeat (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) +vermiculite (10%), M_3: coco chips (50%) + vermicompost (30%) + Perlite (10%) + Vermiculite (10%), M_4: coco chips (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%), M_5: cocopeat (60%) + vermicompost (20%) + perlite (20%) and 2 foliar nutrients *viz*., N_1 : 19:19:19 at 2 g/L and N_2: seaweed extract at 10ml/L with 10 treatment combinations *viz*., T_1: M_1 x N_1, T_2: M_2 x N_1, T_3: M_3 x N_1, T_4: M_4 x N_1, T_5: M_5 x N_1, T_6: M_1 x N_2, T_7: M_2 x N_2, T_8: M_3 x N_2, T_9: M_4 x N_2, T_{10}: M_5 x N_2 each with three replications. Popular ornamental foliage plant *Philodendron xanadu* was used in the experiment. The salient findings of the study are outlined here.

Growing media had a significant influence on vegetative parameters during the period of experiment. M_2 [cocopeat (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) +vermiculite (10%)] and M_4 [coco chips (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%)] were on par and statistically superior with respect to plant height, plant spread, leaf length, leaf width, petiole length, leaf area, leaf longevity, leaf production interval, shoot girth, shoot length, fresh and dry weights of the leaves. Growing medium M_1 [cocopeat (50%) + vermicompost (30%) + perlite (10%) + vermiculite (10%)] also found to be superior for plant height, petiole length and shoot length.

With regard to root parameters, significant influence of growing media was observed only on root length, number of laterals and root volume. Growing media M_2 [cocopeat (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) +vermiculite (10%)] and M_4 [coco chips (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%)] had greatest root length and number of lateral roots while maximum root volume was obtained in growing media M_1 [cocopeat (50%) + vermicompost (30%) + perlite (10%) + vermiculite (10%)] and M_4 [coco chips (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%)]. For fresh and dry weights of the roots, no significant difference was observed due to the growing media.

Plant nutrient content, plant nutrient uptake and total chlorophyll content was significantly influenced by the growing media. For plant nutrient content, media M_1 [cocopeat (50%) + vermicompost (30%) + perlite (10%) + vermiculite (10%)] and M_2 [cocopeat (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) +vermiculite (10%)] were on par and statistically superior due to the growing media whereas highest plant nutrient uptake was obtained in M_1 [cocopeat (50%) + vermicompost (30%) + perlite (10%) + vermiculite (10%)], M_2 [cocopeat (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) +vermiculite (10%)] and M_4 [coco chips (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%)]. Highest total chlorophyll content was noticed in media 4 (M_4).

With regard to foliar nutrients, vegetative parameters like plant spread, number of leaves, leaf length, leaf width, petiole length, leaf longevity, leaf production interval, leaf area, shoot girth, shoot length, fresh and dry weights of the leaves and root parameters like fresh weight of the roots, dry weight of the roots, number of lateral roots, root volume were not influenced by foliar nutrients. Significant variation was noticed only with respect to plant height and root length. N_1 (NPK-19:19:19 at 2 g/L) was found to be superior with respect to plant height whereas greatest root length was obtained with application of N_2 (seaweed extract at 10 ml/L). With respect to plant nutrient content, application of foliar nutrients had significant influence only with respect to nitrogen content and highest nitrogen content was observed with application of N_1 (NPK-19:19:19 at 2 g/L).

There was a significant difference due to the M x N interaction on plant height, number of leaves, leaf area, leaf production interval, shoot length, fresh weight of the roots, dry weight of the roots, root length, plant nutrient content and total chlorophyll content. Interaction effect of both growing media and foliar nutrients with respect to majority of these parameters were evident in treatment combinations of T_2 - M_2 x N_1 [cocopeat (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%) and 19:19:19 at 2 g/L], T_4 - M_4 x N_1 [coco chips (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%) and 19:19:19 at 2 g/L], T_7 - M_2 x N_2 [cocopeat (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%) and seaweed extract at 10 ml/L] and T_9 - M_4 x N_2 [coco chips (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%) and seaweed extract at 10 ml/L].

Physical properties of media were analysed before the experiment. The lowest bulk density with greatest porosity was recorded in growing medium M_4 [coco chips (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%)] whereas greatest water holding capacity was recorded in M_5 [cocopeat (60%) + vermicompost (20%) + perlite (20%)]. With respect to chemical properties of media, all media had favourable range of values for both pH and EC however among different media highest pH and EC value was obtained in M_4 both before and after the experiment. M_2 [cocopeat (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) +vermiculite (10%)] was noted with highest available nitrogen content and highest available phosphorous and potassium content were observed in M_4 before the experiment.

Considering all the vegetative parameters, root parameters, media properties and nutrient status of the plant, it was observed that plants grown in media 2 and 4 had all quality criteria for potted ornamental foliage plants. The major components of these media were cocopeat in M_2 and coco chips in M_4 which contribute 50% of the growing media composition. In addition to this, both of these media consisted of components such as vermicompost, neem cake, vermiculite and perlite. The better performance of plants of these media is due to beneficial effects of media components. Additional amendment added in these media is neem cake. Being organic, neem cake might have nourished the plants and also provided tolerance to pests resulting better plant growth. M_4 consisting of coco chips (0.3 Kg), vermicompost (0.60 Kg), neem cake (0.25 Kg), perlite (0.10 Kg) and vermiculite (0.16 Kg) was found to have lowest weight and cost of growing medium per pot.

Among foliar nutrients, efficacy of both nutrient formulations were found to be the same and it may be concluded that use of seaweed extract is beneficial as it is organic fertilizer which contains enormous amount of nutrients and growth promoting hormones.

Hence the media M_4 containing coco chips (50%), vermicompost (20%), neem cake (10%), perlite (10%), vermiculite (10%) as well as M_2 containing cocopeat (50%), vermicompost (20%), neem cake (10%), perlite (10%), vermiculite (10%) in combination with N_2 (seaweed extract at 10ml/L) can be recommended for compact growth of potted ornamental foliage plants for interior scaping.

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APPENDIX

Appendix 1. Effect of growing media and foliar nutrients on plant height (cm) of *Philodendron xanadu*

Treatments		Dec-20	Jan-21	Feb-21	Mar-21	Apr-21	May-21
GROWING MEDIA	M_1	23.78	25.67	27.72	30.03	33.28	36.16
	M_2	25.92	27.36	28.97	31.14	34.44	37.67
	M_3	24.55	25.61	26.80	28.36	29.83	31.06
	M_4	24.47	26.94	29.64	32.25	34.83	37.72
	M_5	24.44	25.5	26.5	27.64	28.55	29.22
CD (0.05)		NS	NS	2.31	2.56	2.79	2.19
SE(m)		0.61	0.79	0.78	0.86	0.92	0.74
FOLIAR NUTRIENTS	N_1	24.23	26.04	27.90	30.03	32.69	35.27
	N_2	25.03	26.39	27.96	29.73	31.69	33.47
CD (0.05)		NS	NS	NS	NS	NS	1.39
SE(m)		0.39	0.50	0.49	0.54	0.71	0.47

Growing media	M_1: cocopeat (50%) + vermicompost (30%) + perlite (10%) + vermiculite (10%) M_2: cocopeat (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%) M_3: coco chips (50%) + vermicompost (30%) + perlite (10%) + vermiculite (10%) M_4: coco chips (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%) M_5: cocopeat (60%) + vermicompost (20%) + perlite (20%)
Foliar nutrients	N_1: NPK-19:19:19 at 2g/L N_2: seaweed extract at 10 ml/L

Appendix 2. Effect of M x N interaction on plant height (cm) of *Philodendron xanadu*

Treatments		Dec-20	Jan-21	Feb-21	Mar-21	Apr-21	May-21
T_1	M_1 x N_1	21.33	24	26.67	29.39	33.67	37.33
T_2	M_2 x N_1	26.5	27.89	29.28	31.28	35.11	38.78
T_3	M_3 x N_1	24.00	25.28	26.83	29.06	30.89	32.56
T_4	M_4 x N_1	24.67	27.5	30.33	33.17	36.00	39.78
T_5	M_5 x N_1	24.68	25.56	26.39	27.28	27.78	27.89
T_6	M_1 x N_2	26.22	27.33	28.78	30.67	32.89	35.00
T_7	M_2 x N_2	25.33	26.83	28.67	31.00	33.78	36.56
T_8	M_3 x N_2	25.11	25.94	26.78	27.67	28.78	29.56
T_9	M_4 x N_2	24.28	26.39	28.94	31.33	33.67	35.67
T_{10}	M_5 x N_2	24.22	25.44	26.61	28.00	29.33	30.56
CD (0.05)		2.57	NS	NS	NS	NS	3.10
SE(m)		0.87	1.13	1.10	1.22	1.59	1.04

Growing media	M_1: cocopeat (50%) + vermicompost (30%) + perlite (10%) + vermiculite (10%) M_2: cocopeat (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%) M_3: coco chips (50%) + vermicompost (30%) + perlite (10%) + vermiculite (10%) M_4: coco chips (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%) M_5: cocopeat (60%) + vermicompost (20%) + perlite (20%)
Foliar nutrients	N_1: NPK-19:19:19 at 2g/L N_2: seaweed extract at 10 ml/L

Appendix 3. Effect of growing media and foliar nutrients on plant spread (cm) of *Philodendron xanadu*

Treatments		Dec-20	Jan-21	Feb-21	Mar-21	Apr-21	May-21
GROWING MEDIA	**M_1**	96.72	99.27	101.72	104.61	107.66	110.615
	M_2	102.33	106.11	109.05	111.67	113.94	116.28
	M_3	90.39	93.44	98.00	102.22	104.72	107.72
	M_4	97.38	101.33	105.27	109.11	113.44	118.11
	M_5	94.06	97.55	99.55	101.33	103.44	105.16
CD (0.05)		7.46	7.44	7.28	7.50	6.90	6.62
SE(m)		2.51	2.50	2.45	2.52	2.32	2.23
FOLIAR NUTRIENTS	**N_1**	97.13	101.04	104.16	106.84	109.62	112.04
	N_2	95.22	98.04	101.29	104.73	107.67	111.11
CD (0.05)		NS	NS	NS	NS	NS	NS
SE(m)		1.59	1.58	1.55	1.59	1.47	1.41

Growing media	M_1: cocopeat (50%) + vermicompost (30%) + perlite (10%) + vermiculite (10%) M_2: cocopeat (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%) M_3: coco chips (50%) + vermicompost (30%) + perlite (10%) + vermiculite (10%) M_4: coco chips (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%) M_5: cocopeat (60%) + vermicompost (20%) + perlite (20%)
Foliar nutrients	N_1: NPK-19:19:19 at 2g/L N_2: seaweed extract at 10 ml/L

Appendix 4. Effect of M x N interaction on plant spread (cm) of *Philodendron xanadu*

Treatments		Dec-20	Jan-21	Feb-21	Mar-21	Apr-21	May-21
T_1	**M_1 x N_1**	95.33	99.22	101.67	104.56	108.22	111.67
T_2	**M_2 x N_1**	100.67	105.33	108.89	111.67	114.89	117.78
T_3	**M_3 x N_1**	93.67	96.78	101.11	104.44	106.33	108.44
T_4	**M_4 x N_1**	103.44	107.78	111.22	114.33	117.89	120.44
T_5	**M_5 x N_1**	92.56	96.11	97.89	99.22	100.78	101.89
T_6	**M_1 x N_2**	98.11	99.33	101.78	104.67	107.11	109.56
T_7	**M_2 x N_2**	104.00	106.89	109.22	111.67	113.00	114.78
T_8	**M_3 x N_2**	87.11	90.11	94.89	100.00	103.11	107.00
T_9	**M_4 x N_2**	91.33	94.89	99.33	103.89	109.00	115.78
T_{10}	**M_5 x N_2**	95.56	99.00	101.22	103.44	106.11	108.44
CD (0.05)		NS	NS	NS	NS	NS	NS
SE(m)		3.55	3.54	3.46	3.57	3.29	3.15

Growing media	M_1: cocopeat (50%) + vermicompost (30%) + perlite (10%) + vermiculite (10%) M_2: cocopeat (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%) M_3: coco chips (50%) + vermicompost (30%) + perlite (10%) + vermiculite (10%) M_4: coco chips (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%) M_5: cocopeat (60%) + vermicompost (20%) + perlite (20%)
Foliar nutrients	N_1: NPK-19:19:19 at 2g/L N_2: seaweed extract at 10 ml/L

Appendix 5. Effect of growing media and foliar nutrients on number of leaves of *Philodendron xanadu*

Treatments		Dec-20	Jan-21	Feb-21	Mar-21	Apr-21	May-21
GROWING MEDIA	M_1	18.17	20.72	22.55	24.89	27.55	30.22
	M_2	19.33	22.67	24.89	27.89	30.89	34.11
	M_3	17.94	19.11	20.11	21.83	24.17	26.72
	M_4	18.00	21.11	23.72	26.78	30.39	34.05
	M_5	16.28	16.89	17.50	18.38	20.28	21.89
CD (0.05)		NS	2.24	2.26	2.39	2.49	2.91
SE(m)		0.81	0.75	0.76	0.80	0.84	0.98
FOLIAR NUTRIENTS	N_1	17.04	19.38	21.07	23.69	26.64	29.64
	N_2	18.84	20.82	22.44	24.22	26.67	29.16
CD (0.05)		1.53	1.42	NS	NS	NS	NS
SE(m)		0.51	0.48	0.48	0.51	0.53	0.62

Growing media	M_1: cocopeat (50%) + vermicompost (30%) + perlite (10%) + vermiculite (10%) M_2: cocopeat (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%) M_3: coco chips (50%) + vermicompost (30%) + perlite (10%) + vermiculite (10%) M_4: coco chips (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%) M_5: cocopeat (60%) + vermicompost (20%) + perlite (20%)
Foliar nutrients	N_1: NPK-19:19:19 at 2g/L N_2: seaweed extract at 10 ml/L

Appendix 6. Effect of M x N interaction on number of leaves of *Philodendron xanadu*

Treatments		Dec-20	Jan-21	Feb-21	Mar-21	Apr-21	May-21
T_1	$M_1 \times N_1$	17.67	20.67	23.33	26.67	29.78	32.67
T_2	$M_2 \times N_1$	18.56	22.56	24.67	28.44	32.22	36.44
T_3	$M_3 \times N_1$	16.11	17.22	18.22	20.22	22.89	25.89
T_4	$M_4 \times N_1$	17.33	20.78	23.00	26.67	30.89	35.00
T_5	$M_5 \times N_1$	15.56	15.67	16.11	16.44	17.44	18.22
T_6	$M_1 \times N_2$	18.67	20.78	21.78	23.11	25.33	27.78
T_7	$M_2 \times N_2$	20.11	22.78	25.11	27.33	29.56	31.78
T_8	$M_3 \times N_2$	19.78	21.00	22.00	23.44	25.44	27.56
T_9	$M_4 \times N_2$	18.67	21.44	24.44	26.89	29.89	33.11
T_{10}	$M_5 \times N_2$	17.00	18.11	18.89	20.33	23.11	25.56
CD (0.05)		NS	NS	NS	3.38	3.53	4.12
SE(m)		1.15	1.07	1.07	1.14	1.19	1.39

Growing media	M_1: cocopeat (50%) + vermicompost (30%) + perlite (10%) + vermiculite (10%) M_2: cocopeat (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%) M_3: coco chips (50%) + vermicompost (30%) + perlite (10%) + vermiculite (10%) M_4: coco chips (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%) M_5: cocopeat (60%) + vermicompost (20%) + perlite (20%)
Foliar nutrients	N_1: NPK-19:19:19 at 2g/L N_2: seaweed extract at 10 ml/L

Appendix 7. Effect of growing media and foliar nutrients on leaf length (cm) of *Philodendron xanadu*

Treatments		Dec-20	Jan-21	Feb-21	Mar-21	Apr-21	May-21
GROWING MEDIA	M_1	11.43	11.46	11.51	11.53	11.56	11.60
	M_2	12.39	12.44	12.50	12.54	12.56	12.64
	M_3	11.08	11.12	11.16	11.19	11.23	11.27
	M_4	11.75	11.79	11.83	11.87	11.9	11.93
	M_5	10.60	10.64	10.66	10.70	10.73	10.75
CD (0.05)		0.71	0.72	0.72	0.72	0.72	0.73
SE(m)		0.24	0.24	0.24	0.24	0.24	0.25
FOLIAR NUTRIENTS	N_1	11.45	11.49	11.53	11.57	11.60	11.63
	N_2	11.46	11.5	11.54	11.57	11.60	11.65
CD (0.05)		NS	0.46	NS	NS	NS	NS
SE(m)		0.15	0.15	0.15	0.15	0.15	0.16

Growing media	M_1: cocopeat (50%) + vermicompost (30%) + perlite (10%) + vermiculite (10%) M_2: cocopeat (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%) M_3: coco chips (50%) + vermicompost (30%) + perlite (10%) + vermiculite (10%) M_4: coco chips (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%) M_5: cocopeat (60%) + vermicompost (20%) + perlite (20%)
Foliar nutrients	N_1: NPK-19:19:19 at 2g/L N_2: seaweed extract at 10 ml/L

Appendix 8. Effect of M x N interaction on leaf length (cm) of *Philodendron xanadu*

Treatments		Dec-20	Jan-21	Feb-21	Mar-21	Apr-21	May-21
T_1	$M_1 \times N_1$	11.44	11.46	11.49	11.51	11.54	11.57
T_2	$M_2 \times N_1$	12.60	12.67	12.74	12.79	12.82	12.86
T_3	$M_3 \times N_1$	11.10	11.15	11.18	11.20	11.24	11.28
T_4	$M_4 \times N_1$	11.70	11.73	11.77	11.80	11.83	11.86
T_5	$M_5 \times N_1$	10.39	10.46	10.49	10.55	10.57	10.59
T_6	$M_1 \times N_2$	11.42	11.47	11.53	11.56	11.59	11.64
T_7	$M_2 \times N_2$	12.18	12.22	12.27	12.29	12.31	12.43
T_8	$M_3 \times N_2$	11.07	11.09	11.15	11.19	11.22	11.26
T_9	$M_4 \times N_2$	11.81	11.86	11.90	11.94	11.97	12.01
T_{10}	$M_5 \times N_2$	10.82	10.83	10.84	10.86	10.89	10.92
CD (0.05)		NS	NS	NS	NS	NS	NS
SE(m)		0.34	0.34	0.34	0.34	0.34	0.35

Growing media	M_1: cocopeat (50%) + vermicompost (30%) + perlite (10%) + vermiculite (10%) M_2: cocopeat (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%) M_3: coco chips (50%) + vermicompost (30%) + perlite (10%) + vermiculite (10%) M_4: coco chips (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%) M_5: cocopeat (60%) + vermicompost (20%) + perlite (20%)
Foliar nutrients	N_1: NPK-19:19:19 at 2g/L N_2: seaweed extract at 10 ml/L

Appendix 9. Effect of growing media and foliar nutrients on leaf width (cm) of *Philodendron xanadu*

Treatments		Dec-20	Jan-21	Feb-21	Mar-21	Apr-21	May-21
GROWING MEDIA	**M_1**	5.20	5.20	5.23	5.25	5.28	5.29
	M_2	5.72	5.73	5.75	5.77	5.79	5.81
	M_3	5.00	5.01	5.04	5.05	5.07	5.08
	M_4	5.50	5.52	5.54	5.56	5.57	5.59
	M_5	4.65	4.67	4.70	4.72	4.74	4.76
CD (0.05)		0.49	0.49	0.49	0.49	0.49/	0.50
SE(m)		0.16	0.16	0.16	0.17	0.17	0.17
FOLIAR NUTRIENTS	**N_1**	5.18	5.19	5.22	5.24	5.26	5.28
	N_2	5.25	5.26	5.28	5.30	5.32	5.34
CD (0.05)		NS	NS	NS	NS	NS	NS
SE(m)		0.10	0.10	0.10	0.10	0.11	0.11

Growing media	M_1: cocopeat (50%) + vermicompost (30%) + perlite (10%) + vermiculite (10%) M_2: cocopeat (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%) M_3: coco chips (50%) + vermicompost (30%) + perlite (10%) + vermiculite (10%) M_4: coco chips (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%) M_5: cocopeat (60%) + vermicompost (20%) + perlite (20%)
Foliar nutrients	N_1: NPK-19:19:19 at 2g/L N_2: seaweed extract at 10 ml/L

Appendix 10. Effect of M x N interaction on leaf width (cm) of *Philodendron xanadu*

Treatments		Dec-20	Jan-21	Feb-21	Mar-21	Apr-21	May-21
T_1	$M_1 \times N_1$	5.15	5.15	5.18	5.20	5.24	5.26
T_2	$M_2 \times N_1$	5.78	5.79	5.81	5.83	5.85	5.87
T_3	$M_3 \times N_1$	4.96	4.96	4.99	5.01	5.03	5.04
T_4	$M_4 \times N_1$	5.46	5.48	5.51	5.53	5.54	5.56
T_5	$M_5 \times N_1$	4.59	4.62	4.64	4.65	4.66	4.67
T_6	$M_1 \times N_2$	5.26	5.26	5.28	5.30	5.32	5.33
T_7	$M_2 \times N_2$	5.66	5.68	5.69	5.72	5.74	5.75
T_8	$M_3 \times N_2$	5.05	5.06	5.09	5.10	5.12	5.13
T_9	$M_4 \times N_2$	5.55	5.56	5.57	5.59	5.61	5.63
T_{10}	$M_5 \times N_2$	4.72	4.73	4.77	4.79	4.83	4.85
CD (0.05)		NS	NS	NS	NS	NS	NS
SE(m)		0.23	0.23	0.23	0.23	0.24	0.24

Growing media	M_1: cocopeat (50%) + vermicompost (30%) + perlite (10%) + vermiculite (10%) M_2: cocopeat (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%) M_3: coco chips (50%) + vermicompost (30%) + perlite (10%) + vermiculite (10%) M_4: coco chips (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%) M_5: cocopeat (60%) + vermicompost (20%) + perlite (20%)
Foliar nutrients	N_1: NPK-19:19:19 at 2g/L N_2: seaweed extract at 10 ml/L

Appendix 11. Effect of growing media and foliar nutrients on petiole length (cm) of *Philodendron xanadu*

Treatments		Dec-20	Jan-21	Feb-21	Mar-21	Apr-21	May-21
GROWING MEDIA	M_1	17.69	17.85	18.06	18.25	18.45	18.63
	M_2	18.23	18.42	18.63	18.86	19.02	19.20
	M_3	17.61	17.85	18.04	18.27	18.49	18.67
	M_4	18.72	18.90	19.09	19.29	19.43	19.54
	M_5	16.86	17.00	17.16	17.32	17.47	17.64
CD (0.05)		1.55	1.17	1.16	1.15	1.14	1.15
SE(m)		0.39	0.39	0.39	0.39	0.38	0.39
FOLIAR NUTRIENTS	N_1	17.79	17.99	18.20	18.41	18.57	18.73
	N_2	17.86	18.01	18.19	18.39	18.57	18.74
CD (0.05)		NS	NS	NS	0.73	0.72	0.73
SE(m)		0.25	0.25	0.25	0.25	0.24	0.24

Growing media	M_1: cocopeat (50%) + vermicompost (30%) + perlite (10%) + vermiculite (10%) M_2: cocopeat (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%) M_3: coco chips (50%) + vermicompost (30%) + perlite (10%) + vermiculite (10%) M_4: coco chips (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%) M_5: cocopeat (60%) + vermicompost (20%) + perlite (20%)
Foliar nutrients	N_1: NPK-19:19:19 at 2g/L N_2: seaweed extract at 10 ml/L

Appendix 12. Effect of M x N interaction on petiole length (cm) of *Philodendron xanadu*

Treatments		Dec-20	Jan-21	Feb-21	Mar-21	Apr-21	May-21
T_1	M_1 x N_1	17.63	17.83	18.08	18.27	18.45	18.62
T_2	M_2 x N_1	18.31	18.54	18.77	19.03	19.18	19.36
T_3	M_3 x N_1	17.49	17.77	17.96	18.18	18.41	18.61
T_4	M_4 x N_1	18.80	19.00	19.20	19.40	19.56	19.70
T_5	M_5 x N_1	16.71	16.85	17.00	17.17	17.28	17.38
T_6	M_1 x N_2	17.76	17.87	18.05	18.24	18.45	18.65
T_7	M_2 x N_2	18.16	18.30	18.49	18.69	18.87	19.04
T_8	M_3 x N_2	17.73	17.93	18.13	18.37	18.58	18.74
T_9	M_4 x N_2	18.64	18.81	18.99	19.19	19.31	19.39
T_{10}	M_5 x N_2	17.01	17.15	17.33	17.47	17.66	17.89
CD (0.05)		NS	NS	NS	NS	NS	NS
SE(m)		0.55	0.55	0.55	0.55	0.55	0.55

Growing media	M_1: cocopeat (50%) + vermicompost (30%) + perlite (10%) + vermiculite (10%) M_2: cocopeat (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%) M_3: coco chips (50%) + vermicompost (30%) + perlite (10%) + vermiculite (10%) M_4: coco chips (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%) M_5: cocopeat (60%) + vermicompost (20%) + perlite (20%)
Foliar nutrients	N_1: NPK-19:19:19 at 2g/L N_2: seaweed extract at 10 ml/L

Appendix 13. Effect of growing media and foliar nutrients on leaf area (cm^2) of *Philodendron xanadu*

Treatments		Dec-20	Jan-21	Feb-21	Mar-21	Apr-21	May-21
GROWING MEDIA	M_1	577.48	659.08	723.89	801.08	891.47	981.98
	M_2	721.18	857.63	945.59	1069.09	1191.47	1330.16
	M_3	527.94	564.59	599.43	654.68	729.23	810.40
	M_4	617.02	727.96	824.95	937.98	1070.71	1206.11
	M_5	426.24	446.49	466.50	494.53	550.09	597.74
CD (0.05)		103.93	105.32	114.58	123.98	129.34	145.43
SE(m)		34.98	35.45	38.57	41.73	43.54	48.95
FOLIAR NUTRIENTS	N_1	542.10	626.90	688.09	782.84	888.45	996.65
	N_2	605.84	675.40	735.05	800.11	884.74	973.91
CD (0.05)		NS	NS	NS	NS	NS	NS
SE(m)		22.13	22.42	24.39	26.39	27.53	30.96

Growing media	M_1: cocopeat (50%) + vermicompost (30%) + perlite (10%) + vermiculite (10%) M_2: cocopeat (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%) M_3: coco chips (50%) + vermicompost (30%) + perlite (10%) + vermiculite (10%) M_4: coco chips (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%) M_5: cocopeat (60%) + vermicompost (20%) + perlite (20%)
Foliar nutrients	N_1: NPK-19:19:19 at 2g/L N_2: seaweed extract at 10 ml/L

Appendix 14. Effect of M x N interaction on leaf area (cm^2) of *Philodendron xanadu*

Treatments		Dec-20	Jan-21	Feb-21	Mar-21	Apr-21	May-21
T_1	M_1 x N_1	554.86	649.56	739.79	848.15	953.11	1049.49
T_2	M_2 x N_1	706.87	876.89	961.32	1118.51	1276.66	1457.49
T_3	M_3 x N_1	469.49	503.36	536.62	599.35	683.29	776.48
T_4	M_4 x N_1	585.77	703.61	787.34	920.97	1073.64	1222.35
T_5	M_5 x N_1	393.52	401.09	415.40	427.22	455.55	477.45
T_6	M_1 x N_2	600.09	668.61	707.98	754.02	829.84	914.48
T_7	M_2 x N_2	735.48	838.37	929.87	1019.68	1106.28	1202.83
T_8	M_3 x N_2	586.39	625.84	662.24	710.01	775.18	844.32
T_9	M_4 x N_2	648.27	752.30	862.57	954.99	1067.79	1189.88
T_{10}	M_5 x N_2	458.96	491.87	517.60	561.84	644.63	718.03
CD (0.05)		NS	NS	NS	NS	182.91	205.67
SE(m)		49.47	50.14	54.55	59.02	61.57	69.23

Growing media	M_1: cocopeat (50%) + vermicompost (30%) + perlite (10%) + vermiculite (10%) M_2: cocopeat (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%) M_3: coco chips (50%) + vermicompost (30%) + perlite (10%) + vermiculite (10%) M_4: coco chips (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%) M_5: cocopeat (60%) + vermicompost (20%) + perlite (20%)
Foliar nutrients	N_1: NPK-19:19:19 at 2g/L N_2: seaweed extract at 10 ml/L

Appendix 15. Meteorological data during the period of observation

Monthly data (2020-2021)						
Month	**Temperature (°C)**		**RH (%)**			**Rainfall (mm)**
	Max.	**Min.**	**I**	**II**	**Mean**	
December-2020	32.3	21.9	75	55	65	7.7
January-2021	32.3	21.3	78	50	64	45.7
February-2021	34.6	21.6	70	38	54	0.0
March-2021	36.8	23.0	84	34	59	31.8
April-2021	34.9	23.6	89	58	74	72.4

STANDARDIZATION OF SOILLESS MEDIUM AND FOLIAR NUTRIENTS FOR POTTED ORNAMENTAL FOLIAGE PLANTS

By

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ABSTRACT OF THE THESIS

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ABSTRACT

The study entitled "Standardization of soilless medium and foliar nutrients for potted ornamental foliage plants" was conducted at the Department of Floriculture and Landscape Architecture at the College of Agriculture, Vellanikkara during 2020-21. The objective of the study was to standardize soilless medium and foliar nutrients for potted ornamental foliage plants and to work out the economics. Growing media combinations comprised of cocopeat, coco chips, vermicompost, neem cake, perlite and vermiculite in different proportions and foliar nutrients like NPK-19:19:19 and seaweed extract were evaluated to standardize the ideal potting medium and foliar nutrients for raising potted foliage plants.

The experiment was laid out in CRD (factorial) with 5 different growing media *viz*., M_1: cocopeat (50%) + vermicompost (30%) + perlite (10%) + vermiculite (10%), M_2: cocopeat (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) +vermiculite (10%), M_3: coco chips (50%) + vermicompost (30%) + Perlite (10%) + Vermiculite (10%), M_4: coco chips (50%) + vermicompost (20%) + neem cake (10%) + perlite (10%) + vermiculite (10%) and M_5: cocopeat (60%) + vermicompost (20%) + perlite (20%) and 2 different foliar nutrients *viz*., N_1 : NPK-19:19:19 at 2 g/L and N_2: seaweed extract (IFFCO-Sagarika) at 10ml/L with 10 treatment combinations *viz*., T_1: M_1 x N_1, T_2: M_2 x N_1, T_3: M_3 x N_1, T_4: M_4 x N_1, T_5: M_5 x N_1, T_6: M_1 x N_2, T_7: M_2 x N_2, T_8: M_3 x N_2, T_9: M_4 x N_2, T_{10}: M_5 x N_2 each with three replications. Popular ornamental foliage plant *Philodendron xanadu* was used in the experiment.

Vegetative characters are important parameters for potted ornamental foliage plants as they decide the attractiveness and presentability. There was a significant variation with respect to all vegetative parameters due to growing media. M_2 and M_4 were on par and statistically superior with respect to plant height, plant spread, leaf length, leaf width, petiole length, leaf longevity, leaf production interval, leaf area, shoot girth, shoot length, fresh and dry weights of the leaves. In general, it could be observed that plants grown in M_2 and M_4 had all quality criteria for potted ornamental foliage plants.

Root parameters determine the nutrient uptake, translocation and growth of the plants. During the experiment, significant influence of growing media was observed

only on root length, no. of laterals and root volume. Greatest no. of lateral roots as well as longest roots were observed in M_2 and M_4, whereas maximum root volume was noticed in M_1 and M_4. With respect to fresh and dry weights of the roots, no significant difference was noticed due to the growing media.

The physico-chemical properties of the media are important with respect to plants growth as they determine the growth of the root system and availability of nutrients. Medium M_4 had low bulk density and highest porosity which are desirable for growth of roots while medium M_5 was found to have highest water holding capacity. pH and EC of all the growing media were within the optimal range. Media M_2 and M_4 were observed to be promising with respect to plant nutrient content as well as plant nutrient uptake and total chlorophyll content

During the experiment, both NPK-19:19:19 and seaweed extract were applied as a foliar spray at fortnightly intervals. Application of foliar nutrients were found to be non-significant with respect to vegetative parameters *viz*., plant spread, number of leaves, leaf length, leaf width, petiole length, leaf longevity, leaf production interval, leaf area, shoot girth, shoot length, fresh and dry weights of the leaves and root parameters *viz*., fresh and dry weights of the roots, no. of lateral roots and root volume. However foliar nutrients were found to have a significant impact on plant height and root length. Application of N_1 recorded the greatest plant height whereas application of N_2 was found to have the greatest root length. Application of foliar nutrients had significant influence only with respect to nitrogen content and highest nitrogen content was observed with application of N_1

Growing media M_4 and M_2 performed well with respect to vegetative parameters, root parameters, physico-chemical properties of the media. Compact growth of plants and weightless growing media are desirable for interior scaping. Plants grown in M_4 and M_2 were found to have compact growth. These media were light in weight and cost was found less. Efficacy of both nutrient formulations were found to be the same and it may be concluded that use of N_2 is beneficial as seaweed extract is organic fertilizer which contains sufficient amount of nutrients and growth promoting hormones. Hence the media M_4 as well as M_2 in combination with N_2 (seaweed extract) can be recommended for compact growth of potted ornamental foliage plants for interior scaping.