STANDARDIZATION OF POTTING MEDIA FOR *Nephrolepis undulate* J. Sm UNDER PROTECTED CONDITION

KAVANA, G. B

MH2TAG0151

DEPARTMENT OF FLORICULTURE AND LANDSCAPE ARCHITECTURE COLLEGE OF HORTICULTURE, MUDIGERE

UNIVERSITY OF AGRICULTURAL AND HORTICULTURAL SCIENCES, SHIVAMOGGA

August, 2019

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Thesis submitted to the

UNIVERSITY OF AGRICULTURAL AND HORTICULTURAL SCIENCES, SHIVAMOGGA

In partial fulfilment of the requirements

For the award of the degree of

Master of Science (Horticulture)

In

FLORICULTURE AND LANDSCAPE ARCHITECTURE

Mudigere **August, 2019**

DEPARTMENT OF FLORICULTURE AND LANDSCAPE ARCHITECTURE
COLLEGE OF HORTICULTURE, MUDIGERE
UNIVERSITY OF AGRICULTURAL AND HORTICULTURAL SCIENCES
SHIVAMOGGA

CERTIFICATE

This is to certify that the thesis entitled **'STANDARDIZATION OF POTTING MEDIA FOR *Nephrolepis undulate* J. Sm UNDER PROTECTED CONDITION'** submitted in partial fulfillment of the requirements for the award of the degree of **MASTER OF SCIENCE (HORTICULTURE) in FLORICULTURE AND LANDSCAPE ARCHITECTURE to** the College of Horticulture, Mudigere, University of Agricultural and Horticultural Sciences, Shivamogga is a bonafide record of research work carried out by **Ms. KAVANA, G. B., ID NO. MH2TAG0151** (kavanabhyraiah@gmail.com) during the period of study in this university under my guidance and supervision and no part of this thesis has previously formed the basis for the award of any other degree, diploma, associateship, fellowship or any other similar titles

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3. _____
(HEMENTH KUMAR, P.)

ACKNOWLEDGEMENT

Words cannot express the love and gratitude that is in my heart, but this is my humble attempt…A seed cannot grow itself to a gigantic tree, it needs a lot of support from all the single element which exists on the earth. Likewise, a good research work doesn't exist without the support of many hands. This is the best forum to express my deep sense of gratitude to the supporting hands behind me in accomplishing this present investigation.

Firstly, I thank GOD for the good health, essential strength and knowledge he has afforded me through my education trajectory. I couldn't have accomplished this phase of my education without HIS divine blessings to find my way towards a glorious career amidst several hurdles and struggles

With immense pleasure and pride, I owe my deepest gratitude to my beloved Chairperson, **Dr. Chandrashekar, S. Y.** Asst. Professor, Department of Floriculture and Landscape Architecture, College of Horticulture, Mudigere, for his generous, splendid and enthusiastic guidance till last minute helped me in completing this task source of my spirit every moment. It is definitely more difficult to acknowledge his unflinching courage and conviction, valuable suggestions and constructive criticism during the investigation and preparation of the manuscript. Language is inadequate to voice my deep sense of reverence and gratitude for his meticulous care, sustained encouragement and timely help throughout my research work.

I take this opportunity to record my heartfelt thanks and gratitude to my beloved advisory committee members, **Dr. Hanumantharaya, L,** Professor and Head of Department of Entomology, College of Horticulture, Mudigere who rendered valuable help, suggestions, genuine cooperation and constant encouragement provided at every stage of the thesis preparation

It's my fortune to gratefully acknowledge my deep sense of pride and dignity. I humbly place on record my respect and gratitude to **Dr. Sarvajna B. Salimath** Assistant Professor, Assistant Professor (SS&AC), Office of Dean (pgs.) UAHS, Navile, Shivamogga for his marvellous guidance and valuable suggestions during the course of research work.

I am humbly offer my sincere thanks to **Mr. Hemanth kumar, P.** Assistant Professor, Department of Floriculture and Landscape Architecture, College of Horticulture, Hiriyur and member of my Advisory Committee.

I owe my flow of thanks to **Dr. M. Hanumanthappa**, Dean, College of Horticulture, Mudigere, for generous assistance constructive criticism during the studies and for the valuable comments and suggestion in preparation of this thesis.

I am ever indebted to **Mr. Natraj, S. K.,** Assistant Professor and Head, Department of Floriculture and Landscape Architecture and **Dr. Latha** Assistant Professor (Cont.) Department of FLA.

My deepest appreciation goes to my beloved father **Mr. Bhyraiah, G.** for his generous love, care and affection, encouragement, moral support, prayers and guidance which kept me focused and motivated. I am grateful to him for giving me the life I ever dreamed. I can't express my gratitude for my mother **Mrs. Saroja, B.** in words, whose unconditional love has been my greatest strength. She was always beside me during the happy and hard moments to push me and motivate me. I owe a very important debt to my ever-loving and caring brother **Mr. Kiran, G. B**.

It is my pleasure to extend my sincere thanks to my batch mates **Ragini, Shilna, Chaithra, Sahana, Asha, Manasa, Rashmi, Shifa, Chandini, Neethu, Chithra, Amulya, Ruchitha, Shilpa, Raju, Vidya, Sushmitha, Sreelakshmi, Sandesh, Harish, Krishna, Sathish and others** who inspired me to hold tight to my position no matter how complicated it gets, and your friendship has been a welcome release when I get fed up.

I am also thankful to my beloved seniors **Roopa, Priyanka, Vibha, Akshatha, Vidyashree, Bhargavi,** and juniors **Jaya, Sindhu** and **Chaitra,** and lab assistant **Rukmini aunty** who gave timely support and cooperation and helped throughout the study. My sincere thanks to library staffs **Ramachandra, Manu, Shahanaz, Arpitha** for their constant help and support during my M. Sc. programme.

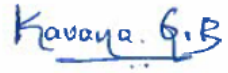
I avail this opportunity to express my heartfelt thanks to Ratan, Vinay, Gavi, Giriyappana, Vishala and Suma, for their kind help during, a research programme.

I would also like to thank the teaching and non-teaching staffs of College of Horticulture, Mudigere and College of Agriculture, Shivamogga, who helped me to accomplish my research work.

Last but not least my heartfelt thanks to my PG and UG students who had boosted me while doing my M.Sc. Programme.

I wish to thank all the others who had helped me in one way or the other in completing the study.

MUDIGERE
August, 2019



(KAVANA, G.B.)

STANDARDIZATION OF POTTING MEDIA FOR *Nephrolepis undulate* J. Sm UNDER PROTECTED CONDITION

(KAVANA, G. B)

ABSTRACT

An investigation on "Standardization of potting media for *Nephrolepis undulate* J. Sm under protected condition" was carried out in experimental block of Department of Floriculture and Landscape Architecture. College of Horticulture Mudigere during 2018 – 2019. The experiment consists of ten treatments *viz*., T_1 - Soil + Sand + FYM (2:1:1), T_2 - Soil + Cocopeat + Vermicompost (2:1:1), T_3 - Soil + Coir pith + Vermicompost (2:1:1), T_4 - Soil + Cocopeat + FYM + Vermicompost (2:1:1:1), T_5 - Soil + Perlite + Coir pith + Vermicompost (2:1:1:1), T_6 - Cocopeat + Sand + FYM (2:1:1), T_7 - Cocopeat + Vermicompost + Coir pith (2:1:1), T_8 - Cocopeat + Vermicompost + FYM (2:1:1), T_9 - Cocopeat + Perlite + Sand + Vermicompost (2:1:1:1) and T_{10} - Cocopeat + Perlite + Coir pith + Vermicompost (2:1:1:1) with three replications with Completely Randomized Design (CRD). The suckers were planted in the 12" pots during October 2018. The significant differences were observed in the treatments. Among them the plants which are grown in the media soil + cocopeat + FYM + vermicompost recorded the maximum plant height (95.30 cm), plant spread in EW and NS (72.00 and 73.67 cm, respectively), number of shoots (6.17), number of croziers (3.10), number of fronds (12.00), frond length and width (87.00 and 15.67 cm, respectively), number of leaflets per frond, sori per leaflet (135.00 and 63.00), total chlorophyll and visual plant grade (2.96 mg/g of fresh weight and 4.85, respectively), shelf and vase life (8.00 and 20.33 days, respectively), N, P and K (5.10, 0.59 and 2.65 %, respectively) with maximum net returns and benefit cost (2.15) ratio. From the investigation, it is concluded that, media containing soil + cocopeat + FYM + vermicompost has significantly enhanced the vegetative, reproductive and quality parameters of *Nephrolepis* fern.

Kavana. G.B
Kavana, G.B
(kavanabhyraiah@gmail.com)

Department of Floriculture and Landscape Architecture
College of Horticulture, Mudigere
UAHS, Shivamogga
August, 2019

Dr. Chandrashekar, S. Y
(chandrashekar.sy@gmail.com)

ಸಂರಕ್ಷಿತ ವಾತವರಣದಲ್ಲಿ ನೆಪ್ರೋಲಿಪಿಸ್ ಅಂಡುಲೇಟ್ ಜೆ. ಎಸ್ ಜರಿಗಿಡದ ಮಾಧ್ಯಮ ಪ್ರಮಾಣೀಕರಣದ ಅಧ್ಯಯನ

(ಕವನ, ಜಿ. ಬಿ)

ಸಾರಾಂಶ

ಸಂರಕ್ಷಿತ ವಾತವರಣದಲ್ಲಿ ನೆಪ್ರೋಲಿಪಿಸ್ ಅಂಡುಲೇಟ್ ಜೆ. ಎಸ್ ಜರಿಗಿಡದ ಮಾಧ್ಯಮ ಪ್ರಮಾಣೀಕರಣದ ಅಧ್ಯಯನದ ಬಗ್ಗೆ ಕ್ಷೇತ್ರ ಸಂಶೋಧನೆಯನ್ನು ತೋಟಗಾರಿಕೆ ಮಹಾವಿದ್ಯಾಲಯ, ಮೂಡಿಗೆರೆಯ ಪುಷ್ಪ ಕೃಷಿ ಮತ್ತು ಉದ್ಯಾನ ವಿನ್ಯಾಸ ವಿಭಾಗ ಪ್ರಯೋಗಿಕ ಬ್ಲಾಕ್‌ನಲ್ಲಿ ೨೦೧೮-೧೯ ರ ಅವಧಿಯಲ್ಲಿ ಕೈಗೊಳ್ಳಲಾಯಿತು. ಪ್ರಯೋಗವನ್ನು ಪಾಲಿಮನೆಯಲ್ಲಿ ಮೂರು ಬಾರಿ ಪುನಾವರ್ತಿಸಿದ ಸಂಪೂರ್ಣ ಯಾದೃಚ್ಚಿಕ ವಿನ್ಯಾಸದಲ್ಲಿ ನಡೆಸಲಾಯಿತು. ಈ ಪ್ರಯೋಗದಲ್ಲಿ ಮಣ್ಣು + ಕೋಕೊ ಪೀಟ್ + ಕೊಟ್ಟಿಗೆ ಗೊಬ್ಬರ + ಎರೆಹುಳುಗೊಬ್ಬರದ ಮಾಧ್ಯಮದಲ್ಲಿ ಉತ್ತಮ ಪಲಿತಾಂಶವನ್ನು ಹೊಂದಿದ್ದು, ಅದರಲ್ಲಿ ಗರಿಷ್ಠ ಸಸ್ಯದ ಎತ್ತರ (೯೫.೩೦ ಸೆಂ. ಮೀ.), ಗಿಡದ ಹರಡುವಿಕೆ ಉತ್ತರ ದಕ್ಷಿಣ ಮತ್ತು ಪೂರ್ವ ಪಶ್ಚಿಮವಾಗಿ (ಕ್ರಮವಾಗಿ ೭೨.೦೦ ಮತ್ತು ೭೩.೬೭ ಸೆಂ. ಮೀ.), ಮರಿಸಸ್ಯಗಳ ಸಂಖ್ಯೆ (೬.೧೭), ಕ್ರೋಜಿಯರ್‌ಗಳ ಸಂಖ್ಯೆ (೩.೧೦), ಫ್ರಾಂಡ್ ಗಳ ಸಂಖ್ಯೆ (೧೨.೦೦), ಕ್ರೋಜಿಯರ್ ಗಳ ಉದ್ದ (೪.೯೩ ಸೆಂ. ಮೀ.), ಫ್ರಾಂಡ್ ಉದ್ದ ಮತ್ತು ಅಗಲ (ಕ್ರಮವಾಗಿ ೮೭.೦೦ ಮತ್ತು ೧೫.೬೭ ಸೆಂ. ಮೀ.), ಎಲೆಯ ಉದ್ದ ಮತ್ತು ಅಗಲ (ಕ್ರಮವಾಗಿ ೮.೩೦ ಮತ್ತು ೨.೧೦ ಸೆಂ. ಮೀ.), ಕಾಂಡದ ಸುತ್ತಳತೆ (೦.೯೫ ಮೀ. ಮೀ.), ಒಂದು ಫ್ರಾಂಡ್‌ನಲ್ಲಿ ಒಟ್ಟು ಎಲೆಗಳ ಸಂಖ್ಯೆ, ಒಂದು ಎಲೆಗೆ ಸೊರಿಯಾಗಳ ಸಂಖ್ಯೆ, ಒಂದು ಸೊರಿಯಾದಲ್ಲಿ ಒಟ್ಟು ಸ್ಪೊರಾಂಜಿಯ ಸಂಖ್ಯೆ ಮತ್ತು ಒಂದು ಸ್ಪೊರಾಂಜಿದಲ್ಲಿ ಒಟ್ಟು ಸ್ಪೊರ್ಸ್‌ಗಳ ಸಂಖ್ಯೆ (ಕ್ರಮವಾಗಿ ೧೩೫.೦೦, ೬೩.೦೦, ೩೫.೫೬ ಮತ್ತು ೫೪.೩೩), ಶೆಲ್ಫ್ ಮತ್ತು ವೇಸ್ ಲೈಫ್ (ಕ್ರಮವಾಗಿ ೮.೦೦ ಮತ್ತು ೨೦.೩೩ ದಿನಗಳು), ಕಾಂಡ ಮತ್ತು ಬೇರಿನ (ತಾಜ ಹಾಗೂ ಒಣ) ತೂಕ (ಕ್ರಮವಾಗಿ ೧೭೮.೧೧, ೮೧.೭೭, ೩೫೩.೬೭ ಮತ್ತು ೧೩೨.೫೬ ಗ್ರಾಂ), ಬೇರಿನ ಉದ್ದ, ಸುತ್ತಳತೆ, (ಕ್ರಮವಾಗಿ ೩೬.೧೧ ಸೆಂ. ಮೀ. ಮತ್ತು ೦.೩೫ ಮೀ. ಮೀ.), ಎಲೆಗಳಲ್ಲಿ ಸಾರಜನಕ, ರಂಜಕ ಮತ್ತು ಪೊಟ್ಯಾಷ್ ಪ್ರಮಾಣ (ಕ್ರಮವಾಗಿ ೫.೧೦, ೦.೫೯ ಮತ್ತು ೨.೬೫ %), ಮತ್ತು ಗರಿಷ್ಠ ನಿವ್ವಳ ಆದಾಯ ಮತ್ತು ಲಾಭ : ನಷ್ಟ ಅನುಪಾತವನ್ನು (೨.೧೫), ಹೊಂದಿದೆ. ವಿವಿಧ ಮಾಧ್ಯಮಗಳ ಪೈಕಿ ಮಣ್ಣು + ಕೋಕೊ ಪೀಟ್ ಕೊಟ್ಟಿಗೆ ಗೊಬ್ಬರ+ ಎರೆಹುಳುಗೊಬ್ಬರದ ಮಾಧ್ಯಮವು ಉತ್ತಮ ಬೆಳವಣಿಗೆಗೆ, ಇಳುವರಿ ಮತ್ತು ಗುಣಮಟ್ಟಕ್ಕೆ ಸಂಭಂದಿಸಿದಂತೆ ಉತ್ತಮ ಪ್ರತಿಕ್ರಿಯೆಯನ್ನು ನೀಡಿದೆ ಎಂದು ಪ್ರಸ್ತುತ ಸಂಶೋಧನೆಯಿಂದ ಕಂಡುಬಂದಿದೆ.

ಪುಷ್ಪ ಕೃಷಿ ಮತ್ತು ಉದ್ಯಾನ ವಿನ್ಯಾಸ ವಿಭಾಗ
ತೋಟಗಾರಿಕೆ ಮಹಾವಿದ್ಯಾಲಯ, ಮೂಡಿಗೆರೆ
ಕೃಷಿ ಮತ್ತು ತೋಟಗಾರಿಕೆ ವಿಶ್ವವಿದ್ಯಾಲಯ, ಶಿವಮೊಗ್ಗ
ಆಗಸ್ಟ್- ೨೦೧೯

Kavana. G. B
ಕವನ, ಜಿ. ಬಿ
(kavanabhyraiah@gmail.com)

ಡಾ॥ ಚಂದ್ರಶೇಖರ್, ಎಸ್. ವೈ.
(chandrashekar.sy@gmail.com)

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INTRODUCTION

I INTRODUCTION

In India with changing life style and increased urban affluence, floriculture has assumed a commercial status in recent times, particularly during the past 2-3 decades. Availability of natural resources like diverse agro-climatic conditions permit production of a wide range of temperate and tropical flowers and cut greens, almost all through the year (Ladha and Gunjal, 2011). In India, flower crops are being grown in 3,24,000 ha with the production of 27,85,000 MT. The total area under flower crops in Karnataka is about 31,000 ha with a production of 2,30,000 MT and 92,000.36 MT of cut flowers (Anon., 2018).

Cut foliages occupy an important position in the local and international markets and constitute an important section of floral industry. It is either used alone in large quantities as a source of decoration or in association with flowers and other accessories for value addition. These attractive plant parts are known differently as cut greens, cut foliages and florists greens. The commercial interest in one such foliage is fern, highly valued in the international florist greenery market because of their beautiful and varied foliage, long post-harvest life, low cost, low investment, year-round availability and versatile design qualities in form, texture and colour. Usually these cut foliage of ferns is harvested when the uppermost leaves are fully expanded to avoid postharvest wilting of the immature shoot tips (Safeena, 2013).

The global diversity of pteridophytes is yet not very clear, however the estimated number of species of world pteridophytes is between 9,000-15,000. On the other hand, there are approximately 13,600 species of pteridophytes, which have been named globally. Similarly, the exact number of Indian species of pteridophytes is also yet not clear due to certain factors like misidentifications, dubious species, new species syndrome *etc.* (Smith *et al.,* 2008). On scrutiny of various enumerations, checklists and recent publications, it came to notice that the number of Indian pteridophyte species is between 950-1000. The maximum diversity of ferns in India is observed in the Himalayas, Eastern and Western Ghats. Amongst 32 families occurring in India, almost 25 families are represented in Sikkim *i.e*. 78.12 (%) Indian families (Chandra *et al.,* 2008).

Ferns were traditionally classified in the class Filices, and later in a division of the plant kingdom named Pteridophyta or Filicophyta. A fern is a member of a group of vascularplants (plants with xylem and phloem) that reproduce *via* spores and have neither seeds nor flowers. They differ from mosses by being vascular *i.e*. having specialized tissues that conduct water and nutrients and in having life cycles in which the sporophyte is the dominant phase. Like other vascular plants, ferns have complex leaves called megaphylls, that are more complex than the microphylls of clubmosses. The ferns are homosporous, leptosporangiate ferns,

sometimes referred to as true ferns found mostly in humid areas. The new leaves typically expand by the unrolling of a tight spiral called as a crozier or fiddlehead of the fern. This uncurling of the leaf is termed circinate vernation and that uncoil and expand into fronds (Olsen, 2007).

Besides the economic values, a large number of them are cultivated for their ornamental value either in indoors of the houses or outdoors in the botanical gardens due to their delicate beauty and grace, used as a hanging basket, greenhouses and conservatories and we find them in the smallest apartments to the largest homes (Poole *et al*., 1984). They are often seen on shady places during spring and summer months. These are usually sold as hanging baskets or potted plants in a variety of container sizes, depending upon market demand and the growth habit of each cultivar. These are also suitable for use around water bodies. Growing ferns as borders and foundations in shade gardens can also be effective (Muthukumar and Prabha, 2012).

Apart from ornamental value, Ferns are used for food because of their nutritive value and low levels of oxalate, and for remediating contaminated soil. They have been subjected to research for their ability to remove some chemical pollutants from the atmosphere, such as bracken fern (*Pteridium aquilinum*) and also have an important role in bioremediation of waste water and found the Chinese bracken fern namely *Pteris vittata* to be a hyperaccumulator of the toxic arsenic metal. It is used as a medicine in treating the various diseases. The medicinal uses of some ferns and pteridophytes of India have also been described (Nair, 1959).

Ferns are extremely diverse in their habitat, form and reproductive methods. The foliage of ferns ranges from dark green to light yellow and others with surprising colors of grey, silver, red and blue-green which increase their utility in different types of floral arrangements. The genus *Nephrolepis* is commonly known as “sword fern” which are evergreen or semi-evergreen, either terrestrial or epiphytic species, distributed in tropical to subtropical regions around the world (Patil and Dongare, 2014).

Nephrolepis genus is widely distributed in the world over as one of the important foliage plants. There are approximately 30 tropical species of *Nephrolepis*, many of which are cultivated as potted plants or landscape plants. The best and popular species is *Nephrolepis undulate* J. Sm and is one of the widely cultivated plants in home gardens and is the most popular cut foliage used in India. The plant is epiphyte or lithophyte, rhizome short, erect, scaly, bearing wiry slender roots, stolons and tubers, scales 1 - 2 mm broad, pale brown, soft membranous, frond is long and broad, unipennate, rachis green, grooved on upper surface, minutely scaly above, pinnae 30 – 50 pairs, long and broad, middle ones larger, gradually narrowing from base to acute apex, falcate near apex, dimidiate at lower base, distinctly auricled and embracing the rachis at anterior base, crenate at margin, herbaceous, veins forked, sori

submarginal, arranged in one row, indusia 1.3 mm broad, broadly reniform (Patil and Dongare, 2014).

The sword fern requires acidic condition for growth and development. Ferns are highly adaptable to all types of soil but thrive in soil that is well-drained and rich in organic matter. Once established, ferns usually require little maintenance. It thrives in loam/clay types of soils and likes soil conditions which are warm and evenly moist. It should be kept moist but avoid overwatering the plant. The fronds will look more lush if the plant is kept slightly root bound, fertilized regularly, and if there is an ample relative humidity in the atmosphere. The fronds should be trimmed regularly to allow light and air to reach the new growth. The high intensity of light and temperature during summer and low night temperatures during winter appear to be detrimental for the sustained growth and the production of foliage (Stamps, 1992).

Growing media generally have three components *i.e*. mainly with water, nutrients, solid (33-50 %) and gases (50-70 %) with (12 %) oxygen and this combination is good for stronger root and shoot growth. Nowadays potted plants are grown in soilless media because of their benefits *i.e*. good water holding capacity, porosity, aeration and free from water logging conditions and less weed growth, nematodes, pest and disease infestation (Abid *et al*., 2017).

In present study, soil, sand, cocopeat, perlite, coir pith, vermicompost and farmyard manure were used in different proportions. The cocopeat improves porosity, water holding capacity, cation exchange capacity and buffers pH well, while that of perlite reduces the soil compaction, where on the hand vermicompost, increases the porosity of soil, provides good aeration, rich in humus and contains valuable vitamins, enzymes and hormones like auxins, gibberellins, *etc*. for better growth and development. The farmyard manure is one of the best growing media which provides all essential nutrients to the plants (Abid *et al*., 2017).

One of the major constraints in exporting of cut foliage plant species is the acceleration of senescence process during storage and transit. Senescence is a highly organized process involving structural, biochemical and molecular changes (Perera *et al*., 2009). The loss of chlorophyll which occurs as a result of chloroplast degradation is the major cause of the cut foliage senescence process. The onset of cut foliage senescence may be induced by various external factors such as high temperature, dark conditions during storage, radiation and pathogens, while internal factors related to senescence are regulated mainly by two phytohormones *i.e*. ethylene and abscisic acid (ABA) (Halevy and Mayak, 1981).

The potting media play important role in the growth and development of foliage plants. The awareness of using these foliage plants is increasing day by day. These are mainly grown in inside and outside showrooms, hotels, houses, institutional

buildings, bungalows *etc*. (Muthukumar and Prabha, 2012). There is a huge demand in the international market for foliage plants. Hence, standardized media will help the landscapers and others concerned in the utilization of *Nephrolepis undulate* J. Sm more efficiently.

Keeping the above points in view, the present study of *Nephrolepis undulate* J. Sm entitled "Standardization of potting media for *Nephrolepis undulate* J. Sm under protected condition" was carried out with the following objectives.

1. To standardize the potting media for *Nephrolepis* under protected condition.

2. To study the effect of potting media for morphological and root parameters of *Nephrolepis.*

3. To work out the economics of different potting media for *Nephrolepis*

REVIEW OF LITERATURE

II REVIEW OF LITERATURE

Foliage plants are one of the important group of ornamentals grown as pot plants. These plants are generally grown for their attractive foliage and retained for longer periods in an interior environment. The commercial interest in one such foliage is fern, highly valued in the international florist greenery market because of their beautiful and varied foliage long post-harvest life. The potting media has important role for proper growth and development of plants, deficiency or excess of any nutrient can lead to improper growth. The nutrient availability is also determined by texture, structure, water holding capacity and element composition of media, but not much work has been done to standardize the media for fern. The commercial cultivation of ferns as cut foliages and the work done on ornamental filler plants for production of cut foliages in India is very meagre compared to cut flowers. Hence, attempts have been made to review the work done with respect to fern and other related foliage plants to various growing media. Literature related to the present study is reviewed under the following major heads.

2.1 Standardization the potting media for *Nephrolepis* under protected condition.
2.2 To study the effect of potting media for morphological and root parameters of *Nephrolepis*.
2.3 To work out the economics of different potting media for *Nephrolepis*.

2.1 Standardization the potting media for *Nephrolepis* under protected condition

Gupta *et al*. (2004) studied the different growing media under protected environment for gerbera in mid hill of Himachal Pradesh. The results revealed that cocopeat + sawdust + sand (1:1:1 v/v) was found to be the best with respect to vegetative and flowering parameters.

John *et al.* (2004) found that, among different growing media studies, soil, sand, sheep or poultry manure (2: 1: 1 v/v) was better for growth and bulb production of tulip cultivar ‘Apeldoorn’.

An experiment was conducted to standardize the media for hardening the plantlets of *Dendrobium* cv. Thongchai Gold with four different growing media *viz*., charcoal, coconut husk, broken pot pieces, thermocol and their combinations. The results revealed that combination of coconut husk and broken pot pieces in 1:1 ratio significantly enhanced the growth parameters and it was best medium for hardening the *in vitro* plantlets of *Dendrobium* cv. Thongchai Gold (Sabareeswaran *et al*., 2008).

Singh *et al*. (2011) conducted experiment to standardize the growing medium in pots for anthurium (*Anthurium adreanum*. L) cv. Flame under protected conditions. The combinations of growing medium significantly influenced the vegetative growth

and flower production of anthurium. The overall best performance was recorded in the medium comprised of saw dust + brick pieces + wooden charcoal + soil + sand + FYM (2:1:1:1:1:1) for almost the parameters like leaf area (229.11 cm^2), petiole length (21.31 cm), minimum days to flowering (260.47), stalk length (36.16 cm), spathe length and width (8.5 and 8.08 cm, respectively).

In order to identify the most adequate substrate formula, Popescu and Popescu (2015) analyzed the effects of different potting growing media for *Petunia hybrida* 'Bravo' and *Nicotiana alata* 'Dinamo' on their photosynthetic capacity, leaf area, and flowering potential by using different growing media *i.e*. soil (FS), biolan peat (BP), acid peat (AP), leaf compost (C), and perlite (P) in different proportions. Growing media with the BP60-AP30-P10 formula seem to be the most adequate growth substrate to develop profitable crops for petunias and ornamental tobacco with high decorative value.

Rajasekar and Suresh (2015) investigated on the standardization of media composition for pot grown roses (*Rosa chinensis* Jacq.) by using different medium *viz*., soil, farm yard manure, leaf mould, vermicompost, coco peat, perlite and vermiculite. Among the growing media, soil + FYM recorded the increased plant height (46.92 cm) and plant spread (E×W-24.90 cm, N×S- 22.41 cm). However, the growing media, soil + FYM + leaf mould recorded the highest number of branches per plant (12.62).

In a view to standardize the growing media for rooftop gardening of gerbera an experiment was carried out by Saha *etal*. (2017).The crops were grown in five growing media *viz.*, sand, cocopeat, vermicompost, vermiculite and perlite. Among that the media composition of sand + coco peat + vermicompost + vermiculite + perlite in the ratio 1:2:2:0.25:0.25 in the container could be considered as ideal for rooftop cultivation of gerbera.

Standardization of a suitable potting media for vegetative and flowering characteristics of Calla lily (*Zantedeschia sprengeri*) was studied by Dabral *et al*. (2019). Suitable potting media was identified by measuring changes in vegetative and floral characteristics. From the study, it can be concluded that growing media combination of garden soil + cocopeat (1:2) can effectively be used for improving the overall quality attributes of flower for its use as a cut flower or as a pot plant.

Nair and Bharathi (2019) conducted experiment on the standardization of substrate composition for pot plant production of tuberose var. Arka Sugandhi. Arka fermented cocopeat was used as the main component of all the substrates with different amendments. The substrate combination of Arka fermented cocopeat (AFC) + soil + sand + FYM (1:1:1:1 v/v) was found to be most suitable media for pot plant production of tuberose var. Arka Sugandhi.

2.2 To study the effect of potting media for morphological and root parameters of *Nephrolepis*

Handrek (1992) conducted an experiment on growth of ferns in soilless media, as affected by pH, iron and Ca/Mg ratio. Ferns require basic growing media and were grown in a pine bark/peat/perlite/sand (6:2:1:1). The visual quality of ferns growing in soil less media were investigated using four taxa requiring alkaline media and two require acid media. The results indicated a wide range in response to pH and basic exchangeable cations among fern species. Ferns reputed to need alkaline growing media were intolerant of low pH value. All species tested grew well in the soil less media used over the pH range 5.5-6.5.

Nair *et al*. (2015) studied the influence of substrates and nutrient levels on production and quality of cut foliage in leather leaf fern (*Rumohra adiantiformis*). A combination of cocopeat + sand + vermicompost (1:1:1 v/v) as substrate and the application of N, P and K @100:30:60 kg/ha/year resulted in the maximum number of cut foliage per plant (26.42), length of lamina (2.59 cm), length of stipe (4.04 cm) , length of frond (12.00 cm) and width of frond (4.93 cm).

A pot experiment with *Nephrolepis* fern was conducted under 25 per cent green shade net conditions by Sandeep *et al*. (2018). The factor A comprising of *Nephrolepis falcata*, *Nephrolepis cordifolia* duffi, *Nephrolepis multifolia* and factor B comprising of soil, cocopeat, farmyard manure, vermicompost and sand. Among all the treatment combinations *Nephrolepis falcata* grown in medium consisting of cocopeat + sand + vermicompost (1:1:1 v/v) was found to be statistically significant under shade net conditions.

Other ornamental crops

The effect of rooting media on rooting characteristics and on growth of stem cuttings of *Pelargonium graveolens* under standard mist propagation was investigated by Altman and Freudenberg (1983). Perlite was found to be superior to all other media and supported the greatest fresh weight accumulation of both roots and new leaves. The numbers of adventitious roots and leaves were equal in both perlite and standard peat: perlite mixture.

Cresswell (1992) reported that cocopeat has several qualities that recommended as a peat substitute. These having high water holding capacity equal or superior to sphagnum peat, excellent drainage equal to sphagnum peat, absence of weeds and pathogens, renewable resources with no ecological drawbacks to its use.

Merrow (1994) reported that growth index (3.54) and dry weight (36.74 g) of *Ixora coccinea* was significantly better in coir based medium than sedge peat based medium. *Pentas* grown equally well in coir and sphagnum peat based medium.

Growth index and top dry weight of *Ixora coccinea* were significantly lower in the coir based than sphagnum peat based medium. Results revealed that coir dust seems to be an acceptable substitute for sphagnum or sedge peat in soilless container media.

Merrow (1995) noticed that, for anthurium, growth index (3.54) and shoot dry weight were only marginally higher in the coir than in the sedge peat medium. It grew well in the coir and the sphagnum peat medium. It was confirmed that high quality coir dust appears to be an acceptable substitute for sphagnum or sedge peat in soilless container media.

The effects of three substrates (perlite, peat-perlite 1:1 and pumice) on yield and flower quality of three gerbera cultivars (Fame, Rosabella and Sunspot), were studied by Fakhri *et al*., 1995. Culture in peat-perlite (1:1) mixture produced better or similar yield and flower quality. The performance of gerberas in perlite culture was intermediate while in pumice was the lowest.

Evans and Iles (1997) observed that viburnum grown in 25 per cent and 50 per cent coir were taller than plants grown in peat based substrates. Persian lilac plants grown in coir based substrates had similar heights as plants grown in peat based substrates. After two seasons, viburnum grown in 100 per cent coir had greater plant width than plants grown in 100 per cent peat.

The study on standardization of potting media for Vanda orchid (*Vanda roschildiana*), the plants were planted in different potting media *viz*., brick pieces, charcoal and coir dust. Results revealed that plant grown in brick pieces + coir dust produced the highest number of leaves (7.66) (Rajamani *et al.,* 1999).

Barrios *et al*. (2000) reported that aglaonema performed best in mixtures of soil and sand (1:1) with aerobic compost or anaerobic compost or earthworm compost or manure in terms of plant height (56.80 cm), leaf number (31.00) and leaf length (12.9 cm).

Jawaharlal *et al*. (2001) tried various types of potting media *i.e*. FYM, river sand, loam soil, leaf mould, cocopeat and coconut fiber and their combination for anthurium cv. Temptation and revealed that the plants grown in cocopeat medium as well as in combination of leaf mould and cocopeat produced highest number of branches and suckers per plant.

Scagel (2003) found that leaves of *Kalmia latifolia, Rhododendron spp, Arctostaphylos* and *Pieris japonica* had higher chlorophyll content when grown in coir amended media than in peat amended media.

Singh and Nair (2003) reported that in cuttings of syngonium, dieffenbachia, dracaena cv. Gold Dust and sansevieria shoot growth was promoted in red soil + sand

+ compost mix at 1:2:1 ratio. Plant height, number of shoots, number of leaves were maximum with 2:1:1.

Aswath and Pillai (2004) reported that medium containing higher proportion of cocopeat had good physico- chemical properties in gerbera. They further reported that the nutrient content increases with increased cocopeat proportion.

Bhatia *et al*. (2004) found that media consisting soil + FYM + coco peat (2:1:1) to be the best medium for growth parameters *viz*., plant height and number of shoots per plant in carnation cv. Sunrise.

Stronjny and Nowak (2004) studied the effect of different growing media on the growth of some bedding plants (begonia and salvia). Several growing media made of sphagnum peat blended with different additives like perlite, sand and vermiculite were evaluated in respect to their physical properties and influence on bedding plant growth. All investigated media showed their usefulness in bedding plant production with satisfying results, but the growth was most intensive in the mixture of medium structured white peat and black peat 1:1.

In anthurium cv. Lady Jane, Gowda *et al*. (2005) found that plant height, number of leaves per plant and leaf area were highest when the plants were grown in coir pith medium than vermicomposted coir pith, soilrite and soil + vermicomposted coir pith. The number of suckers per plant during the second year of the experiment was highest in coir pith medium.

Ficus binnendijkii (Amstelqueen) is a very attractive plant and a new addition to the landscape industry of the area. To optimize the propagation technology for this important plant, a study was conducted to see the effect of rooting media on the root initiation and development. Five different rooting media were used including silt, sawdust, rice husk, leaf mold and control (soil + silt + FYM at 1:1:1 ratio). The cuttings grown in leaf mold produced maximum leaves (7.0), which were the longest (20cm leaf length) with maximum leaf area (84.7cm^2) and maximum roots (15) (Shah *et al*., 2006).

Gupta and Gupta (2007) found that the growing media, sand + soil + FYM was most suited for establishment of plants and produced higher number of shoots (12.00) per plant in alstroemeria cv. Aladdin.

Khayyat *et al*. (2007) reported that freshness, leaf area, leaf number, mean root length, root number, shoot number, root fresh and dry weight, shoot fresh and dry weight and mean shoot length of pothos. Parameters such as freshness, shoot length, shoot fresh and dry weight, root fresh and dry weight and root number were higher in the media containing only cocopeat. Shoot number (8.00) was higher in the medium containing equal leaf-mold: sand mixture compared to the other media.

Khelikuzzaman (2007) conducted an experiment on effect of different potting media on growth of a hanging ornamental plant (*Tradescantia sp*.). It includes different potting mixtures. *i.e*. five soil mixtures were 100 per cent cocopeat, 100 per cent topsoil, 1part cocopeat :1part topsoil, 1part cocopeat: 1 part sand, and 1 part cocopeat: 1 part topsoil: 1 part sand. The experiment proved that soil mixture 1 part cocopeat: 1 part topsoil: 1 part sand was significantly better than other mixtures. It gave significantly higher vegetative fresh weight (1.246 g), significantly a greater number of stems (98.00) and secondary branches (33.00) as well as number of leaves (321.00) per plant.

The effects of vermicompost of an animal manure origin on the growth and flowering of *Petunia hybrida* 'Dream Neon Rose' grown under glasshouse conditions were determined by Chamani *et al*. (2008). Vermicompost had significant ($P<0.05$) positive effects on flower numbers, leaf growth and shoot fresh and dry weights compared to both control and peat amended media.

Plant tissue analysis studies by Chamani *et al*. (2008) in petunia hybrida 'Dream Neon Rose' revealed that, total extractable N, P and K were highest in plants grown in 60 per cent vermicompost medium and lowest in plants grown in 60 per cent sphagnum peat medium.

Devadas (2008) studied the experiment on influence of potting mixture on acclimatization and growth of *in vitro* developed plantlets of *Zygopetalum intermedium*. They used different medium *i.e*. cocopeat, coconut husk, tree fern, white moss, brick and charcoal. The plantlets grown in potting mixture comprising white moss + charcoal recorded maximum increase in root number (12.00) and root length (17.89 cm).

Treder (2008) studied the effect of cocopeat and fertilization on the growth and flowering of oriental lily 'Star Gazar'. Cocopeat was evaluated as a growing medium for oriental lily forcing. The mixture of sphagnum peat, bark and sand (5:1:1 v/v) was used as a control medium. Lilies grown in cocopeat flowered earlier, had better quality expressed as higher fresh and dry weight of flowers and leaves, had longer flower buds, better root system.

The effect of different level of farmyard manures (0t/ha, 15t/ha, 25t/ha and 35t/ha) on the growth and yield of *Amaranthus cruentus* was studied by Akparobi., 2009. Results showed that all parameters measured increased with plant age and significant differences ($P > 0.05$) were observed among the farmyard manure levels. Addition of more manure to the seedlings had positive effect on all the parameters measured. The seedlings treated with manure level of 35 t/ha had the highest mean values of 123.27 cm, 11 585 cm^2, 141.56, 1.75 kg and 0.99 kg per plant for plant height, leaf area, number of leaves, fresh and dry weight respectively.

In the experiment on effect of some substrate mixtures on growth and development of anthurium grown under protected structure with partially controlled environmental condition, the effect of substrate *viz.*, FYM + sand, FYM + cocopeat, FYM + cocofibre, FYM + brick piece + sand and FYM + brick piece on the vegetative growth was studied. The maximum number of leaves (7.66) and leaf lamina diameter (20.40cm) were recorded in FYM + coco fibre (Kalirana and Dubey, 2009).

A study designed by Naggar and Nasharty (2009) to study the effect of different growing media (clay, composted leaves and sand + composted leaves (1: 1 v/v) on the vegetative growth of leaves of amaryllis (*Hippeastrum vittatum*, Herb).The results indicated that using the different growing media had significant effect on the most of the most vegetative growth characteristics, flowering parameters, bulbs productivity and leaf chemical composition parameters (total chlorophylls content, N, P and K contents).

Thangam *et al*. (2009) studied the performance of gerbera in different growing media and reported that soil + vermicompost (3:1 v/v) gave significant result with respect to growth of gerbera under humid conditions.

Wazir *et al*. (2009) noticed that growing medium consisting soil + cocopeat + vermicompost + FYM + sand in equal proportions by volume was the best substrate for vegetative parameters like plant height and spread in alstroemeria.

Dhaduk and Yadav (2010) revealed that dutch rose cv. Naranga plant grown in a medium consisting of cocopeat + leaf mould (1:1) produced taller plant (67.40 cm), higher shoot length (35.46 cm), maximum number of leaves and leaf area (35.46 cm^2) as compared to other treatments.

An experiment was conducted to study the standardization of potting media for growing chrysanthemum as pot mum in seven growing media *viz*., soil + sand + FYM (2:1:1), soil + sand + vermicompost (2:1:1), soil + sand + vermicompost + FYM (2:1:1:1), cocopeat + sand + FYM (2:1:1), cocopeat + sand + vermicompost (2:1:1) and cocopeat + sand + FYM + vermicompost (2:1:0.5:0.5). Maximum plant height (38.66 cm) was recorded when plants grown in pots containing cocopeat, number of shoots per plant was maximum (4.92) in plants grown in cocopeat + sand + FYM + vermicompost (2:1:0.5:0.5) (Dhiman *et al*., 2010)

Younis *et al.* (2010) concluded that media combination of sand + silt + compost + spent compost in ratio of (1:1:1:1, v/v) proved to be the best media for growth and development of croton (*Codiaeum variegatum*) cv. ‘Gold Sun’.

Herath *et al*. (2011) showed that potting medium consisting of leaf mould + soil + sand in 1:1:1 ratio had a significantly higher performance with regard to fresh

weight of plant (7.54g), leaf length (17.25cm) than coir dust + compost + sand in 1:1:1 ratio (5.93g and 13.68cm) in *Ophiopogon japonicus*. Results revealed that leaf mould + soil + sand in 1:1:1 ratio was the best potting medium for the growth of *O. japonicus* than coir dust + compost + sand.

A study was conducted to investigate the effects of different growing media consisted of cocopeat (coir), soil and sand solely or in combination on hyacinth growth. Results indicated that growing media affected the measured traits. Parameters such as visual quality (4.09), leaf number, leaf fresh and dry weights (43.56 and 13.98 g) and root fresh and dry weights (56.11 and 14.67 g), were higher in the mixture containing equal amount of sand: cocopeat compared to other media (Nazari *et al*., 2011).

The highest photosynthetic rate, mesophyll efficiency and fresh weight of hyacinth (*Hyacinthus orientalis* L.) cv. Sonbol- e Irani were observed in the media containing only cocopeat and the highest transpiration rate and stomatal conductance from the medium consisted of only sand. The highest water use efficiency was obtained in soil/ cocopeat/ sand (2:1:1 v/v) medium (Nazari *et al*., 2011).

Effect of growing media and organic nutrition on vegetative growth in anthurium plants (*Anthurium andreanum* cv. Tropical) was reported by Basheer and Thekkayam, 2012. Among the media treatments, sand + coir pith compost was found to produce the maximum plant height (41.66 cm), leaf area (574.48 cm^2) and petiole length at the fourth week after emergence (16.29 cm) and shortest phyllachron (39.94 days), highest fresh and dry weight of leaves (5.14 and 1.2 g, respectively) and their N and K content (1.61and 2.23 %, respectively).

To study the effects of different amendments in growing medium on growth and flowering in gerbera under greenhouse condition using available materials *viz.*, soil, farm yard manure (FYM), vermicompost, samridhi (a soil conditioner) and sawdust. The results revealed that the medium amended with soil + FYM + vermicompost + samridhi + sawdust took maximum number of days (9.81 days) for the appearance of first new leaf. Leaf length (35.45 cm) and leaf width (17.24 cm) was found to be significantly higher in medium amended with samridhi. Maximum plant height (29.89 cm), number of leaves per plant (31.10 leaves), and vase life (13.17 days) was found highest in medium amended with samridhi. Based on the results obtained, samridhi was found to be a better soil conditioner for enhanced growth and flowering in gerbera (Sindhu *et al*., 2012).

Effect of different potting media combinations on growth and vase life of tuberose (*Polianthes tuberosa* linn.) was investigated by (Ikram *et al*., 2012). The different treatments included the combinations of FYM, poultry manure, sand, leaf compost and coconut coir in equal ratio. The maximum plant spread, number of

leaves and vase life was recorded in sand+FYM. Coconut coir + FYM contributed to the maximum values of plant height (57.72 cm), leaf area and spike length (15.89 cm). Maximum plantlets were counted for sand+ poultry manure.

Dhananjaya and Sulladmath (2013) reported that the potting media containing coffee cherry husk + FYM + soil + sand (2:1:1:1 v/v) proportion was noted most suited for commercial production of anthurium cv. 'Singapore Hybrid' in terms of maximum number of leaves (5.80), highest suckers per plant (6.10) and highest yield (2.30 flowers/ plant).

Kakoei and Salehi (2013) investigated the effects of different pot mixtures on spathiphyllum (*Spathiphyllum wallisii* regel) growth and development. The highest number of suckers was obtained in equal leaf mold: sand mixture. It is concluded that these differences represent a direct effect on the rooting process and that substrate characteristics are of the utmost importance for the quality of rooted plants.

Karim *et al*. (2013) reported that application of 50 per cent and 75 per cent of vermicompost enhanced plant growth and development by increasing fresh and dry mass in leaf tissues as well as the enhanced leaf area in azalea. However, the highest applied levels of vermicompost (100 %) did not have desirable effects.

Kayalvizhi *et al*. (2013) conducted an experiment on the influence of growth media on development of *Asparagus densiflora* 'Meyersii'comprising various combinations of soil, sand, FYM, vermicompost and microbial consortia (*Azospirillum*, *Phosphobacteria* and *Pseudomonas fluorescens*). From among the media combinations used, the treatment involving Soil + Sand + FYM + Vermicompost @ 2:1:1:0.5 (670g+375g+375g+165g) was found to be the best substrate for vegetative and root characters like plant height, shoot number (12.00), leaflet number, leaflet length, leaflet width, root number (8.90), root length (18.90 cm) and vase-life (18.24 days) in *Asparagus densiflora* 'Meyersii'.

The effect of different rooting substrates on rooting of geranium stem cuttings were investigated by Kumar and Ahmed (2013) under mist chamber. All the substrates significantly affected the rooting of stem cuttings. The maximum rooting (94.05 %), length of root system (11.19 cm), number of roots (34.41), root fresh and dry weight were found highest (4.00 g and 527.73 mg) in media cocopeat.

Bala and Singh (2013) studied the effect of different potting media for pot mum production in chrysanthemum grown under open and poly house conditions var. Yellow Charm. Results revealed that the plants grown in soil + sand + FYM + vermicompost (2:1:0.5:0.5 v/v) media produced significantly a greater number of branches per plant (39.97), plant height (20.46 cm) and plant spread (21.75 cm)

The comparative effect of different potting media with different compositions on growth and flowering of *Antirrhinum majus* L. (floral shower) studied by Mehmood *et al*. (2013). The data for both morphological and physiological parameters analyzed statistically showed significant effect of media combinations over control values. The results regarding growth and flowering parameters showed significant increase in leaf mould potting media.

Tatleri *et al*. (2013) found that the media comprising of cocopeat + vermicompost (3:1) was found to produce the maximum plant height and other growth parameters in *Dracaena marginata.*

A mixture of sand, mushroom compost, coconut coir, and peat proved to be the best, by promoting root and shoot growth, fresh and dry weights of root and shoot, and also improved overall quality of the plant reported by Younis (2013) for anatomical and morphological variation in *Dracaena reflexa* 'Variegata'.

Chauhan *et al*. (2014) investigated the effect of different media on growth, flowering and cut flower yield in gerbera (*Gerbera jamesonii* Bolus) cv. Alcochete under protected condition using various media *viz*., normal soil, rice husk, coco peat, castor cake, vermicompost, farm yard manure (FYM) and sawdust. The results revealed that the media amended with normal soil + rice husk + cocopeat + castor cake + vermicompost (1:1:1:1:1) performed better for maximum plant height (22.93 and 24.50 cm, respectively) and plant spread (34.49 and 42.07 cm^2, respectively) at first flower appearance and peak flowering stage as well as highest number of leaves and suckers per plant (17.13 and 3.61, respectively).

Gupta *et al*. (2014) tested the influence of vermicompost application in potting media on growth and flowering of marigold crop. The plant grown in vermicompost containing potting media had 2-3 times more plant height than control. Results showed that the addition of vermicompost in appropriate quantities to potting media has significantly positive effects on growth and flowering of marigold seedlings including plant biomass (59.80 g), plant height (79.11 cm).

Effect of growing media properties and its correlation study in gerbera production was carried out under protected condition with different growing media combinations *viz.* soil, sand, FYM, vermicompost, cocopeat and rice husk. Significant relationships were observed between different growing media parameters with flower quality and yield parameters of gerbera. The different growing media parameters such as water holding capacity, pH, EC, organic carbon content (%), available N, P, K (%) content, and growing media respiration has significant effect on growth, quality and yield of gerbera (Panj *et al*., 2014)

Sardoei and Rahbarian (2014) conducted an experiment on effect of different media on growth indexes of ornamental plants under system mist. To evaluate the

effect of growth medium on *Pandanus sanderi*, *Rosmarinus offinalis*. Results showed that the mean media 50 per cent peat moss + 25 per cent sand + 25 per cent perlite and 50 per cent peat moss + 25 per cent sand + 25 per cent perlite has the highest average stem length 94.50, 40 and 62.50 cm. The highest number of branches in the bed 50 per cent peat moss + 25 per cent sand + 25 per cent perlite, with a mean 29.25, and the lowest bed of 50 per cent peat palm + 25 per cent sand + 25 per cent perlite with an average of 14, respectively, which showed a statistically significant difference.

Swetha *et al*. (2014) conducted an experiment on effect of potting media on growth and quality of ornamental foliage plant, aglaonema cv. Ernesto's Favourite, was evaluated. Soil, cocopeat and sphagnum peat, in combination with sand, FYM and vermicompost in various proportions, were used as potting media. The maximum plant height (71.36 cm), number of leaves (16.00), leaf length (60.39 cm), leaf width (10.13 cm), leaf area (208.36 cm^2), plant growth index (63.37 cm), fresh weight of root (45.00 g), dry weight of root (8.53 g), visual plant grade (4.50), colour grade (4.58), root grade (4.45), and, N (3.46 %), P (0.95 %) and K content in leaf (1.91 %) were recorded with the medium containing cocopeat + sand + vermicompost in 2:1:1, (v/v) combination at 150 days after planting.

The quality of potting media plays a significant role in the performance of indoor plants. Therefore, a study to examine response of *Dracaena fragrans* and *Cordyline terminalis* to different growing media was investigated by Olosunde *et al*. (2014). Treatments consisted of Dracaena varieties (*D. fragrans* and *C. terminalis*) and growing media (topsoil, rice husk, sawdust, topsoil + rice husk, topsoil + sawdust, rice husk + sawdust) and (topsoil, sawdust, wood shavings, topsoil + sawdust, topsoil + wood-shavings, sawdust + wood shavings). Data collected on plant height, number of leaves, leaf area, chlorophyll content, number and length of roots. *C. terminalis* was taller with more (34.00) leaves and longer (52 cm) roots but low chlorophyll content compared to *D. fragrans*. Homogenous topsoil medium was generally poorer in most of the parameters measured. Interactive effects of varieties and growing medium was significant ($p = 0.05$). Growth responses of both varieties suggested that rice husk + topsoil and sawdust + topsoil composite media are the best for growing potted *D. fragrans* and *C. terminalis*.

Karthikeyan and Jawaharlal (2015) observed that chrysanthemum grown in FYM + vermicompost + cocopeat (10:1:1 v/v) recorded best growing media for growth and development of chrysanthemum.

An investigation was carried out to study the effect of growing media on the production of anthurium (*Anthurium andreanum*) cv. Tropical. Four levels of growing media *viz*., coir pith + coconut husk, coir pith + brick pieces, coconut husk + brick pieces and control (soil media) were used. Among the different treatment combinations, growing media with coir pith + coconut husk envisaged maximum

plant height (79.67 cm), plant spread (73.00 cm) (Muraleedharan and Karuppaiah, 2015)

Saleem *et al.* (2015) stated that combination of soil + silt + leafmould (1:1:1 v/v) proportion was most suited for increasing the plant height, number of leaves and fresh and dry weight of stem in zinnia cv. Benary's Gaint Deep Red.

Nair and Bharathi (2015) investigated influence of potting media composition on pot mum production. Chrysanthemum cv. Sadhbhavana, was grown in pots on seven different potting media combinations, the constituents being soil, sand, FYM, cocopeat and vermicompost. Cocopeat + sand + FYM + vermicompost (2:1:0.5:0.5v/v) was found to be one of the best potting media combinations resulting in the production of highest number of branches per plant (0.76) and the plant spread (0.91 cm).

Sarkar *et al*. (2016) evaluated effect of pot mixtures on the morphological characteristics for optimum growth and development of dieffenbachia and dracaena in pots. The different growing media compositions were different combination of soil, sand, FYM, cocopeat and vermicompost. Both *Dieffenbachia bowmannii* and *Dracaena reflexa* produced maximum plant height (56.98 cm), large leaf length (9.81 cm), large leaf width (5.78 cm) and plant spread (76.00 cm) in media of soil+ sand+ FYM @ 2:1:1.

Chavada *et al*. (2017) tested the effect of potting media on growth, flower yield and quality of rose (*Rosa hybrida* L.) cv. Top Secret under protected condition. This experiment includes combinations of different available growing media *viz*., cocopeat, FYM, leaf mould, perlite and soil (control) in greenhouse condition. The growth parameters *viz*., plant height (60.46 cm), leaf area (36.98 cm^2), number of leaf per flowering stalk (20.23) and stalk length of cut flower (36.23 cm) were significantly maximum obtained with soil + cocopeat + leaf mould (1:1:1) media combination which followed by soil + cocopeat + perlite.

Pot production of *Dracaena reflexa* in different growing substrates was studied by Abid *et al*. (2017) with the aim to identify the best one by using different medium *viz*., silt, coco coir, leaf manure and farm yard manure. Results showed that combination of silt + FYM improved root and shoot parameters like fresh mass (68.00 g), root and shoot length (19.83 and 29.01 cm) while, combination of silt + leaf manure + coco coir in increased plant height (67.95 cm), leaf area, plant spread, number of leaves per plant and dry mass significantly than all other combinations.

The effects of different potting media in different croton (*Codieum variegatum*) varieties under shade net conditions was studied by Anjana *et al*. (2017). Four varieties were evaluated with four different growing media in shade net condition. Cocopeat (CP), vermicompost (VC) and farmyard manure (FYM) in

different proportions were used as growing media. Maximum number of leaves (8.10) and plant height (67.90 cm) was recorded in *Rustifolia* with the media containing cocopeat + vermicompost + farmyard manure in 1:2:1 (v/v) combination.

Muhammed *et al.* (2017) evaluated growth response of song of India (*Dracaena reflexa*) to various growing substrates. Six months old *Dracaena reflexa* were planted in earthen pots composed of different treatments combinations of silt, coco coir, leaf manure and farm yard manure. Results showed that combination of silt + FYM improved root and shoot parameters like fresh mass, root and shoot length, SPAD value and mortality while, combination of silt + leaf manure + coco coir in increased plant height (67.89 cm), leaf area (43.09 cm^2), plant spread (58.00 cm), number of leaves per plant (57.00) and dry mass (53.00 g) significantly than all other combinations.

Padhiyar *et al*. (2017) investigated the Influence of different potting media on growth and flowering of pot chrysanthemum var. Ajina Purple. Various growing media under study *viz*., soil, sand, vermicompost, bio compost, poultry manure and cocopeat were used for experimentation. The results revealed that among different treatment, cocopeat + vermicompost + bio compost (2:1:1 v/v) exhibited maximum plant height (30.87 cm), number of branches per plant (16.40), fresh weight of plant (342.80 g) and dry weight of plant (170.87 g).

Pooja *et al*. (2017) described that effect of growing media on growth and flowering of cut roses under protected environmental conditions. soil based substrates like, soil + FYM + sand (G_1), soil + FYM + cocopeat (G_2) and soil + FYM + sawdust (G_3) mixed in 2:1:1 (v/v) and three fertilizers treatments *viz*., water soluble fertilizers (F_1), commercial straight fertilizers (F_2) and Biofertilizers + water soluble fertilizers (F_3), thereby making a total of nine treatment combinations which were replicated thrice. Results revealed that plants grown in a medium containing soil + FYM + sawdust and fertilized with water soluble fertilizers (G_3F_1) resulted in maximum plant height (75.28 cm), leaf area (35.45 cm^2), number of flowers per plant (15.9) and flower yield of 2,61,800 flower stems per hectare.

Rajera *et al*. (2017) conducted experiment on effect of growing media on growth, flower production of LA hybrid lilies. They used seven growing media sand, soil, FYM, cocopeat and vermicompost. Findings revealed that earliest sprouting, number of leaves per plant, weight of stem and vase life was recorded best when LA hybrids bulbs were grown in media vermicompost + cocopeat (2:1:1, v/v). However, plant height (89.54 cm) and stem length was recorded best when LA hybrids bulbs were grown in media sand + soil + FYM (1:1:1, v/v). Hence, it can be concluded that for quality flower production of LA hybrids cultivars a medium containing (sand + soil + FYM) + vermicompost + cocopeat (2:1:1, v/v) was found most suitable.

Saha *etal*. (2017) studied best the growing media for rooftop gardening of gerbera. The experiment which was carried out by to study the plant height, plant spread, leaves per plant, root volume and root number. The crops were grown in five growing media. The highest plant height (40.83 cm), plant spread (55.16 cm), leaves per plant (47.35), root volume (104.18 cc), and root number (276.82) was recorded for the media composition of sand + cocopeat + vermicompost + vermiculite + perlite in the ratio 1:2:2:0.25:0.25 by volume in the container could be considered as ideal for rooftop cultivation of gerbera in Assam conditions.

Pot experiment was conducted to evaluate growth performance of cast iron (*Aspidistra elatior* L.) using various potting media in different combinations *i.e.* garden soil, peat moss, leaf manure, compost, coconut fiber and farm yard manure at the ratio of 1:1 (v/v) to evaluate the best growing media for growth and quality of *Aspidistra elatior* L. (Shahid, 2017). Growing medium analysis showed that growing medium with less water holding capacity, low nutrients and less organic matter can be altered with alteration in organic materials using different combinations at different rates.

To observe the effect of different growing medium combination on rhizogenesis of some genotypes of rose through stem cuttings a study conducted by Dawa *et al*. (2018). Influence of growing medium significantly improved various rooting characteristics. But superior results were obtained with medium (sand 70 per cent +manure 30 per cent) which, recorded minimum days to root initiation (22.13), maximum rooting (83.33 %), primary root number (15.52), root length (8.88 cm).

An experiment was conducted to standardize the media for hardening the plantlets of *Dendrobium* var. Thongchai Gold with four different growing media and their combinations *viz*., charcoal, coconut husk, broken pot pieces, thermocol and their combinations. The results revealed that combination of coconut husk and broken pot pieces in 1:1 ratio significantly enhanced the plant height (9.02 cm) and number of leaves per plantlet (4.61) (Sabareeswaran *et al*., 2018).

Impact of growing medium composition on morphological development of chrysanthemum (*Chrysanthemum morifolium* Ramat cv. Snowball) reported by Thakur *et al*. (2018). Results revealed among different media combination, vegetative growth with maximum plant height (56.89 cm), number of leaves (24.00) and root suckers per plant (5.00) in the case of cocopeat + FYM (2: 1).

In order to investigation of vermicompost effect on growth and yield of marigold in pot medium, an experiment was done by Shadanpour *et al*. (2019). The results showed that added vermicompost to the growth media tend to improve the growth and yield of marigold than in the control. Vermicompost increased the plant growth and nutrient concentration in shoot. The best impact of vermicompost

obtained at the 60 per cent rate. Therefore, the vermicompost is an appropriate medium for growth of ornamental plant.

2.3 To work out the economics of different potting media for *Nephrolepis*

The cost of production of gerbera cv. Paganini in 100 m^2 using best growing medium *i.e*. cocopeat + sawdust + sand (1:1:1 v/v) based upon the results obtained was calculated for Solan-Nauni condition. Cost analysis in growing gerbera showed that grower can earn the net profit of Rs. 18794.00 (Gupta *et al*., 2004).

Barreto and Jagtap (2006) reported that cocopeat combined with compost (1: 1 v/v) produced flowers with highest net return Rs. 2,45,000 followed by the combination of cocopeat 60 per cent + perlite 20 per cent + rice husk 20 per cent. The substrates cocopeat + vermicompost (1: 1 v/v) was also found to be cheaper than the peat combination for better yield and quality flowers.

Kadam *et al*. (2007) studied the cost of economics of gerbera with three different substrates like soil + FYM + sand (1: 1: 1), red soil + FYM + sand (1: 1: 1), red soil + FYM + sand + rice husk (3: 3: 3: 1) on cultivar Bianaca, Dian and King Alexander. The maximum benefit cost ratio was observed in red soil + FYM + sand + rice husk (1.46) followed by soil + FYM + sand (1.06). The maximum net profit per sq. m (Rs.162) was recorded in red soil + FYM + sand + rice husk followed by soil + FYM + sand (Rs.104) and the least in red soil + FYM + sand (Rs.22).

Padhiyar (2017) studied the economics of different growing media in chrysanthemum. The mean cost of growing media was Rs. 69.34 while, the mean number of flowers per sq. m. were 127. The gross and net monitory returns per sq. m. were Rs. 381.32 and Rs. 317.28 respectively.

MATERIAL AND METHODS

III MATERIAL AND METHODS

The present investigation on " Standardization of potting media for *Nephrolepis undulate* J. Sm under protected condition " was carried out under naturally ventilated poly house in the experimental field of Department of Floriculture and Landscape Architecture, College of Horticulture Mudigere, University of Agricultural and Horticultural Sciences, Shivamogga during the period from 2018- 19.

The details of the experiment, material used, techniques, methodology, observations recorded and statistical analysis adopted for conducting the experiment during the course of investigations are described in this chapter

3.1 Geographical location of the experimental site

The experiment was carried out in the experimental block of department of Floriculture and Landscape Architecture, College of Horticulture Mudigere, which is situated in the Western Ghats and represents the typical hill zone (Zone-9 and Region V) of Karnataka and lies at 13^{o} 25' North latitude and 75^{o} 25' East longitude with an altitude of 980 m above mean sea level (MSL). It encompasses an area of 1155 sq. km of which 15 per cent covers in forest area which is around 30, 604 hectares. Vegetation is moist deciduous type and also finds shola- like vegetation (Parashurama *et al*., 2016).

3.2 Climate conditions of the experimental site

The mean monthly weather data for the year 2018-19 recorded at Zonal Agricultural and Horticultural Research Station (ZAHRS), Mudigere are presented in Appendix-1.

The climate in the Mudigere region is cool and pleasant throughout the year with an average rainfall of 2420.00 mm, mainly distributed over a period of six to eight months from May to December with the peak period of rainfall during June to August. The average annual maximum temperature is 27.78^{o}C and the minimum temperature is 19.41^{o}C. The average mean relative humidity is 82.96 per cent.

3.3. Experimental details

3.3.1. Collection of suckers

The experiment carried out with the *Nephrolepis undulate* J. Sm. And the suckers of *Nephrolepis* fern were collected around mudigere region and used for planting.

3.3.2 Characteristic feature of Nephrolepis undulate J. Sm

Nephrolepis undulate J. Sm is one of the widely cultivated plants in home gardens and is the most popular cut foliage used in India (Singh, 2015) produced and sold in large quantities. Plant is epiphyte or lithophyte, rhizome short, erect, scaly,

bearing wiry slender roots and stolons and tubers, and requires acidic condition for growth and development.

3.3.3 Design and layout of the experiment

Location: College of Horticulture	Mudigere
Number of treatments	10
Number of replications	3
Planting method	Pot culture
Number of plants per pot	1
Planting time	October 2018
Design	Complete Randomized Design (CRD)

3.3.4 Different potting media used

Different proportions of potting media consisting of soil, sand, cocopeat, FYM, vermicompost, coir pith and perlite were mixed in different ratio accordance with the treatments and were filled to the pots, placed in poly house.

3.3.4.1 soil

Soil is the basic material. It forms the major portion in the combination of different media. Cheaply available and easy to handle. Most soils on the average are composed of 50 per cent air and water 46-49 per cent mineral particles and 1-6 per cent organic matter. The mineral particles of soil are sand (0.05-2 mm), silt (0.002-0.05 mm) and clay (< 0.002 mm) (Gohil *et al*., 2018).

3.3.4.2 Sand

Naturally occurring granular material composed of finely divided rock and mineral particles. Diameter ranges from 0.06 mm to 2 mm. Most common constituent of sand is silica (silicon dioxide, SiO_2), usually in the form of quartz. Increase the water holding capacity and aeration of the mix. Sand may also be used to provide weight to the mix (Gohil *et al*., 2018).

3.3.4.3 Cocopeat

A byproduct of processed coconut husks is known as cocopeat. The husk contains 20 per cent to 30 per cent fiber of varying length and holds 8-9 times its weight

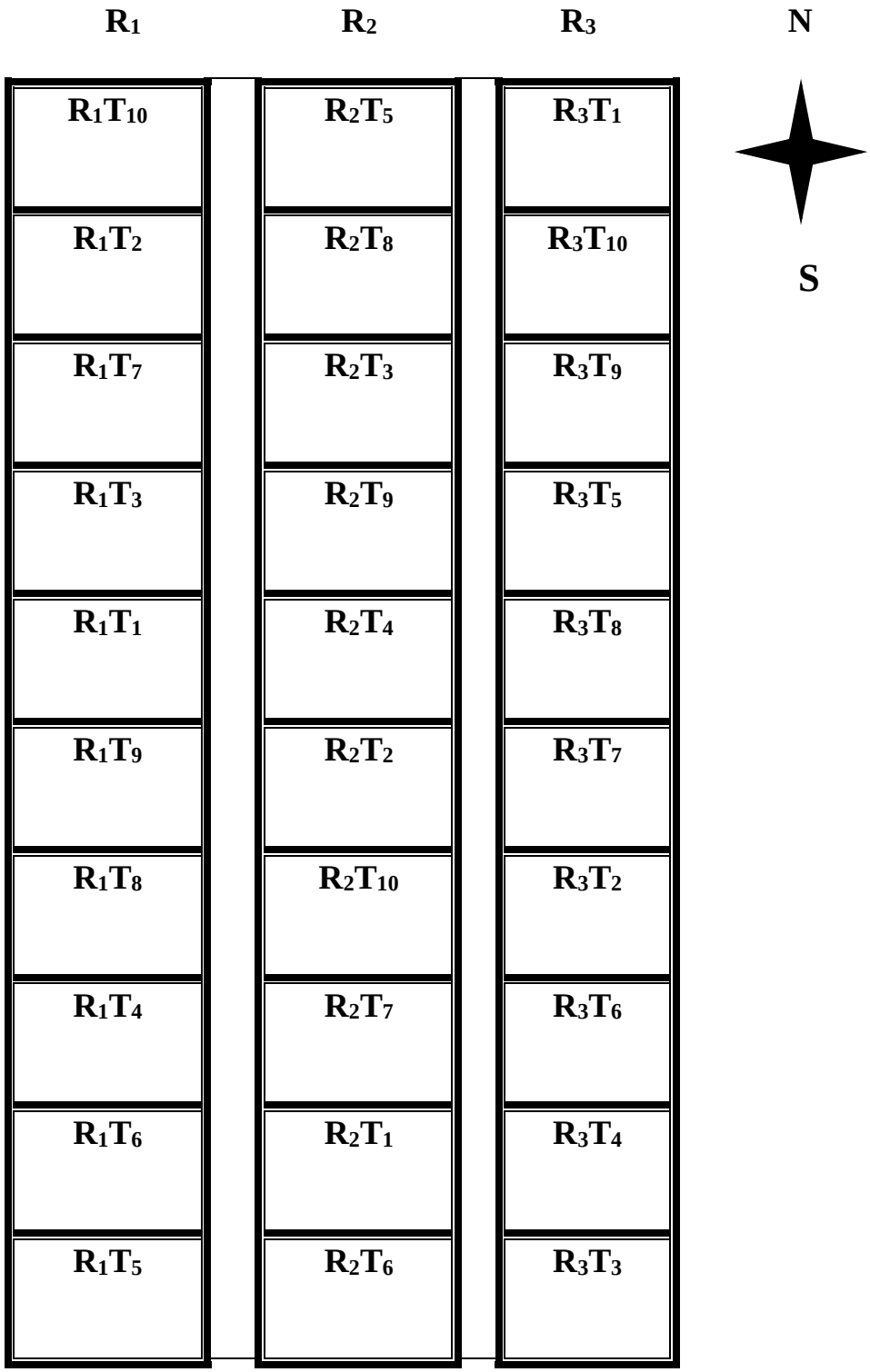


Fig. 1. Plan and layout of the experimental plot under protected condition

in water and can be reused for up to 4 years. On an average cocopeat contains 1.24 per cent of N, 0.06 per cent of P and 1.20 per cent of K. The properties of cocopeat make it resistant to bacterial and fungal growth, easy to handle and great oxygenation properties which is important for healthy root development. Environment friendly (Gohil *et al*., 2018).

3.3.4.4 FYM

Farmyard manure refers to the decomposed mixture of dung and urine of farm animals along with litter and left-over material from roughages or fodder fed to the cattle. On an average well decomposed farmyard manure contains 0.5 per cent N, 0.2 per cent P_2O_5 and .0.5 per cent K_2O (Gohil *et al*., 2018).

3.3.4.5 Vermicompost

Also known as worm castings, worm humus or worm manure. The end product of the breakdown of organic matter by the earthworm. This compost is an odorless, clean, organic material containing adequate quantities of N (0.5 - 1.5 %), P (0.1 – 3 %), K (0.15 - 0.56 %) and several micronutrients essential for plant growth. Vermicompost is rich in all essential plant nutrients. It improves pot structure, texture, aeration, and water holding capacity. Vermicompost is rich in beneficial micro flora such as a fixers, P- solubilizers, cellulose decomposing micro-flora *etc.* It prevents nutrient losses and increases the use efficiency of chemical fertilizers. Only vermicompost contain plant growth regulators like auxin and gibberellins (Gohil *et al*., 2018).

3.3.4.6 Coir pith

Coir is a versatile natural fiber extracted from mesocarp tissue, or husk of the coconut. It is byproduct of coconut husk. On an average cocopeat contains 0.26 per cent of N, 0.01 per cent of P and 0.78 per cent of K (Gohil *et al*., 2018).

3.3.4.7 Perlite

Perlite is a grayish-white silicaceous volcanic rock in origin, mined from lava flows. Improves aeration and drainage. It is clean, odorless and safe to handle. Perlite is almost pH neutral (Gohil *et al*., 2018).

3.3.5 Treatment details

T_1	Soil + Sand + FYM (2:1:1) (Control)
T_2	Soil + Cocopeat + Vermicompost (2:1:1)
T_3	Soil + Coir pith + Vermicompost (2:1:1)
T_4	Soil + Cocopeat + FYM + Vermicompost (2:1:1:1)
T_5	Soil + Perlite + Coir pith + Vermicompost (2:1:1:1)
T_6	Cocopeat + Sand + FYM (2:1:1)
T_7	Cocopeat + Vermicompost + Coir pith (2:1:1)
T_8	Cocopeat + Vermicompost + FYM (2:1:1)
T_9	Cocopeat + Perlite + Sand + Vermicompost (2:1:1:1)
T_{10}	Cocopeat + Perlite + Coir pith + Vermicompost (2:1:1:1)

3.4 Cultural operations

3.4.1 Planting

Small holes (about 5-6 cm depth and width) at each spot of planting were made. Uniform sized plants (one plant/pot) were placed into the holes and the media around the plant was pressed. Plants were watered immediately after planting and maintained under protected condition.

3.4.2 Irrigation

Immediately after planting of suckers, they were lightly watered and later irrigation was done every day depending upon the moisture content. The weeds were removed in the pots as and when noticed.

3.4.3 Weeding

The plots are kept free from weeds throughout the growing period. Hand weeding was done as and when required to avoid crop weed competition. The first weeding was done after 75 days after planting and later as and when required.

3.5 Collection of experimental data

Five plants were selected randomly from each treatment and selected plants were tagged in each treatment and replication, for the purpose of recording the observations. The mean value of the data obtained from five plants in each treatment was worked out.

3.5.1 Vegetative parameters

The observations were recorded at 60, 90, 120, 150 and 180 days after planting for all the vegetative growth parameters such as.,

1. Plant height (cm)
2. Plant spread (cm)
3. Number of shoots
4. Number of fronds
5. Number of croziers
6. Crozier length (cm)
7. Frond length (cm)
8. Frond width (cm)
9. Number of leaflets
10. Leaflet length (cm)
11. Leaflet breadth (cm)
12. Shoot diameter (mm)
13. Number of leaflets
14. Number of sori per leaflet
15. Number of spores per sporangia

The data on all vegetative characters were collected from five randomly tagged plants in each treatment and average was worked out.

3.5.1.1 Plant height (cm)

The planted suckers allowed grow for 60 days then the plant height was measured from the collar region to the highest tip of the plant with the help of measuring scale at monthly intervals from 60 days onwards to 180 days after planting and expressed in terms of centimeters.

3.5.1.2 Plant spread (cm)

The plant spread was measured by taking the canopy spread of both North - South and East - West direction of tagged plants with the help of measuring scale at monthly intervals from 60, 90, 120, 150 and 180 days after planting and mean was calculated and expressed in centimeters.

3.5.1.3 Number of shoots (suckers)

Number of newly emerged shoots were counted after 60 days to 90, 120, 150 and 180 days after planting and recorded and expressed as a Number of shoots per pot.

3.5.1.4 Number of croziers

The number of croziers emerged were counted after 60 days to 90, 120, 150 and 180 days after planting and recorded and expressed as number of croziers per plant.

3.5.1.5 Number of fronds per plant

The number of fronds per plant was counted after 60 days to 90, 120, 150 and 180 days after planting and recorded and expressed as number of fronds per plant.

3.5.1.6 Frond length (cm)

The length of the frond was measured from the base to the tip of the leaf after 60 days to 90, 120, 150 and 180 days after planting. Five opened leaves in each tagged plant was measured and average of these five was worked out and expressed in centimeters.

3.5.1.7 Frond width (cm)

The breadth of the frond was measured at the centre of the frond after 60 days to 90, 120, 150 and 180 days after planting and expressed in centimeters.

3.5.1.8 Number of leaflets

Number of leaflets were counted at peak period of plant growth, recorded and expressed in terms of number of leaflets per frond.

3.5.1.9 Leaflet length (cm)

The length of the leaflet was measured from the base (where leaflet attach to the midrib) to the tip of the leaflet after 60 days to 90, 120, 150 and 180 days after planting. Leaflets of five fully opened fronds in each plant was measured and average of these five was worked out and expressed in terms of centimeters.

3.5.1.10 Leaflet breadth (cm)

The breadth of the leaflet was measured at the centre of the leaflet after 60 days to 90, 120, 150 and 180 days after planting and expressed in centimeters

3.5.1.11 Shoot diameter (mm)

The diameter of shoot is measured and recorded with the help of digital Vernier calipers after 60 days to 90, 120, 150 and 180 days after planting and expressed in terms of millimeters.

3.5.1.12 Number of leaflets per frond

The number leaflets per frond was counted and recorded at peak growing season and expressed as number of leaflets per frond.

3.5.1.13 Number of sori per leaflet

The total number of sori were counted in the tagged plants at the time of peak growing season, which are present on under surface of leaf at peak period of growth of the plant.

3.5.1.14 Number of spores per sporangia

For counting the spores select the frond which is fully opened and without indusium. Sori is removed with the help of needle and it is slightly crushed to separate the sporangia. From that sporangia individual spores were counted under microscope and expressed in terms of numbers.

3.5.2 Qualitative parameters

Qualitative parameters were analyzed and recorded at grand growth period of the plant of five selected plants in each treatment, and those qualitative parameters are

1. Vase life (days)
2. Shelf life (days)
3. Visual plant grade
4. Colour grade
5. Chlorophyll content (mg/g fresh weight)

3.5.2.1 Vase life (days)

Vase life was expressed in terms of days taken from the date of harvest till the foliages were found unfit for continuing in vase containing normal tap water *i.e*. just before they started showing the symptoms of wilting. Cut foliages were discarded when one-third of the foliage were brown or wilted. This stage was considered to be the end of potential useful longevity of fronds and the number of days taken for this was recorded as vase life of the frond.

3.5.2.2 Shelf life (days)

Fully opened fronds were harvested and kept in conical flask under laboratory conditions. Number of days was counted till the fronds lost their marketable quality.

3.5.2.3 Visual plant grade

The foliage plant species are rated according to its fullness, growth and visual appearance *viz*., texture, shape and pattern and size of the foliage during the grand growth period. Visual plant grade was determined by following 1-5 scale grade system

where 1 = dead, 2 = poor quality, 3 = fair quality, 4 = good quality and 5 = excellent quality (Swetha *et al*., 2014)

3.5.2.4 Colour grade

For the assessment of colour characteristics, the Royal Horticultural Society (RHS) – 2015 (6^{th} edition) colour chart was used to record the variations. All observations on the colour of frond was made on the inner side.

3.5.2.5 Chlorophyll content (mg/g fresh weight)

Chlorophyll content of leaf was analyzed by collecting the healthy, fully matured leaves from the middle of the frond at peak growth stage.

Fresh and fully matured leaves from the plant were brought from the field and were cut into small pieces. 0.1 g of sample was incubated in 7.0 ml of DMSO for 12hrs. After the incubation, supernatant was collected by decanting and leaf tissue was discarded. Then the volume of the supernatant was made up to 10 ml using DMSO.

The absorbance of the extract was measured at 645 nm, 652 nm and 663 nm using DMSO as blank in spectrophotometer. The chlorophyll-a, chlorophyll-b and total chlorophyll contents were calculated by using the formulae given below.

$$\text{Chlorophyll-a} = \{12.7\ (A663) - 2.69\ (A645)\} \times \frac{V}{1000 \times W \times a}\ \text{(mg/g fresh weight)}$$

$$\text{Chlorophyll-b} = \{22.9\ (A645) - 4.68\ (A663)\} \times \frac{V}{1000 \times W \times a}\ \text{(mg/g fresh weight)}$$

$$\text{Total chlorophyll} = \{20.2\ (A645) + 8.02\ (A663)\} \times \frac{V}{1000 \times W \times a}\ \text{(mg/g fresh weight)}$$

Where,

A = Absorbance at specific wave length (645 nm, 652 nm and 663 nm)

V = Volume of the extract (10 ml)

W = Fresh weight of the sample (100 mg)

a = Path length of light in cuvette (1 cm)

3.5.3 Root and shoot parameters

3.5.3.1 Shoot biomass (g)

The shoots were separated from the tagged plants at the collar region and the fresh weight of shoots was recorded using an electronic balance and the mean values were expressed in grams. After recording the fresh weight, the same shoots were dried under shade till constant weight was noted. The mean dry weight was noted and expressed in grams.

3.5.3.2 Root biomass (g)

The roots were separated from the tagged plants at the collar region and the fresh weight of roots was recorded using an electronic balance and the mean values were expressed in grams. After recording the fresh weight, the same roots were dried under shade till constant weight was noted. The mean dry weight was noted and expressed in grams.

3.5.3.3 Root length (cm)

The length of the longest root per plant in each treatment was measured from the point of initiation of the root to the growing tip and their mean was used to express the length of the root in centimeters.

3.5.3.4 Root diameter (mm)

Diameter of root is measured and recorded with the help of digital Vernier calipers and expressed in terms of millimeters.

3.5.3.5 Root volume (cc)

The roots were separated from the sampled cuttings and the roots of each treatments were dipped in the measuring cylinder of 1000ml and the readings were recorded in cubic centimeter.

3.5.4 Media analysis

3.5.4.1 pH

pH of different medium was determined by potentiometric method in 1: 2.5 soil water suspension using pH meter having a glass-calomel combined electrode (Jackson, 1973).

3.5.4.2 Electrical conductivity (ds/m)

An electrical conductivity of media samples was measured in soil-water extract of 1: 2.5 ratio using conductivity bridge (Jackson, 1973) and expressed in ds/m.

3.5.4.3 Organic carbon (%)

Organic content of the different medium was determined by Walkley and Black wet titration method as described by Jackson in 1973. The organic carbon expressed in percentage.

$$\%OC = \frac{(BTV - STV) \times N.\ of\ FAS \times 0.003}{Wt.\ of\ soil\ sample} \times 100$$

Where,

BTV= Blank titrate value
STV= Sample titrate value
N. of FAS= Normality of ferrous ammonium sulphate

3.5.4.4 Available nitrogen (%)

The available nitrogen was determined by modified alkaline potassium permanganate method as described by Subbaiah and Asija (1956). Available Nitrogen was calculated by using formula

$$\text{Available N (kg/ha)} = \frac{sample\ TV - Blank\ TV \times N.\ of\ H_2SO_4 \times 0.014}{Wt.\ of\ sample} \times 2 \times 10^6 \times 1.12$$

Where,

TV - Titre Value

N - Normality

3.5.4.5 Available phosphorous (%)

The available phosphorous in soil was extracted by using Bray's extractant reagent. The ammonium molybdate solution and stannous chloride solution was added to this filtrate solution. The aliquot was taken and estimated by using spectrophotometer. Standard solutions of P with concentration of 0, 0.1, 0.2, 0.4, 0.6, 0.8 and 1.0 ppm were prepared.

$$\text{Available P (kg/ha)} = \frac{Graph\ ppm}{10^6} \times \frac{Vol.of\ extractant}{Wt.of\ soil} \times \frac{Vol.\ made}{Aliquot\ taken} \times 2 \times 10^6 \times 2.29$$

3.5.4.6 Available potassium (%)

The available potassium was extracted from soil by using neutral normal ammonium acetate solution and the aliquot was fed to calibrated flame photometer for K estimation. 0, 10, 20, 30 and 40 ppm of K standard solution was pipetted out to volumetric flask from 100 ppm of potassium standard solution (Black, 1965). These samples were fed to flame photometer to obtain flame photometer reading (graph ppm).

$$\text{Available K (kg/ha)} = \frac{Graph\ ppm}{10^6} \times \frac{Vol.of\ extractant}{Wt.of\ soil} \times \frac{Vol.\ made}{Aliquot\ taken} \times 2 \times 10^6 \times 1.12$$

3.5.5 Plant analysis

3.5.5.1 Preparation of plant samples

Fully matured index leaf was collected on 180 days after planting from each treatment of selected tagged plants. The collected leaf samples were decontaminated by washing thoroughly with ordinary water. These samples were dried in oven at 60°C till constant weight is obtained. Then powdered with the help of pestle and mortar and used for analysis.

3.5.5.2 Estimation of nitrogen (%)

Nitrogen content was determined by Kjeldhal's method. Half gram digested plant sample is distilled using micro- Kjeldhal unit and the liberated ammonia is trapped

in boric acid containing mixed indicator and titrated against 0.01N H_2SO_4 (Jackson, 1973). The content in the leaves is expressed in per cent.

$$\%N = \frac{TV \times N.\ of\ H_2SO_4 \times 0.014}{Wt.\ of\ sample} \times 100$$

Where,

TV - Titre Value

N - Normality

3.5.5.3 Estimation of phosphorous (%)

Diacid digested plant sample was used for the determination of total phosphorous by developing vanadomolybdo phosphoric yellow colour following the method of Jackson, 1973. The intensity of yellow colour was read in spectrometer at 470 nm, and the phosphorous content in the leaves is expressed in per cent.

$$\%P = \frac{Graph\ ppm \times Vol.of\ digested\ sample \times Vol.\ made \times 100}{Wt.of\ manure \times Aliquot\ taken \times 10^6}$$

3.5.5.4 Estimation of potassium (%)

Potassium content was determined by flame photometer using specific filter and LPG flame. Diluted diacid digest was fed to atomizer through capillary tube and concentration was directly on the display monitor. The potassium content on the dry weight basis was calculated and expressed in terms of per cent.

$$\%K = \frac{Graph\ ppm \times Vol.\ of\ digested\ sample \times 100 \times Vol.of\ dilution}{Wt.\ of\ sample \times 10^6 \times Aliquot\ taken}$$

3.5.6 Incidence of pest and diseases

During experimentation any pest and diseases occurrence on plant were recorded.

3.6 Economics of cultivation

The cost of cultivation of *Nephrolepis undulate* J. Sm using different media in different proportions were worked out based on present market price. Potted plants and fronds were sold at local market in Mudigere. Economic analysis of different potting media and *Nephrolepis* fern in terms of gross returns, net returns and B: C ratio were calculated by the following the formula.

3.6.1 Cost of cultivation

The prices of all inputs prevailing at the time of their use, the labour cost were considered to work out the cost of cultivation.

3.6.2 Gross returns

The gross income was worked out based on the prevailing market price of fresh foliage. Expressed in rupees per hectare (₹).

3.6.3 Net returns

The net income per hectare was calculated by using the following formula. Expressed in rupees per hectare (₹).

Net income (₹/ha) = Gross income (₹/ha) – Cost of cultivation (₹/ha)

3.6.4 Benefit: Cost ratio

Cost ratio for different treatments was worked out based on the price of inputs used for cultivation and price of marketable produce in local market by using the formula and it is expressed in ratio.

$$\text{Benefit : Cost ratio} = \frac{Net\ income\ (₹/ha)}{Cost\ of\ cultivation\ (₹/ha)}$$

(a) Potting stage

(b) Planting stage

(c) Initial establishment stage

Plate 1. General view of experimental site at various stages of experimentation

Plate 2. General view of experimental plot at grand growth stage

EXPERIMENTAL RESULTS

IV EXPERIMENTAL RESULTS

The results obtained in the present investigation on "Standardization of potting media for *Nephrolepis undulate* J. Sm under protected condition" are presented in this chapter.

4.1 Vegetative and reproductive parameters

The vegetative parameters such as, plant height (cm), plant spread (cm), number of shoots, number of croziers, number of fronds, crozier length (cm), frond length (cm), frond width (cm), leaflet length (cm), leaflet breadth (cm) and shoot diameter (mm) were recorded at different stage of crop growth. The reproductive parameters *i.e.* number of sori per leaflet, number of sporangia per sori and number of spores per sporangia were recorded at grand growth stage along with number of leaflets per frond. The results obtained from these parameters were analyzed and are presented in the tables from 1- 12.

4.1.1 Plant height (cm)

The data on plant height of *Nephrolepis undulate* J. Sm at different stages of plant growth are presented in Table 1. The treatments showed significant differences with respect to plant height at various stages of growth *i.e.* 60, 90, 120, 150 and 180 days.

The significant differences were observed with respect to plant height in different treatments of potting media at 60 days after planting. Among the different treatments, the maximum plant height was recorded in the treatment T_4- soil + cocopeat + FYM + vermicompost in 2:1:1:1 (47.82 cm), which was on par with T_5 - soil + perlite + coir pith + vermicompost (2:1:1:1) (46.45 cm) while, the minimum plant height (33.63 cm) was recorded in the treatment T_1 - soil + sand + FYM (2:1:1) (control).

At 90 days after planting significantly maximum plant height was recorded in T_4- soil + cocopeat + FYM + vermicompost in 2:1:1:1 (72.33 cm) which was on par with the treatment T_5 - soil + perlite + coir pith + vermicompost (2:1:1:1) (70.63 cm) while, the minimum plant height (40.06 cm) was recorded in the treatment T_1 - soil + sand + FYM (2:1:1) (control).

The height of the plant varied significantly among the different treatments of potting media at 120 days after planting. The T_4- soil + cocopeat + FYM + vermicompost in 2:1:1:1 treatment recorded maximum plant height (92.00 cm) which was on par with T_5 - soil + perlite + coir pith + vermicompost (2:1:1:1) (91.17 cm) while, the minimum plant height (49.03 cm) was recorded in the treatment T_1 - soil + sand + FYM (2:1:1) (control).

Table 1. Effect of potting media on plant height of *Nephrolepis undulate* J. Sm at various stages of growth under protected condition

Treatment No.	Treatment details	Plant height(cm)				
		Days after planting				
		60	90	120	150	180
T_1	Soil + Sand + FYM (2:1:1)(control)	33.63	40.06	49.03	53.41	55.63
T_2	Soil + Cocopeat + Vermicompost (2:1:1)	38.80	41.46	66.50	67.00	73.38
T_3	Soil + Coirpith + Vermicompost (2:1:1)	40.19	48.43	68.31	71.47	74.12
T_4	Soil + Cocopeat + FYM + Vermicompost (2:1:1:1)	47.82	72.33	92.00	94.67	95.30
T_5	Soil + Perlite + Coirpith + Vermicompost (2:1:1:1)	46.45	70.63	91.17	93.00	93.97
T_6	Cocopeat + Sand + FYM (2:1:1)	35.05	43.03	74.46	80.87	81.13
T_7	Cocopeat + Vermicompost + Coirpith (2:1:1)	41.70	54.14	83.85	86.33	86.46
T_8	Cocopeat + Vermicompost + FYM (2:1:1)	35.15	50.77	59.83	64.42	68.48
T_9	Cocopeat + Perlite + Sand + Vermicompost (2:1:1:1)	37.66	51.19	57.39	61.74	64.79
T_{10}	Cocopeat + Perlite + Coirpith + Vermicompost (2:1:1:1)	37.50	41.17	62.49	65.19	69.94
	S. Em ±	**1.12**	**0.77**	**1.49**	**2.10**	**1.15**
	CD @ 1%	**4.52**	**3.09**	**6.00**	**8.44**	**4.65**

Among different combinations of potting media, plant height varied significantly at 150 days after planting. The treatment T_4- soil + cocopeat + FYM + vermicompost in 2:1:1:1 recorded maximum plant height (94.67 cm) which was on par with T_5 - soil + perlite + coir pith + vermicompost (2:1:1:1) (93.00 cm) and T_7- cocopeat + vermicompost + coir pith (2:1:1) (86.33 cm) while, the minimum plant height (53.41 cm) was recorded in the treatment T_1 - soil + sand + FYM (2:1:1) (control).

The height of the plant varied significantly among the different combinations of media at 180 days after planting. The treatment T_4- soil + cocopeat + FYM + vermicompost in 2:1:1:1 recorded maximum plant height (95.30 cm) which was on par with T_5 - soil + perlite + coir pith + vermicompost (2:1:1:1) (93.97 cm) while, the minimum plant height (55.63 cm) was noted in the treatment T_1 - soil + sand + FYM (2:1:1) (control).

4.1.2 Plant spread in East-West direction (cm)

The results obtained regarding the plant spread in East-West direction of *Nephrolepis undulate* J. Sm at different growth stages are presented in Table 2. The plant spread increased continuously as the growing period progressed in different combination of potting media.

At 60 days after planting, significantly maximum plant spread (49.43 cm) in East-West direction was recorded in T_4- soil + cocopeat + FYM + vermicompost (2:1:1:1) which was on par with T_5 - soil + perlite + coir pith + vermicompost (2:1:1:1) (47.21 cm) while, the minimum plant spread (35.83 cm) was recorded in the treatment T_1 - soil + sand + FYM (2:1:1) (control).

There were significant differences with respect to the plant spread among the treatments at 90 days after planting. The maximum plant spread (47.91 cm) in East-West direction at 90 days after planting was recorded in T_4- soil + cocopeat + FYM + vermicompost in 2:1:1:1 (51.00 cm) which was on par with T_5 - soil + perlite + coir pith + vermicompost (2:1:1:1) while, the minimum plant spread (36.71 cm) was recorded in the treatment T_1 - soil + sand + FYM (2:1:1) (control).

At 120 and 150 days after planting, the maximum plant spread (55.00 and 62.33 cm, respectively) in East-West direction was recorded in T_4- soil + cocopeat + FYM + vermicompost in 2:1:1:1 which was on par with T_5 - soil + perlite + coir pith + vermicompost (2:1:1:1) (52.00 and 61.33 cm, respectively) while, the minimum plant spread (40.33 and 45.00 cm, respectively) was recorded in the treatment T_1 - soil + sand + FYM (2:1:1) (control).

At 180 days after planting, significantly maximum plant spread in East-West direction was recorded in T_4- soil + cocopeat + FYM + vermicompost in 2:1:1:1 (72.00 cm) which was on par with T_5 - soil + perlite + coir pith + vermicompost (2:1:1:1)

(70.00 cm) while, the minimum plant spread (56.67 cm) was recorded in the treatment T_1 - soil + sand + FYM (2:1:1) (control).

4.1.3 Plant spread in North-South direction (cm)

The data with respect to plant spread in North-South direction of different treatments at different growth stages are presented in Table 2. Significant variation was observed among different treatments of potting media for plant spread in North-South direction at different growth stages.

At 60 days after planting, significantly maximum plant spread (38.92 cm) in North-South direction was recorded in T_4- soil + cocopeat + FYM + vermicompost in 2:1:1:1 which was on par with T_5 - soil + perlite + coir pith + vermicompost (2:1:1:1) (38.75 cm) and T_8- cocopeat + vermicompost + FYM (2:1:1) (36.25 cm) while, the minimum plant spread (32.14 cm) was recorded in the treatment T_1 - soil + sand + FYM (2:1:1) (control).

At 90 and 120 days after planting, the maximum plant spread in North-South direction was recorded in T_4- soil + cocopeat + FYM + vermicompost in 2:1:1:1 (43.33 and 43.43 cm, respectively) which was on par with T_5 - soil + perlite + coir pith + vermicompost (2:1:1:1) (40.00 and 42.33cm, respectively) while, the minimum plant spread (33.33 and 35.67 cm, respectively) was recorded in the treatment T_1 - soil + sand + FYM (2:1:1) (control).

There were significant differences with respect to the plant spread among the treatments at 150 days after planting. The maximum plant spread in North-South direction at 150 days after planting was recorded in T_4- soil + cocopeat + FYM + vermicompost in 2:1:1:1 (63.67 cm) which was on par with T_5 - soil + perlite + coir pith + vermicompost (2:1:1:1) (59.67 cm) while, the minimum plant spread (45.33 cm) was recorded in the treatment T_1 - soil + sand + FYM (2:1:1) (control).

At 180 days after planting, significantly maximum plant spread in North-South direction was recorded in T_4- soil + cocopeat + FYM + vermicompost in 2:1:1:1 (73.67 cm) which was on par with T_5 – soil + perlite + coir pith + vermicompost (2:1:1:1) (71.33 cm) while, the minimum plant spread (57.33 cm) was recorded in the treatment T_1 - soil + sand + FYM (2:1:1) (control).

Table 2. Effect of potting media on plant spread of *Nephrolepis undulate* J. Sm at various stages of growth under protected condition

Treatment No.	Treatment details	Plant spread (cm)									
		Days after planting									
		60		90		120		150		180	
		EW	NS	EW	NS	EW	NS	EW	NS	EW	NS
T_1	Soil + Sand + FYM (2:1:1)(control)	35.83	32.14	36.71	33.33	40.33	35.67	45.00	45.33	56.67	57.33
T_2	Soil + Cocopeat + Vermicompost (2:1:1)	39.22	35.49	41.67	37.33	45.67	39.00	55.67	53.67	68.67	68.67
T_3	Soil + Coir pith + Vermicompost (2:1:1)	44.09	34.83	45.33	37.00	49.33	38.67	57.67	58.33	67.33	68.33
T_4	Soil + Cocopeat + FYM + Vermicompost (2:1:1:1)	49.43	38.92	51.00	43.33	55.00	43.00	62.33	63.67	72.00	73.67
T_5	Soil + Perlite + Coir pith + Vermicompost (2:1:1:1)	47.21	38.75	47.91	40.00	52.00	42.33	61.33	59.67	70.00	71.33
T_6	Cocopeat + Sand + FYM (2:1:1)	39.15	34.73	41.33	35.50	45.33	38.00	48.67	50.33	58.00	60.33
T_7	Cocopeat + Vermicompost + Coir pith (2:1:1)	40.66	34.67	40.99	35.67	42.33	39.00	47.33	46.00	60.33	60.67
T_8	Cocopeat + Vermicompost + FYM (2:1:1)	38.43	36.25	41.69	36.67	43.00	39.67	47.67	45.67	60.00	61.00
T_9	Cocopeat + Perlite + Sand + Vermicompost (2:1:1:1)	40.19	35.01	42.11	36.00	43.33	39.00	48.33	45.33	57.67	58.33
T_{10}	Cocopeat + Perlite + Coir pith + Vermicompost (2:1:1:1)	38.83	34.79	40.00	36.00	44.00	38.33	55.33	50.00	68.00	69.00
	S. Em ±	**1.12**	**0.98**	**0.92**	**0.92**	**1.10**	**0.99**	**1.00**	**1.01**	**0.79**	**1.16**
	CD @ 1%	**4.51**	**3.96**	**3.71**	**3.70**	**4.44**	**4.00**	**4.02**	**4.07**	**3.17**	**4.68**

4.1.4 Number of shoots

The results obtained regarding the number of shoots of *Nephrolepis undulate* J. Sm at different growth stages are presented in Table 3. The number of shoots increased continuously as the growing period progressed in different combination of potting media.

At 60 days after planting, significantly maximum number of shoots was observed in T_4- soil + cocopeat + FYM + vermicompost in 2:1:1:1 (2.20) which is followed by T_5 - soil + perlite + coir pith + vermicompost (2:1:1:1) (2.00) while, the minimum number of shoots (1.15) was recorded in the treatment T_1 - soil + sand + FYM (2:1:1) (control).

The number of shoots varied significantly among the different treatments at 90 days after planting. The treatment T_4- soil + cocopeat + FYM + vermicompost in 2:1:1:1 recorded maximum number of shoots (3.17) which was on par with T_5 - soil + perlite + coir pith + vermicompost (2:1:1:1) (3.03) and T_6- cocopeat + sand + FYM (2:1:1) (2.90) while, the minimum number of shoots (2.03) was recorded in the treatment T_1 - soil + sand + FYM (2:1:1) (control).

At 120 days after planting, the treatment T_4- soil + cocopeat + FYM + vermicompost in 2:1:1:1 significantly recorded maximum number of shoots (4.57) which was on par with T_5 - soil + perlite + coir pith + vermicompost (2:1:1:1) (4.23) while, the minimum number of shoots (3.10) was recorded in the treatment T_1 - soil + sand + FYM (2:1:1) (control).

The significant differences were observed with respect to number of shoots in different treatments at 150 days after planting. The maximum number of shoots was recorded in the treatment T_4- soil + cocopeat + FYM + vermicompost in 2:1:1:1 (5.13) which is followed by T_5 - soil + perlite + coir pith + vermicompost (2:1:1:1) (4.33) while, the minimum number of shoots (3.20) was recorded in the treatment T_1 - soil + sand + FYM (2:1:1) (control).

The number of shoots varied significantly among the different treatments at 180 days after planting. The maximum number of shoots was recorded in the treatment T_4- soil + cocopeat + FYM + vermicompost in 2:1:1:1 (6.17) which was on par with T_5 - soil + perlite + coir pith + vermicompost (2:1:1:1) (6.07) while, the minimum number of shoots (3.53) was recorded in the treatment T_1 - soil + sand + FYM (2:1:1) (control).

Table 3. Effect of potting media on number of shoots of *Nephrolepis undulate* J. Sm at various stages of growth under protected condition

Treatment No.	Treatment details	Number of shoots				
		Days after planting				
		60	**90**	**120**	**150**	**180**
T_1	Soil + Sand + FYM (2:1:1)(control)	1.15	2.03	3.10	3.20	3.53
T_2	Soil + Cocopeat + Vermicompost (2:1:1)	1.33	2.07	3.07	3.20	3.77
T_3	Soil + Coir pith + Vermicompost (2:1:1)	1.53	2.37	3.13	3.30	3.60
T_4	Soil + Cocopeat + FYM + Vermicompost (2:1:1:1)	2.20	3.17	4.57	5.13	6.17
T_5	Soil + Perlite + Coir pith + Vermicompost (2:1:1:1)	2.00	3.03	4.23	4.33	6.07
T_6	Cocopeat + Sand + FYM (2:1:1)	1.55	2.90	3.03	3.13	3.97
T_7	Cocopeat + Vermicompost + Coir pith (2:1:1)	0.91	2.43	2.10	2.20	3.10
T_8	Cocopeat + Vermicompost + FYM (2:1:1)	1.43	2.50	4.03	4.27	4.37
T_9	Cocopeat + Perlite + Sand + Vermicompost (2:1:1:1)	1.43	2.23	4.17	4.20	4.30
T_{10}	Cocopeat + Perlite + Coir pith + Vermicompost (2:1:1:1)	1.20	2.07	3.63	3.80	3.83
	S. Em ±	**0.04**	**0.07**	**0.09**	**0.10**	**0.10**
	CD @ 1%	**0.17**	**0.27**	**0.36**	**0.40**	**0.40**

4.1.5 Number of croziers

The results obtained regarding the number of croziers of *Nephrolepis undulate* J. Sm at different growth stages are presented in Table 4.

At 60 days after planting, significantly maximum number of croziers was observed in T_4- soil + cocopeat + FYM + vermicompost in 2:1:1:1 (4.40) which was on par with T_5 - soil + perlite + coir pith + vermicompost (2:1:1:1) (4.23) while, the minimum number of croziers (2.90) was recorded in the treatment T_7- cocopeat + vermicompost + coir pith (2:1:1).

The treatment T_4- soil + cocopeat + FYM + vermicompost in 2:1:1:1 having maximum number of croziers (2.17) at 90 days after planting which is followed by T_5 - soil + perlite + coir pith + vermicompost (2:1:1:1) (1.83) while, the minimum number of croziers (1.33) was recorded in the treatment T_2- soil + cocopeat + vermicompost (2:1:1).

The significant differences were observed with respect to number of croziers at 120 days after planting. The maximum number of croziers was recorded in T_4- soil + cocopeat + FYM + vermicompost in 2:1:1:1(2.00) which is followed by T5 - soil + perlite + coir pith + vermicompost (2:1:1:1) (1.73) while, the minimum number of croziers (1.23) was recorded in the treatment T_2- soil + cocopeat + vermicompost (2:1:1).

Similar trend was also noticed at 150 days after planting. The maximum number of croziers was observed in the treatment T_4- Soil + cocopeat + FYM + vermicompost in 2:1:1:1 (2.10) which was on par with T_2- soil + cocopeat + vermicompost (2:1:1) (2.07) and T_5- soil + perlite + coir pith + vermicompost (2:1:1:1) (2.03) while, the minimum number of croziers (1.43) was recorded in the treatment T_1 - soil + sand + FYM (2:1:1) (control).

The treatment T_4- soil + cocopeat + FYM + vermicompost in 2:1:1:1 (3.10) recorded the maximum number of croziers at 180 days after planting which was followed by T_5- soil + perlite + coir pith + vermicompost (2:1:1:1) (2.48) while, the minimum number of croziers (1.60) was recorded in the treatment T_1 - soil + sand + FYM (2:1:1) (control).

Table 4. Effect of potting media on number of croziers of *Nephrolepis undulate* J. Sm at various stages of growth under protected condition

Treatment No.	Treatment details	Number of croziers				
		Days after planting				
		60	**90**	**120**	**150**	**180**
T_1	Soil + Sand + FYM (2:1:1) (control)	3.30	1.53	1.43	1.44	1.60
T_2	Soil + Cocopeat + Vermicompost (2:1:1)	3.23	1.33	1.23	2.07	2.10
T_3	Soil + Coir pith + Vermicompost (2:1:1)	3.10	1.47	1.37	1.47	2.30
T_4	Soil + Cocopeat + FYM + Vermicompost (2:1:1:1)	4.40	2.17	2.00	2.10	3.10
T_5	Soil + Perlite + Coir pith + Vermicompost (2:1:1:1)	4.23	1.83	1.73	2.03	2.48
T_6	Cocopeat + Sand + FYM (2:1:1)	3.70	1.60	1.40	1.93	2.10
T_7	Cocopeat + Vermicompost + Coir pith (2:1:1)	2.90	1.77	1.63	1.47	2.03
T_8	Cocopeat + Vermicompost + FYM (2:1:1)	3.20	1.53	1.57	1.58	1.70
T_9	Cocopeat + Perlite + Sand + Vermicompost (2:1:1:1)	3.33	1.63	1.77	1.77	2.20
T_{10}	Cocopeat + Perlite + Coir pith + Vermicompost (2:1:1:1)	3.60	1.53	1.23	1.57	1.97
	S. Em ±	**0.10**	**0.04**	**0.04**	**0.05**	**0.06**
	CD @ 1%	**0.40**	**0.16**	**0.17**	**0.19**	**0.24**

4.1.6 Number of fronds

The data pertaining to the number of fronds per plant of different treatments of potting media was given in the Table 5. The significant differences were observed for number of fronds per plant among different treatments of potting media.

At 60 days after planting, significant differences were noticed among the different treatments of potting media for number of fronds per plant. The maximum number of fronds per plant was observed in the treatment T_4- soil + cocopeat + FYM + vermicompost in 2:1:1:1 (3.96) which was on par with T_5 - soil + perlite + coir pith + vermicompost (2:1:1:1) (3.73) while, the minimum number of fronds (2.78) was recorded in the treatment T_1 - soil + sand + FYM (2:1:1) (control).

At 90 days after planting, significantly maximum number of fronds per plant was observed in the treatment T_4- soil + cocopeat + FYM + vermicompost in 2:1:1:1 (5.60) which was on par with T_6- cocopeat + sand + FYM (2:1:1) (5.47) and T_5 - soil + perlite + coir pith + vermicompost (2:1:1:1) (5.43) while, the minimum number of fronds (3.13) was recorded in the treatment T_1 - soil + sand + FYM (2:1:1) (control).

The treatment T_4- soil + cocopeat + FYM + vermicompost in 2:1:1:1 having maximum number of fronds (10.53) at 120 days after planting which is followed by T_5 - soil + perlite + coir pith + vermicompost (2:1:1:1) (9.57) while, the minimum number of fronds (7.23) was recorded in the treatment T_1 - soil + sand + FYM (2:1:1) (control).

Similar trend was also noticed at 150 and 180 days after planting. The maximum number of fronds was observed in the treatment T_4- soil + cocopeat + FYM + vermicompost in 2:1:1:1 (11.40 and 12.00, respectively) which was on par with (10.50) T_7- cocopeat + vermicompost + coir pith (2:1:1) at 150 days after planting and (T_4) on par with T_5 - soil + perlite + coir pith + vermicompost (2:1:1:1) (11.33) at 180 days after planting while, the minimum number of fronds (8.57 and 8.63, respectively) was recorded in the treatment T_1 - soil + sand + FYM (2:1:1) (control).

4.1.7 Crozier length (cm)

The data pertaining to the crozier length of different treatments of potting media was given in the Table 6. The significant differences were observed for crozier length among different treatments of potting media.

At 60 and 90 days after planting, the maximum length of crozier was observed in the treatment T_4- soil + cocopeat + FYM + vermicompost in 2:1:1:1 (4.90 and 4.97cm, respectively) which was on par with T_5- soil + perlite + coir pith + vermicompost (2:1:1:1) (4.80 and 4.83 cm, respectively) while, the minimum crozier length (2.27 and 2.47 cm, respectively) was recorded in T_1 - soil + sand + FYM (2:1:1) (control).

Table 5. Effect of potting media on number of fronds of *Nephrolepis undulate* J. Sm at various stages of growth under protected condition

Treatment No.	Treatment details	Number of fronds				
		Days after planting				
		60	**90**	**120**	**150**	**180**
T_1	Soil + Sand + FYM (2:1:1) (control)	2.78	3.13	7.23	8.57	8.63
T_2	Soil + Cocopeat + Vermicompost (2:1:1)	2.58	3.43	6.30	8.87	9.47
T_3	Soil + Coir pith + Vermicompost (2:1:1)	3.20	5.00	8.53	8.60	9.03
T_4	Soil + Cocopeat + FYM + Vermicompost (2:1:1:1)	3.96	5.60	10.53	11.40	12.00
T_5	Soil + Perlite + Coir pith + Vermicompost (2:1:1:1)	3.73	5.43	9.57	9.67	11.33
T_6	Cocopeat + Sand + FYM (2:1:1)	3.30	5.47	9.20	10.47	10.50
T_7	Cocopeat + Vermicompost + Coir pith (2:1:1)	3.02	4.77	8.63	10.50	10.97
T_8	Cocopeat + Vermicompost + FYM (2:1:1)	3.13	4.80	7.20	8.37	10.67
T_9	Cocopeat + Perlite + Sand + Vermicompost (2:1:1:1)	3.30	4.27	7.40	8.97	9.17
T_{10}	Cocopeat + Perlite + Coir pith + Vermicompost (2:1:1:1)	3.05	4.63	9.13	10.15	10.17
	S. Em ±	**0.08**	**0.13**	**0.22**	**0.24**	**0.25**
	CD @ 1%	**0.34**	**0.54**	**0.89**	**0.98**	**0.99**

Table 6. Effect of potting media on crozier lengthof *Nephrolepis undulate* J. Sm at various stages of growth under protected condition

Treatment No.	Treatments details	Crozier length(cm)				
		Days after planting				
		60	90	120	150	180
T_1	Soil + Sand + FYM (2:1:1) (control)	2.27	2.47	2.33	2.33	2.43
T_2	Soil + Cocopeat + Vermicompost (2:1:1)	4.50	4.50	4.50	4.70	4.60
T_3	Soil + Coir pith + Vermicompost (2:1:1)	2.52	2.50	2.62	2.66	2.53
T_4	Soil + Cocopeat + FYM + Vermicompost (2:1:1:1)	4.90	4.97	4.83	4.97	4.93
T_5	Soil + Perlite + Coir pith + Vermicompost (2:1:1:1)	4.80	4.83	4.93	4.87	4.88
T_6	Cocopeat + Sand + FYM (2:1:1)	2.41	2.47	2.48	2.41	2.43
T_7	Cocopeat + Vermicompost + Coir pith (2:1:1)	2.93	3.00	3.07	3.00	3.03
T_8	Cocopeat + Vermicompost + FYM (2:1:1)	2.61	2.87	2.91	2.74	2.80
T_9	Cocopeat + Perlite + Sand + Vermicompost (2:1:1:1)	3.57	3.43	3.50	3.57	3.53
T_{10}	Cocopeat + Perlite + Coir pith + Vermicompost (2:1:1:1)	4.32	4.17	4.16	4.12	4.20
	S. Em ±	**0.06**	**0.06**	**0.08**	**0.08**	**0.08**
	CD @ 1%	**0.23**	**0.25**	**0.33**	**0.31**	**0.32**

At 120 days after planting, the maximum length of crozier was observed in the treatment T_5- soil + perlite + coir pith + vermicompost (2:1:1:1) (4.93 cm) which was on par with T_4- soil + cocopeat + FYM + vermicompost in 2:1:1:1 (4.83 cm), while the minimum crozier length (2.23 cm) was recorded in T_1 - soil + sand + FYM (2:1:1) (control).

At 150 and 180 days after planting, the length of crozier varied significantly. The maximum length of crozier was observed in the treatment T_4- soil + cocopeat + FYM + vermicompost in 2:1:1:1 (4.97 and 4.93 cm, respectively) which was on par with T_5- soil + perlite + coir pith + vermicompost (2:1:1:1) (4.87and 4.88 cm, respectively) while, the minimum crozier length (2.33 and 2.43 cm, respectively) was recorded in T_1 - soil + sand + FYM (2:1:1) (control).

4.1.8 Frond length (cm)

The data pertaining to the length of fronds of *Nephrolepis undulate* J. Sm at different stages of plant growth are presented in Table 7. Different treatments showed significant differences with respect to frond length at various growth stages.

At 60 days after planting, the maximum frond length was noticed in the T_4- soil + cocopeat + FYM + vermicompost in 2:1:1:1 (39.96 cm) which was on par with T_5 - soil + perlite + coir pith + vermicompost (2:1:1:1) (36.67 cm) while, the minimum frond length (32.06 cm) was recorded in the treatment T_1 - soil + sand + FYM (2:1:1) (control).

The treatment T_4- soil + cocopeat + FYM + vermicompost in 2:1:1:1 (59.30 cm) recorded maximum frond length at 90 days after planting which was on par with both T_5 - soil + perlite + coir pith + vermicompost (2:1:1:1) and T_3- soil + coir pith + vermicompost (2:1:1) (56.03 and 55.63 cm, respectively) while, the minimum frond length (36.37 cm) was recorded in the treatment T_8-cocopeat + vermicompost + FYM (2:1:1).

Significant differences were observed among the treatments. Among that, the treatment T_4- soil + cocopeat + FYM + vermicompost in 2:1:1:1 (60.26 cm) recorded maximum frond length at 120 DAP which was on par with both T_7- cocopeat + vermicompost + coir pith (2:1:1) (59.97 cm) and T_3- soil + coir pith + vermicompost (2:1:1) (59.35 cm) while, the minimum frond length (37.03 cm) was recorded in the treatment T_8-cocopeat + vermicompost + FYM (2:1:1).

At 150 days after planting, the maximum frond length was noticed in the T_4- soil + cocopeat + FYM + vermicompost in 2:1:1:1 (82.32 cm) which was on par with T_5 - soil + perlite + coir pith + vermicompost (2:1:1:1) (80.23 cm) and T_6- cocopeat + sand + FYM (2:1:1) (80.22) while, the minimum frond length (52.81 cm) was recorded in the treatment T_1 - soil + sand + FYM (2:1:1) (control).

Table 7. Effect of potting media on frond length of *Nephrolepis undulate* J. Sm at various stages of growth under protected condition

Treatment No.	Treatment details	Frond length(cm)				
		Days after planting				
		60	90	120	150	180
T_1	Soil + Sand + FYM (2:1:1) (control)	32.06	43.99	54.87	52.81	54.38
T_2	Soil + Cocopeat + Vermicompost (2:1:1)	32.15	38.79	39.25	58.81	69.33
T_3	Soil + Coir pith + Vermicompost (2:1:1)	34.15	55.63	59.35	66.14	75.00
T_4	Soil + Cocopeat + FYM + Vermicompost (2:1:1:1)	39.96	59.30	60.26	82.32	87.00
T_5	Soil + Perlite + Coir pith + Vermicompost (2:1:1:1)	36.67	56.03	58.33	80.23	85.59
T_6	Cocopeat + Sand + FYM (2:1:1)	31.55	49.42	49.88	80.22	80.47
T_7	Cocopeat + Vermicompost + Coir pith (2:1:1)	30.94	40.56	59.97	62.63	81.02
T_8	Cocopeat + Vermicompost + FYM (2:1:1)	31.73	36.37	37.03	58.03	62.00
T_9	Cocopeat + Perlite + Sand + Vermicompost (2:1:1:1)	32.33	39.10	39.33	63.54	63.67
T_{10}	Cocopeat + Perlite + Coir pith + Vermicompost (2:1:1:1)	32.50	43.03	43.36	60.37	62.33
	S. Em ±	**0.90**	**1.20**	**1.34**	**1.58**	**1.25**
	CD @ 1%	**3.61**	**4.82**	**5.40**	**6.34**	**5.03**

The frond length varied significantly at 180 days after planting. Among that, the treatment T_4- soil + cocopeat + FYM + vermicompost in 2:1:1:1 (87.00 cm) recorded maximum frond length which was on par with T_5 - soil + perlite + coir pith + Vermicompost (2:1:1:1) (85.59 cm) while, the minimum frond length (54.38 cm) was recorded in the treatment T_1 - soil + sand + FYM (2:1:1) (control).

4.1.9 Frond width (cm)

Data pertaining to the width of frond of *Nephrolepis undulate* J. Sm at different stages of growth is presented in Table 8. Irrespective of the growth stages, all the treatments showed significant differences with respect to frond width during the experimental period.

At 60 days after planting width of frond varied significantly. The maximum width of frond was produced in the treatment T_4- soil + cocopeat + FYM + vermicompost in 2:1:1:1(11.95 cm) which was followed by T_5 - soil + perlite + coir pith + vermicompost (2:1:1:1) (10.57 cm) while, the minimum frond width (8.28 cm) was recorded in the treatment T_9- cocopeat + perlite + sand + vermicompost (2:1:1:1).

At 90 days after planting, the maximum width of frond was recorded in the treatment T_4- soil + coco peat + FYM + vermicompost in 2:1:1:1 (12.99 cm) which was followed by T_5 – soil + perlite + coir pith + vermicompost (2:1:1:1) (11.56 cm) while, the minimum frond width (8.99 cm) was recorded in the treatment T_9- cocopeat + perlite + sand + vermicompost (2:1:1:1).

Width of frond varied significantly among the treatments at 120 days after planting. The maximum width of frond was recorded in the treatment T_4- soil + coco peat + FYM + vermicompost in 2:1:1:1(14.47 cm) which was on par with T_5 - soil + perlite + coir pith + vermicompost (2:1:1:1) (13.57 cm) while, the minimum frond width (10.17 cm) was recorded in the treatment T_1 - soil + sand + FYM (2:1:1) (control).

Similar trend was also noticed at 150 and 180 days after planting. The maximum width of frond was recorded in the treatment T_4- soil + cocopeat + FYM + vermicompost in 2:1:1:1 (14.93 and 15.67 cm, respectively) which was followed by T_5 - soil + perlite + coir pith + vermicompost (2:1:1:1) (13.61 and 14.87 cm, respectively) while, the minimum frond width (11.33 and 12.00 cm, respectively) was recorded in the treatment T_1 - soil + sand + FYM (2:1:1) (control).

Table 8. Effect of potting media on frond width of *Nephrolepis undulate* J. Sm at various stages of growth under protected condition

Treatment No.	Treatment details	Frond width (cm)				
		Days after planting				
		60	90	120	150	180
T_1	Soil + Sand + FYM (2:1:1) (control)	9.33	10.40	10.17	11.33	12.00
T_2	Soil + Cocopeat + Vermicompost (2:1:1)	9.39	9.96	10.26	12.33	13.10
T_3	Soil + Coir pith + Vermicompost (2:1:1)	9.90	10.51	13.29	13.33	14.82
T_4	Soil + Cocopeat + FYM + Vermicompost (2:1:1:1)	11.95	12.99	14.47	14.93	15.67
T_5	Soil + Perlite + Coir pith + Vermicompost (2:1:1:1)	10.57	11.56	13.57	13.61	14.87
T_6	Cocopeat + Sand + FYM (2:1:1)	10.40	11.50	13.51	13.59	13.99
T_7	Cocopeat + Vermicompost + Coir pith (2:1:1)	9.39	12.66	12.67	13.17	13.43
T_8	Cocopeat + Vermicompost + FYM (2:1:1)	10.43	11.35	11.50	12.00	12.30
T_9	Cocopeat + Perlite + Sand + Vermicompost (2:1:1:1)	8.28	8.99	10.36	13.43	14.00
T_{10}	Cocopeat + Perlite + Coir pith + Vermicompost (2:1:1:1)	9.49	9.95	12.33	13.25	13.93
	S. Em ±	**0.25**	**0.32**	**0.31**	**0.28**	**0.26**
	CD @ 1%	**1.02**	**1.27**	**1.23**	**1.14**	**1.03**

4.1.10 Leaflet length (cm)

The data pertaining to length of leaflet of *Nephrolepis undulate* J. Sm at different stages of plant growth are presented in Table 9. Different treatments showed significant differences with respect to leaflet length at various growth stages.

At 60 days after planting, leaflet length was found to be significantly maximum in T_4- soil + coco peat + FYM + vermicompost in 2:1:1:1(5.65 cm) which was on par with T_6- cocopeat + sand + FYM (2:1:1) (5.17 cm) and T_3- soil + coir pith + vermicompost (2:1:1) (5.09) while, the minimum length of leaflet (3.74 cm) was recorded in the treatment T_1 - soil + sand + FYM (2:1:1) (control).

The leaflet length varied significantly at 90 days after planting. The maximum length of leaflet was recorded in T_4- soil + cocopeat + FYM + vermicompost in 2:1:1:1(5.95 cm) which was T_3- soil + coir pith + vermicompost (2:1:1) (5.48 cm) while, the minimum length of leaflet (4.10 cm) was recorded in the treatment T_1 - soil + sand + FYM (2:1:1) (control).

Similar trend was also noticed at 120 and 150 days after planting. The maximum length of leaflet was recorded in the treatment T_4- soil + cocopeat + FYM + vermicompost in 2:1:1:1(8.23 and 8.27 cm, respectively) which was on par with T_5 - soil + perlite + coir pith + vermicompost (2:1:1:1) (7.93 and 8.13 cm, respectively) while, the minimum frond width (4.11 and 4.57 cm, respectively) was recorded in the treatment T_1 - soil + sand + FYM (2:1:1) (control).

The leaflet length varied significantly among the treatments. The maximum length of leaflet at 180 days after planting observed in the treatment T_4- soil + cocopeat + FYM + vermicompost in 2:1:1:1(8.30 cm) which was on par with T_5 - soil + perlite + coir pith + vermicompost (2:1:1:1) (8.20 cm) while, the minimum frond width (5.60 cm) was recorded in the treatment T_1 - soil + sand + FYM (2:1:1) (control).

4.1.11 Leaflet breadth (cm)

The data pertaining to breadth of leaflet of *Nephrolepis undulate* J. Sm at different stages of plant growth are presented in Table 10. The different treatments showed significant differences with respect to leaflet breadth at various growth stages.

The leaflet breadth varied significantly 60 days after planting. The maximum breadth of leaflet was produced in the treatment T_4- soil + cocopeat + FYM + vermicompost in 2:1:1:1 (1.83 cm) which was on par with T_5 - soil + perlite + coir pith + vermicompost (2:1:1:1) (1.71 cm) and T_6- cocopeat + sand + FYM (2:1:1) (1.70) while the minimum breadth of leaflet was produced in the treatment (1.00 cm) T_1 - soil + sand + FYM (2:1:1) (control).

Table 9. Effect of potting media on leaflet length of *Nephrolepis undulate* J. Sm at various stages of growth under protected condition

Treatment No.	Treatment details	Leaflet length(cm)				
		Days after planting				
		60	90	120	150	180
T_1	Soil + Sand + FYM (2:1:1) (control)	3.74	4.10	4.11	4.57	5.60
T_2	Soil + Cocopeat + Vermicompost (2:1:1)	4.63	5.29	6.70	6.73	7.50
T_3	Soil + Coir pith + Vermicompost (2:1:1)	5.09	5.48	7.01	7.17	7.83
T_4	Soil + Cocopeat + FYM + Vermicompost (2:1:1:1)	5.65	5.95	8.23	8.27	8.30
T_5	Soil + Perlite + Coir pith + Vermicompost (2:1:1:1)	4.99	5.37	7.93	8.13	8.20
T_6	Cocopeat + Sand + FYM (2:1:1)	5.17	5.36	8.07	8.10	8.17
T_7	Cocopeat + Vermicompost + Coir pith (2:1:1)	4.87	5.34	5.38	7.03	7.47
T_8	Cocopeat + Vermicompost + FYM (2:1:1)	4.25	5.36	6.79	6.93	7.11
T_9	Cocopeat + Perlite + Sand + Vermicompost (2:1:1:1)	3.98	4.22	5.77	5.83	5.90
T_{10}	Cocopeat + Perlite + Coir pith + Vermicompost (2:1:1:1)	4.75	5.29	6.85	7.36	7.40
	S. Em ±	**0.43**	**0.06**	**0.19**	**0.09**	**0.12**
	CD @ 1%	**1.73**	**0.25**	**0.75**	**0.37**	**0.48**

Table 10. Effect of potting media on leaflet breadth of *Nephrolepis undulate* J. Sm at various stages of growth under protected condition

Treatment No.	Treatment details	Leaflet breadth(cm)				
		Days after planting				
		60	**90**	**120**	**150**	**180**
T_1	Soil + Sand + FYM (2:1:1) (control)	1.00	1.17	1.27	1.33	1.37
T_2	Soil + Cocopeat + Vermicompost (2:1:1)	1.05	1.21	1.37	1.39	1.71
T_3	Soil + Coir pith + Vermicompost (2:1:1)	1.47	1.53	1.54	1.56	1.66
T_4	Soil + Cocopeat + FYM + Vermicompost (2:1:1:1)	1.83	1.98	1.99	2.00	2.10
T_5	Soil + Perlite + Coir pith + Vermicompost (2:1:1:1)	1.71	1.86	1.89	1.90	1.94
T_6	Cocopeat + Sand + FYM (2:1:1)	1.70	1.77	1.78	1.82	1.84
T_7	Cocopeat + Vermicompost + Coir pith (2:1:1)	1.30	1.35	1.37	1.41	1.48
T_8	Cocopeat + Vermicompost + FYM (2:1:1)	1.15	1.25	1.42	1.45	1.64
T_9	Cocopeat + Perlite + Sand + Vermicompost (2:1:1:1)	1.18	1.24	1.57	1.61	1.74
T_{10}	Cocopeat + Perlite + Coir pith + Vermicompost (2:1:1:1)	1.19	1.45	1.45	1.53	1.66
	S. Em ±	**0.04**	**0.04**	**0.02**	**0.04**	**0.04**
	CD @ 1%	**0.16**	**0.17**	**0.09**	**0.15**	**0.17**

At 90 days after planting, the treatment T_4- soil + cocopeat + FYM + vermicompost in 2:1:1:1(1.98 cm) significantly recorded the maximum breadth of leaflet length, which was on par with T_5 - soil + perlite + coir pith + vermicompost (2:1:1:1) (1.86 cm) while, the minimum breadth of leaflet was produced in the treatment (1.17 cm)T_1 - soil + sand + FYM (2:1:1) (control).

At 120 days after planting, significantly maximum leaflet breadth was observed in the treatment T_4- soil + coco peat + FYM + vermicompost in 2:1:1:1 (1.99 cm) which was followed by T_5 - soil + perlite + coir pith + vermicompost (2:1:1:1) (1.89 cm) while, the minimum breadth of leaflet was produced in the treatment (1.27 cm)T_1 - soil + sand + FYM (2:1:1) (control).

Similar trend was also noticed at 150 and 180 days after planting. The maximum breadth of leaflet was recorded in the treatment T_4- soil + cocopeat + FYM + vermicompost in 2:1:1:1(2.00 and 2.10 cm, respectively) which was on par with T_5 - soil + perlite + coir pith + vermicompost (2:1:1:1) (1.90 and 1.94 cm, respectively) while, the minimum leaflet breadth (1.33 and 1.37 cm, respectively) was recorded in the treatment T_1 - soil + sand + FYM (2:1:1) (control).

4.1.12 Shoot diameter (mm)

The data pertaining to diameter of shoot of *Nephrolepis undulate* J. Sm at different stages of plant growth are presented in Table 11. The different treatments showed significant differences with respect to shoot diameter at various growth stages.

The diameter of the shoot varied significantly at 60 days after planting, The maximum diameter of the shoot was recorded in the treatment T_4- soil + cocopeat + FYM + vermicompost in 2:1:1:1 (0.18 mm) which was on par with T_5 - soil + perlite + coir pith + vermicompost (2:1:1:1) (0.15 mm) while, the minimum diameter of shoot (0.14 mm) was recorded in the treatment T_1 - soil + sand + FYM (2:1:1) (control).

At 90 days after planting, significantly maximum diameter of the shoot was recorded in the treatment T_4- soil + cocopeat + FYM + vermicompost in 2:1:1:1(0.27 mm) which was on par with T_5 - soil + perlite + coir pith + vermicompost (2:1:1:1) and T_3- soil + coir pith + vermicompost (2:1:1) (0.26 and 0.26 mm respectively) while, the minimum shoot diameter (0.21 mm) was recorded in the treatment T_1 - soil + sand + FYM (2:1:1) (control).

Significantly maximum diameter of the shoot was recorded at 120 days after planting in the treatment T_4- soil + coco peat + FYM + vermicompost in 2:1:1:1 (0.51 mm) which was on par with T_5 - soil + perlite + coir pith + vermicompost (2:1:1:1) (0.50 mm) while, the minimum shoot diameter (0.43 mm) was recorded in the treatment T_1 - soil + sand + FYM (2:1:1) (control).

At 150 days after planting, diameter of the shoot varied significantly. The maximum shoot diameter was recorded in the treatment T_4- soil + cocopeat + FYM +

Table 11. Effect of potting media on shoot diameter of *Nephrolepis undulate* J. Sm at various stages of growth under protected condition

Treatment No.	Treatment details	Shoot diameter(mm)				
		Days after planting				
		60	90	120	150	180
T_1	Soil + Sand + FYM (2:1:1) (control)	0.14	0.21	0.43	0.50	0.62
T_2	Soil + Cocopeat + Vermicompost (2:1:1)	0.14	0.24	0.48	0.64	0.84
T_3	Soil + Coir pith + Vermicompost (2:1:1)	0.14	0.26	0.49	0.62	0.81
T_4	Soil + Cocopeat + FYM + Vermicompost (2:1:1:1)	0.18	0.27	0.51	0.71	0.95
T_5	Soil + Perlite + Coir pith + Vermicompost (2:1:1:1)	0.15	0.26	0.50	0.62	0.86
T_6	Cocopeat + Sand + FYM (2:1:1)	0.14	0.24	0.45	0.61	0.78
T_7	Cocopeat + Vermicompost + Coir pith (2:1:1)	0.14	0.25	0.47	0.51	0.77
T_8	Cocopeat + Vermicompost + FYM (2:1:1)	0.13	0.24	0.46	0.60	0.81
T_9	Cocopeat + Perlite + Sand + Vermicompost (2:1:1:1)	0.13	0.23	0.43	0.51	0.71
T_{10}	Cocopeat + Perlite + Coir pith + Vermicompost (2:1:1:1)	0.14	0.23	0.45	0.62	0.82
	S. Em ±	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**
	CD @ 1%	**0.04**	**0.05**	**0.05**	**0.02**	**0.05**

vermicompost in 2:1:1:1 (0.71 mm) which was followed by T_2- soil + cocopeat + vermicompost (2:1:1) (0.64 mm) while, the minimum shoot diameter (0.50 mm) was recorded in the treatment T_1 - soil + sand + FYM (2:1:1) (control).

Significantly shoot diameter varied at 180 days after planting. The maximum shoot diameter was recorded in the treatment T_4- soil + cocopeat + FYM + vermicompost in 2:1:1:1 (0.95 mm) which was followed by T_5 - soil + perlite + coir pith + vermicompost (2:1:1:1) (0.86 mm) while, the minimum shoot diameter (0.62 mm) was recorded in the treatment T_1 - soil + sand + FYM (2:1:1) (control).

4.1.13 Number of leaflets per frond

The data pertaining to leaflet numbers per frond of *Nephrolepis undulate* J. Sm at the time of peak plant growth are presented in Table 12. Different treatments showed significant differences with respect to number of leaflets at grand growth stage.

At the time of grand plant growth the number of leaflets varied significantly, the maximum number of leaflets were recorded in the treatment T_4- soil + cocopeat + FYM + vermicompost in 2:1:1:1 (135.00) which was on par with the treatment T_5 - soil + perlite + coir pith + vermicompost (2:1:1:1) (130.20) while, the minimum number of leaflets per frond was observed in the treatment (65.78) T_1 - soil + sand + FYM (2:1:1) (control).

4.1.14 Number of sori per leaflet

The data pertaining to sori number per leaflet of *Nephrolepis undulate* J. Sm at 90 days after planting are presented in Table 12. Different treatments showed significant differences with respect to number of sori per leaflet at 90 days after planting.

The number of sori per leaflet varied significantly at 90 days after planting, among the different treatments of combinations of media the maximum sori count were noted in the T_4- soil + cocopeat + FYM + vermicompost in 2:1:1:1 (63.00) which was on par with the treatment T_5 - soil + perlite + coir pith + vermicompost (2:1:1:1) (59.33) while, the minimum number of sori per leaflet was observed in the treatment (27.67) T_1 - soil + sand + FYM (2:1:1) (control).

4.1.15 Number of sporangia per sori

The data pertaining to sporangia number per sori of *Nephrolepis undulate* J. Sm at 90 days after planting are presented in Table 12. Different treatments showed significant differences with respect to number of sporangia per sori at 90 days after planting.

At 90 days after planting, significantly maximum number of sporangia were recorded in the treatment T_4- soil + cocopeat + FYM + vermicompost in 2:1:1:1 (35.56) which was on par with the treatment T_5 - soil + perlite + coir pith + vermicompost

(2:1:1:1) (34.89) while, the minimum number of sporangia per sori was observed in the treatment (21.22) T_1 - soil + sand + FYM (2:1:1) (control).

4.1.16. Number of spores per sporangia

The data pertaining to number of spores per sporangia of *Nephrolepis undulate* J. Sm at 90 days after planting are presented in Table 12. Different treatments showed significant differences with respect to number of spores per sporangia at 90 days after planting.

The number of spores per sporangia significantly maximum in the treatment T_4- soil + cocopeat + FYM + vermicompost in 2:1:1:1 (54.33) at 90 days after planting which was on par with the treatment T_5 - soil + perlite + coir pith + vermicompost (2:1:1:1) (50.00) while, the minimum number of spores per sporangia was observed in the treatment (35.22) T_1 - soil + sand + FYM (2:1:1) (control).

4.2 Qualitative parameters

4.2.1 Colour grade

For the assessment of leaf colour, the Royal Horticultural Society (RHS) – 2015 (6^{th} edition) colour chart has been used. The leaf colour varied between the treatments which is presented in Table 13.

The moderate yellowish green 138A was observed in T_4- soil + cocopeat + FYM + vermicompost in 2:1:1:1 and T_3- soil + coir pith + vermicompost (2:1:1) while that of moderate olive green 137B was observed in T_8- cocopeat + vermicompost + FYM (2:1:1) and T_9- cocopeat + perlite + vermicompost (2:1:1:1).

For the treatment T_2- soil + cocopeat + vermicompost (2:1:1) and T_5- soil + perlite + coir pith + vermicompost (2:1:1:1) the colour grade was moderate yellow green 139C while, that of greyish olive green NN137A was observed in T_1- soil + sand + FYM (2:1:1) (control) and moderate yellowish green N138B was observed in T_6- cocopeat + sand + FYM (2:1:1).

The moderate yellow green 138B was noted in T_7- cocopeat + vermicompost + coir pith (2:1:1) while that of brilliant yellow green 149B was observed in T_{10}- cocopeat + perlite + coir pith + vermicompost (2:1:1:1).

4.2.2 Visual plant grade

The data recorded on visual plant grade at grand growth stage of *Nephrolepis undulate* J. Sm in different potting media was presented in Table 14. Significantly visual plant grade varied among the different treatments.

Table 12. Effect of potting media on number of leaflets and reproductive parameters of *Nephrolepis undulate* J. Sm under protected condition

Treatment No.	Treatment details	Number of leaflets per frond	Number of sori per leaflet	Number of sporangia per sori	Number of spores per sporangia
T_1	Soil + Sand + FYM (2:1:1) (control)	65.78	27.67	21.22	35.22
T_2	Soil + Cocopeat + Vermicompost (2:1:1)	73.97	49.22	24.00	42.22
T_3	Soil + Coir pith + Vermicompost (2:1:1)	91.97	47.22	28.78	43.22
T_4	Soil + Cocopeat + FYM + Vermicompost (2:1:1:1)	135.00	63.00	35.56	54.33
T_5	Soil + Perlite + Coir pith + Vermicompost (2:1:1:1)	130.20	59.33	34.89	50.00
T_6	Cocopeat + Sand + FYM (2:1:1)	113.73	42.33	25.22	37.78
T_7	Cocopeat + Vermicompost + Coir pith (2:1:1)	93.70	43.00	25.86	37.89
T_8	Cocopeat + Vermicompost + FYM (2:1:1)	77.20	45.67	24.63	38.00
T_9	Cocopeat + Perlite + Sand + Vermicompost (2:1:1:1	82.40	41.11	26.89	37.67
T_{10}	Cocopeat + Perlite + Coir pith + Vermicompost (2:1:1:1)	82.33	51.89	23.33	37.67
	S. Em ±	**1.42**	**1.16**	**0.74**	**1.14**
	CD @ 1%	**5.72**	**4.67**	**2.99**	**4.57**

Table 13. Effect of potting media on colour gradeof *Nephrolepisundulate* J. Sm at under protected condition

Treatment No.	Treatment details	Colour code (as per RHS chart)	Colour
T_1	Soil + Sand + FYM (2:1:1) (control)	NN137A, Fan 3	Greyish olive green
T_2	Soil + Cocopeat + Vermicompost (2:1:1)	139C, Fan 3	Moderate yellow green
T_3	Soil + Coir pith + Vermicompost (2:1:1)	138A, Fan 3	Moderate yellowish green
T_4	Soil + Cocopeat + FYM + Vermicompost (2:1:1:1)	138A, Fan 3	Moderate yellowish green
T_5	Soil + Perlite + Coir pith + Vermicompost (2:1:1:1)	139C, Fan 3	Moderate yellow green
T_6	Cocopeat + Sand + FYM (2:1:1)	N138B, Fan 3	Moderate yellowish green
T_7	Cocopeat + Vermicompost + Coir pith (2:1:1)	138B, Fan 3	Moderate yellow green
T_8	Cocopeat + Vermicompost + FYM (2:1:1)	137B, Fan 3	Moderate olive green
T_9	Cocopeat + Perlite + Sand + Vermicompost (2:1:1:1	137B, Fan 3	Moderate olive green
T_{10}	Cocopeat + Perlite + Coir pith + Vermicompost (2:1:1:1)	149B, Fan 3	Brilliant yellow green

At grand growth stage visual plant grade varied significantly among the different treatments. The maximum visual plant grade was noted in the treatment T_4- soil + cocopeat + FYM + vermicompost in 2:1:1:1 (4.85) which was followed by T_5- soil + perlite + coir pith + vermicompost (2:1:1:1) (4.54) while, the minimum visual plant grade (3.08) was recorded in the treatment T_1- soil + sand + FYM (2:1:1) (control).

4.2.3 Chlorophyll content (mg/g of fresh weight)

The data pertaining to chlorophyll content of *Nephrolepis undulate* J. Sm at different combination of media were observed at grand plant growth stage. Significantly chlorophyll content varied among the different treatments at grand growth stage of plants which was presented in the Table 14.

4.2.3.1 Chlorophyll "a" (mg/g of fresh weight)

The chlorophyll "a" content varied significantly among the different treatments. The maximum chlorophyll "a" content was noted in the treatment T_4- soil + cocopeat + FYM + vermicompost in 2:1:1:1 (1.99 mg/g of fresh weight) which was on par with T_5- soil + perlite + coir pith + vermicompost (2:1:1:1) (1.97 mg/g of fresh weight) and T_6- cocopeat + sand + FYM (2:1:1) (1.87 mg/g of fresh weight) while, minimum chlorophyll "a" content was recorded in the treatment (0.98 mg/g of fresh weight) T_1- soil + sand + FYM (2:1:1) (control).

4.2.3.2 Chlorophyll "b" (mg/g of fresh weight)

Significantly chlorophyll "b" content varied among the different treatments. The maximum chlorophyll "b" content was noted in the treatment T_4- soil + cocopeat + FYM + vermicompost in 2:1:1:1 (0.97 mg/g of fresh weight) which was followed by T_5- soil + perlite + coir pith + vermicompost (2:1:1:1) (0.88 mg/g of fresh weight) while, minimum chlorophyll "b" content was recorded in the treatment (0.33 mg/g of fresh weight) T_1- soil + sand + FYM (2:1:1) (control).

4.2.3.3 Total Chlorophyll (mg/g of fresh weight)

At the time of grand growth stage total chlorophyll varied significantly among the different treatment. The maximum total chlorophyll content was noted in T_4- soil + cocopeat + FYM + vermicompost in 2:1:1:1 (2.96 mg/g of fresh weight) which was on par with T_5- soil + perlite + coir pith + vermicompost (2:1:1:1) (2.84 mg/g of fresh weight while, minimum total chlorophyll content was recorded in the treatment (1.35 mg/g of fresh weight) T_1- soil + sand + FYM (2:1:1) (control).

Table 14. Effect of potting media on chlorophyll content and visual plant grade of *Nephrolepis undulate* J. Sm at under protected condition

Treatment No.	Treatment details	Chlorophyll content (mg / g fresh weight)			Visual plant grade
		Chlorophyll "a"	Chlorophyll "b"	Total Chlorophyll	
T_1	Soil + Sand + FYM (2:1:1) (control)	0.98	0.33	1.35	3.08
T_2	Soil + Cocopeat + Vermicompost (2:1:1)	1.64	0.75	2.39	3.23
T_3	Soil + Coir pith + Vermicompost (2:1:1)	1.70	0.51	2.21	3.73
T_4	Soil + Cocopeat + FYM + Vermicompost (2:1:1:1)	1.99	0.97	2.96	4.85
T_5	Soil + Perlite + Coir pith + Vermicompost (2:1:1:1)	1.97	0.88	2.84	4.54
T_6	Cocopeat + Sand + FYM (2:1:1)	1.87	0.87	2.75	4.34
T_7	Cocopeat + Vermicompost + Coir pith (2:1:1)	1.39	0.64	2.02	3.94
T_8	Cocopeat + Vermicompost + FYM (2:1:1)	1.05	0.37	1.51	3.51
T_9	Cocopeat + Vermicompost + FYM (2:1:1)	1.09	0.46	1.42	3.94
T_{10}	Cocopeat + Perlite + Coir pith + Vermicompost (2:1:1:1)	1.74	0.54	2.28	3.33
	S. Em ±	**0.04**	**0.02**	**0.05**	**0.02**
	CD @ 1%	**0.16**	**0.07**	**0.19**	**0.09**

4.2.4 Shelf life (days)

The data pertaining to shelf life of *Nephrolepis undulate* J. Sm at different combination of media were observed during plant growth stage. Significantly shelf life varied among the different treatments during plant growth stage which was presented in the Table 15.

The shelf life varied significantly, among the different treatments the maximum shelf life was observed in the treatment T_4- soil + cocopeat + FYM + vermicompost in 2:1:1:1 (8.0 days) which was followed by T_5- soil + perlite + coir pith + vermicompost (2:1:1:1) (7.0 days) while, minimum shelf life was recorded in the treatment (6.0 days) T_1- soil + sand + FYM (2:1:1) (control).

4.2.5 Vase life (days)

The data pertaining to vase life of *Nephrolepis undulate* J. Sm at different combination of media were observed during plant growth stage. Significantly vase life varied among the different treatments which was presented in the Table 15.

The treatment T_4- soil + cocopeat + FYM + vermicompost in 2:1:1:1 (20.33 days) significantly recorded maximum vase life, which was followed by T_5- soil + perlite + coir pith + vermicompost (2:1:1:1) (18.33 days) while, minimum vase life was recorded in the treatment (15.00 days) T_1- soil + sand + FYM (2:1:1) (control).

4.3 Shoot and root parameters

4.3.1 Shoot biomass (g)

The data pertaining to shoot biomass of *Nephrolepis undulate* J. Sm at different combination of media were observed after harvesting. Significantly shoot biomass varied among the different treatments after harvesting which was presented in the Table 16.

4.3.1.1 Fresh weight of the shoot (g)

Significantly maximum fresh weight of shoot was recorded in the treatment T_4- soil + cocopeat + FYM + vermicompost in 2:1:1:1 (178.11 g) which was on par with the treatment T_5- soil + perlite + coir pith + vermicompost (2:1:1:1) (176.00 g) and T_6- cocopeat + sand + FYM (2:1:1) (164.22 g) while, minimum fresh weight of shoot was recorded in the treatment (135.78 g) T_1- soil + sand + FYM (2:1:1) (control).

4.3.1.2 Dry weight of the shoot (g)

Significantly maximum dry weight of shoot was recorded in the treatment T_4- soil + cocopeat + FYM + vermicompost in 2:1:1:1 (81.77 g) which was on par with the treatment T_5- soil + perlite + coir pith + vermicompost (2:1:1:1) (78.78 g).

Table 15. Effect of potting media on shelf life and vase life of *Nephrolepis undulate* J. Sm at under protected condition

Treatment No.	Treatment details	Shelf life(days)	Vase life (days)
T_1	Soil + Sand + FYM (2:1:1) (control)	6.00	15.00
T_2	Soil + Cocopeat + Vermicompost (2:1:1)	6.87	17.67
T_3	Soil + Coir pith + Vermicompost (2:1:1)	6.03	20.00
T_4	Soil + Cocopeat + FYM + Vermicompost (2:1:1:1)	8.00	20.33
T_5	Soil + Perlite + Coir pith + Vermicompost (2:1:1:1)	7.00	18.33
T_6	Cocopeat + Sand + FYM (2:1:1)	6.00	16.33
T_7	Cocopeat + Vermicompost + Coir pith (2:1:1)	6.67	16.67
T_8	Cocopeat + Vermicompost + FYM (2:1:1)	7.00	15.67
T_9	Cocopeat + Perlite + Sand + Vermicompost (2:1:1:1	6.33	15.33
T_{10}	Cocopeat + Perlite + Coir pith + Vermicompost (2:1:1:1)	6.17	16.33
	S. Em ±	**0.16**	**0.43**
	CD @ 1%	**0.66**	**1.75**

While, minimum dry weight of shoot was recorded in the treatment (60.89 g) T_1- soil + sand + FYM (2:1:1) (control).

4.3.2 Root biomass (g)

The data pertaining to root biomass of *Nephrolepis undulate* J. Sm at different combination of media were observed. Significantly root biomass varied among the different treatments which was presented in the Table 16.

4.3.2.1 Fresh weight of the root (g)

Significantly, fresh weight of the root varied among the treatments. The maximum fresh weight of root was recorded in the treatment T_4- soil + cocopeat + FYM + vermicompost in 2:1:1:1 (353.67 g) which was followed by the treatment T_5- soil + perlite + coir pith + vermicompost (2:1:1:1) (244.44 g) while, minimum fresh weight of root was recorded in the treatment (95.11 g) T_1- soil + sand + FYM (2:1:1) (control).

4.3.2.2 Dry weight of the root (g)

The dry weight of the root varied significantly among the treatments. The maximum dry weight of root was recorded in the treatment T_4- soil + cocopeat + FYM + vermicompost in 2:1:1:1 (132.56 g) which was on par with the T_8- cocopeat + vermicompost + FYM (2:1:1) (128.22 g) treatment T_5- soil + perlite + coir pith + vermicompost (2:1:1:1) (123.56 g) and while, minimum dry weight of root was recorded in the treatment (62.11 g) T_1- soil + sand + FYM (2:1:1) (control).

4.3.3 Root length (cm)

The data pertaining to root length of *Nephrolepis undulate* J. Sm in different combinations of media were observed after harvesting. Significantly the root length varied among the different treatments which was presented in the Table 17.

Significantly the maximum length of the root was noted in the treatment T_4- soil + cocopeat + FYM + vermicompost in 2:1:1:1 (36.11 cm) which was followed by T_7- cocopeat + vermicompost + coir pith (2:1:1) (31.00 cm) while, the minimum root length was noted in the treatment (27.89 cm) T_1- soil + sand + FYM (2:1:1) (control).

4.3.4 Root diameter (mm)

The data pertaining to root diameter of *Nephrolepis undulate* J. Sm in different combination of media were observed after harvesting. Significantly root diameter varied among the different treatments which was presented in the Table 17.

Table 16. Effect of potting media on shoot and root biomass of *Nephrolepis undulate* J. Sm under protected condition at 180days after planting

Treatment No.	Treatment details	Shoot biomass(g)		Root biomass(g)	
		Fresh weight	Dry weight	Fresh weight	Dry weight
T_1	Soil + Sand + FYM (2:1:1) (control)	135.78	60.89	95.11	62.11
T_2	Soil + Cocopeat + Vermicompost (2:1:1)	141.33	61.00	176.56	71.33
T_3	Soil + Coir pith + Vermicompost (2:1:1)	175.44	73.09	199.00	77.67
T_4	Soil + Cocopeat + FYM + Vermicompost (2:1:1:1)	178.11	81.77	353.67	132.56
T_5	Soil + Perlite + Coir pith + Vermicompost (2:1:1:1)	176.00	78.78	244.44	123.56
T_6	Cocopeat + Sand + FYM (2:1:1)	164.22	70.11	197.78	107.00
T_7	Cocopeat + Vermicompost + Coir pith (2:1:1)	158.22	70.00	143.78	80.78
T_8	Cocopeat + Vermicompost + FYM (2:1:1)	141.56	62.11	186.78	128.22
T_9	Cocopeat + Perlite + Sand + Vermicompost (2:1:1:1)	154.11	64.99	188.67	94.11
T_{10}	Cocopeat + Perlite + Coir pith + Vermicompost (2:1:1:1)	155.56	65.56	119.22	68.44
	S. Em ±	**4.46**	**1.46**	**3.27**	**5.06**
	CD @ 1%	**17.95**	**5.88**	**13.14**	**20.38**

Significantly the maximum root diameter was noted in the treatment T_4- soil + cocopeat + FYM + vermicompost in 2:1:1:1 (0.35 mm) which was followed T_5- soil + perlite + coir pith + vermicompost (2:1:1:1) (0.30 mm) and T_9- coco peat + perlite + sand + vermicompost (2:1:1:1) (0.30 mm) while, the minimum root diameter was noted in the treatment (0.20 mm) T_1- soil + sand + FYM (2:1:1) (control).

4.3.5 Root volume (cc)

The data pertaining to root volume of *Nephrolepis undulate* J. Sm in different combination of media were observed after harvesting. The root volume varied significantly among the different treatments which was presented in the Table 17.

Significantly the maximum root volume was noted in the treatment T_4- soil + cocopeat + FYM + vermicompost in 2:1:1:1 (85.33 cc) which was on par with the treatment T_5- soil + perlite + coir pith + vermicompost (2:1:1:1) (83.33 cc) while, the minimum root volume was noted in the treatment (53.38 cc) T_1- soil + sand + FYM (2:1:1) (control).

4.4 Media analysis

4.4.1 Before planting

The data pertaining to analysis of media of *Nephrolepis undulate* J. Sm in different combination of media were observed before planting. It is significantly varied among the different treatments before planting which was presented in the Table 18.

4.4.1.1 pH

Soil reaction before planting was analyzed by potentiometric method, and it was varied significantly among the different combinations of media. The treatment T_4- soil + coco peat + FYM + vermicompost (2:1:1:1) (6.13) recorded the minimum pH, which was followed by T_5- soil + perlite + coir pith + vermicompost (2:1:1:1) (6.20) while the minimum pH was recorded in T_1- soil + sand + FYM (2:1:1) (control) (7.60).

4.4.1.2 EC (ds/m)

Before planting EC was analyzed by conductometric method, and it is varied significantly among the different treatments. The minimum EC was noted in the treatment T_4- soil + cocopeat + FYM + vermicompost (2:1:1:1) (0.24 ds/m), which was on par with T_5- soil + perlite + coir pith + vermicompost (2:1:1:1) (0.31 ds/m) whereas, minimum EC was noted in T_1- soil + sand + FYM (2:1:1) (0.76 ds/m) (control).

4.4.1.3 Organic carbon (%)

The total organic carbon content varied significantly among the different treatments. the maximum amount of total organic carbon content was noted in the treatment T_4- soil + cocopeat + FYM + vermicompost in 2:1:1:1 (0.78 %) which was

followed by T_5- soil + perlite + coir pith + vermicompost (2:1:1:1) (0.71 %) while, minimum organic carbon content was recorded in the treatment (0.54 %) T_1- soil + sand + FYM (2:1:1) (control).

4.4.1.4 Available nitrogen (%)

The total available nitrogen varied significantly among the different treatments. The maximum amount of total nitrogen content was noted in the treatment T_4- soil + cocopeat + FYM + vermicompost in 2:1:1:1 (1.19 %) which was on par with the treatment T_5- soil + perlite + coir pith + vermicompost (2:1:1:1) (1.13 %) while, minimum nitrogen content was recorded in the treatment (0.50 %) T_1- soil + sand + FYM (2:1:1) (control).

4.4.1.5 Available phosphorous (%)

Before planting media was analyzed for the total amount of available phosphorous and it is varied significantly among the treatments. The maximum amount of total phosphorous content was noted in the treatment T_4- soil + cocopeat + FYM + vermicompost in 2:1:1:1 (1.41 %) which was on par with the treatment T_5- soil + perlite + coir pith + vermicompost (2:1:1:1) (1.21 %) while, minimum phosphorous content was recorded in the treatment (0.52 %) T_1- soil + sand + FYM (2:1:1) (control).

4.4.1.6 Available potassium (%)

The total potassium content varied significantly among the different treatments. the maximum amount of total potassium content was observed in the treatment T_4- soil + cocopeat + FYM + vermicompost in 2:1:1:1 (1.43 %) which was followed by T_5- soil + perlite + coir pith + vermicompost (2:1:1:1) (1.23 %) while, minimum potassium content was recorded in the treatment (0.56 %) T_1- soil + sand + FYM (2:1:1) (control).

4.4.2 After 180 days after planting

The data pertaining to analysis of media of *Nephrolepis undulate* J. Sm in different combination of media were observed after harvesting. It is significantly varied among the different treatments after 180 days which was presented in the Table 18.

4.4.2.1 pH

After 180 days, soil reaction was analyzed by potentiometric method, and it was varied significantly among the different combinations of media. The minimum pH was noted in T_4- soil + cocopeat + FYM + vermicompost (2:1:1:1) (5.80) followed by T_5- soil + perlite + coir pith + vermicompost (2:1:1:1) (5.87), whereas, the maximum pH was recorded in T_1- soil + sand + FYM (2:1:1) (control) (0.32 ds/m) (7.07) and T_7- cocopeat + vermicompost + coir pith (2:1:1) (7.07).

4.4.2.2 EC (ds/m)

After harvesting EC was analyzed by conductometric method, and it is varied significantly among the different treatments. The minimum EC was noted in T_4- soil + cocopeat + FYM + vermicompost (2:1:1:1) (0.21 ds/m) followed by T_5- soil + perlite + coir pith + vermicompost (2:1:1:1) (0.23 ds/m) whereas, maximum EC was noted in T_1- soil + sand + FYM (2:1:1) (control) (0.61 ds/m).

4.4.2.3 Organic carbon (%)

The total organic carbon content varied significantly among the different treatments after harvesting. The maximum amount of total organic carbon content was noted in the treatment T_4- soil + cocopeat + FYM + vermicompost in 2:1:1:1 (0.72 %) which was on par with the treatment T_5- soil + perlite + coir pith + vermicompost (2:1:1:1) (0.69 %) while, minimum organic carbon content was recorded in the treatment (0.51 %) T_1- soil + sand + FYM (2:1:1) (control).

4.4.2.4 Available nitrogen (%)

The total available nitrogen varied significantly among the different treatments. The maximum amount of total nitrogen content was noted in the treatment T_4- soil + cocopeat + FYM + vermicompost in 2:1:1:1 (0.80 %) which was on par with the treatment T_5- soil + perlite + coir pith + vermicompost (2:1:1:1) (0.77 %) while, minimum nitrogen content was recorded in the treatment (0.40 %) T_1- soil + sand + FYM (2:1:1) (control).

4.4.2.5 Available phosphorous (%)

Before planting media was analyzed for the total amount of available phosphorous and it is varied significantly among the treatments. The maximum amount of total phosphorous content was noted in the treatment T_4- soil + cocopeat + FYM + vermicompost in 2:1:1:1 (1.21 %) which was followed by the treatment T_5- soil + perlite + coir pith + vermicompost (2:1:1:1) (1.07 %) while, minimum phosphorous content was recorded in the treatment (0.41 %) T_1- soil + sand + FYM (2:1:1) (control).

4.4.2.6 Available potassium (%)

The total potassium content varied significantly among the different treatments. the maximum amount of total potassium content was observed in the treatment T_4- soil + cocopeat + FYM + vermicompost in 2:1:1:1 (1.22 %) which was followed by T_5- soil + perlite + coir pith + vermicompost (2:1:1:1) (1.10 %) while, minimum potassium content was recorded in the treatment (0.42 %) T_1- soil + sand + FYM (2:1:1) (control).

Table 17. Effect of potting media on root length, diameter and volume of *Nephrolepis undulate* J. Sm under protected condition

Treatment No.	Treatment details	Root length(cm)	Root diameter(mm)	Root volume(cc)
T_1	Soil + Sand + FYM (2:1:1) (control)	27.89	0.20	53.38
T_2	Soil + Cocopeat + Vermicompost (2:1:1)	32.89	0.21	71.00
T_3	Soil + Coir pith + Vermicompost (2:1:1)	29.89	0.26	75.00
T_4	Soil + Cocopeat + FYM + Vermicompost (2:1:1:1)	36.11	0.35	85.33
T_5	Soil + Perlite + Coir pith + Vermicompost (2:1:1:1)	30.56	0.30	83.33
T_6	Cocopeat + Sand + FYM (2:1:1)	30.00	0.23	79.33
T_7	Cocopeat + Vermicompost + Coir pith (2:1:1)	31.00	0.24	81.35
T_8	Cocopeat + Vermicompost + FYM (2:1:1)	29.78	0.23	62.33
T_9	Cocopeat + Perlite + Sand + Vermicompost (2:1:1:1)	28.11	0.30	62.67
T_{10}	Cocopeat + Perlite + Coir pith + Vermicompost (2:1:1:1)	28.56	0.25	60.71
	S. Em ±	**0.79**	**0.01**	**0.67**
	CD @ 1%	**3.18**	**0.02**	**2.71**

Table 18. The pH, EC (ds/m), OC, N, P and K (%) content of the potting media under protected condition

Treat. No.	Treatment details	Before planting						After planting					
		pH	EC (ds/m)	OC (%)	N (%)	P (%)	K (%)	pH	EC (ds/m)	OC (%)	N (%)	P (%)	K (%)
T_1	Soil + Sand + FYM (2:1:1)(control)	7.60	0.76	0.54	0.50	0.52	0.56	7.07	0.61	0.51	0.40	0.41	0.42
T_2	Soil + Cocopeat + Vermicompost (2:1:1)	6.47	0.38	0.64	0.83	0.91	0.93	5.87	0.25	0.58	0.71	0.81	0.82
T_3	Soil + Coir pith + Vermicompost (2:1:1)	6.80	0.63	0.65	1.00	1.12	1.13	6.10	0.52	0.63	0.73	0.91	0.92
T_4	Soil + Cocopeat + FYM + Vermicompost (2:1:1:1)	6.13	0.24	0.78	1.19	1.41	1.43	5.80	0.21	0.72	0.80	1.21	1.22
T_5	Soil + Perlite + Coir pith + Vermicompost (2:1:1:1)	6.20	0.31	0.71	1.13	1.21	1.23	5.87	0.23	0.69	0.77	1.07	1.10
T_6	Cocopeat + Sand + FYM (2:1:1)	6.23	0.56	0.64	0.93	1.00	1.13	5.93	0.41	0.57	0.51	0.91	0.92
T_7	Cocopeat + Vermicompost + Coir pith (2:1:1)	7.10	0.39	0.66	0.83	0.73	0.83	7.07	0.30	0.63	0.50	0.61	0.71
T_8	Cocopeat + Vermicompost + FYM (2:1:1)	6.23	0.44	0.68	0.97	0.90	0.93	6.00	0.31	0.65	0.60	0.81	0.85
T_9	Cocopeat + Vermicompost + FYM (2:1:1)	6.53	0.62	0.60	0.93	1.03	1.09	6.23	0.48	0.58	0.70	0.93	0.93
T_{10}	Cocopeat + Perlite + Coir pith + Vermicompost (2:1:1:1)	6.93	0.32	0.62	0.73	0.81	0.84	6.27	0.28	0.59	0.61	0.70	0.71
	S. Em ±	**0.10**	**0.01**	**0.01**	**0.03**	**0.02**	**0.02**	**0.10**	**0.01**	**0.01**	**0.02**	**0.01**	**0.02**
	CD @ 1%	**0.40**	**0.04**	**0.04**	**0.10**	**0.10**	**0.09**	**0.42**	**0.04**	**0.05**	**0.06**	**0.05**	**0.09**

4.5 Plant analysis

Effect of potting media on N, P and K content of *Nephrolepis undulate* J. Sm was calculated and it is varied significantly among the treatments which was presented in Table 19.

4.5.1 Available nitrogen (%)

The total available nitrogen varied significantly among the different treatments. The maximum amount of total nitrogen content was noted in the treatment T_4- soil + cocopeat + FYM + vermicompost in 2:1:1:1 (5.10 %) which was followed by the treatment T_2- soil + cocopeat + vermicompost (2:1:1) (3.56 %) while, minimum nitrogen content was recorded in the treatment (1.80 %) T_1- soil + sand + FYM (2:1:1) (control).

4.5.2 Available phosphorous (%)

At the time of grand plant growth stage, plant was analyzed for the total amount of available phosphorous and it is varied significantly among the treatments. The maximum amount of total phosphorous content was noted in the treatment T_4- soil + cocopeat + FYM + vermicompost in 2:1:1:1 (0.59 %) which was followed by the treatment T_5- soil + perlite + coir pith + vermicompost (2:1:1:1) (0.47 %) while, minimum phosphorous content was recorded in the treatment (0.29 %) T_1- Soil + Sand + FYM (2:1:1) (control).

4.5.3 Available potassium (%)

The total potassium content varied significantly among the different treatments. the maximum amount of total potassium content was observed in the treatment T_4- soil + cocopeat + FYM + vermicompost in 2:1:1:1 (2.65 %) which was followed by T_5- soil + perlite + coir pith + vermicompost (2:1:1:1) (1.77 %) while, minimum potassium content was recorded in the treatment (0.78 %) T_1- soil + sand + FYM (2:1:1) (control).

4.6 Incidence of pest and diseases

There is no major pest and diseases was reported to *Nephrolepis undulate* J. Sm during study period under protected condition.

4.7 Economics

The total cost, gross returns, net returns and benefit to cost ratio of *Nephrolepis undulate* J. Sm grown under protected condition per hectare are presented in Table 20 and appendix II.

The treatment T_4- soil + cocopeat + FYM + vermicompost (2:1:1:1) recorded the maximum gross returns (₹ 338400.00) and net returns (₹ 229990.00) followed by T_6- cocopeat + sand + FYM (2:1:1) which realized maximum gross returns (₹ 335200.00) and net returns (₹ 228700.00)

Table 19. Effect of potting media on N, P and K of *Nephrolepis undulate* J. Sm at grand growth stage

Treatment No.	Treatment details	Plant analysis		
		N (%)	P (%)	K (%)
T_1	Soil + Sand + FYM (2:1:1) (control)	1.80	0.29	0.78
T_2	Soil + Cocopeat + Vermicompost (2:1:1)	3.56	0.36	1.66
T_3	Soil + Coir pith + Vermicompost (2:1:1)	2.59	0.43	0.88
T_4	Soil + Cocopeat + FYM + Vermicompost (2:1:1:1)	5.10	0.59	2.65
T_5	Soil + Perlite + Coir pith + Vermicompost (2:1:1:1)	2.90	0.47	1.77
T_6	Cocopeat + Sand + FYM (2:1:1)	2.01	0.46	1.16
T_7	Cocopeat + Vermicompost + Coir pith (2:1:1)	2.43	0.44	1.59
T_8	Cocopeat + Vermicompost + FYM (2:1:1)	3.33	0.39	1.48
T_9	Cocopeat + Perlite + Sand + Vermicompost (2:1:1:1)	2.20	0.38	1.18
T_{10}	Cocopeat + Perlite + Coir pith + Vermicompost (2:1:1:1)	3.41	0.38	1.69
	S. Em ±	**0.06**	**0.01**	**0.02**
	CD @ 1%	**0.25**	**0.04**	**0.08**

Table 20. Economics of *Nephrolepis undulate*J. Sm under protected condition (1000m^2)

Treatment No.	Treatments	Total cost of production (₹/ha)	Gross Income (₹ /ha)	Net Income (₹ /ha)	B: C ratio
T_1	Soil + Sand + FYM (2:1:1)(control)	98500.00	252800.00	154300.00	1.56
T_2	Soil + Cocopeat + Vermicompost (2:1:1)	104500.00	278400.00	173900.00	1.66
T_3	Soil + Coir pith + Vermicompost (2:1:1)	102500.00	278400.00	175900.00	1.71
T_4	Soil + Cocopeat + FYM + Vermicompost (2:1:1:1)	108500.00	338400.00	229990.00	2.15
T_5	Soil + Perlite + Coir pith + Vermicompost (2:1:1:1)	110500.00	335200.00	224700.00	2.03
T_6	Cocopeat + Sand + FYM (2:1:1)	106500.00	335200.00	228700.00	2.14
T_7	Cocopeat + Vermicompost + Coir pith (2:1:1)	110500.00	312000.00	201500.00	1.82
T_8	Cocopeat + Vermicompost + FYM (2:1:1)	110500.00	312000.00	201500.00	1.82
T_9	Cocopeat + Perlite + Sand + Vermicompost (2:1:1:1)	118500.00	312000.00	193500.00	1.63
T_{10}	Cocopeat + Perlite + Coir pith + Vermicompost (2:1:1:1)	118500.00	311000.00	193500.00	1.62

Note: Marketable price of fern pot @ Rs.600 and 750(visual grade basis) and Rs. 8 per frond

while, minimum gross returns (₹ 252800.00) and net returns (₹ 154300.00) was in the treatment T_1- soil + sand + FYM (2:1:1) (control). The benefit to cost ratio (B: C) was maximum (1: 2.15) in T_4- soil + cocopeat + FYM + vermicompost (2:1:1:1) which was followed by T_6- cocopeat + sand + FYM (2:1:1) (1: 2.14) while, the minimum was noted in T_1- soil + sand + FYM (2:1:1) (control) (1: 1.56).

DISCUSSION

V DISCUSSION

A cut-foliages occupy an important position in the local and international markets and constitute an important section of floral industry. The commercial interest in one such foliage is fern, highly valued in the international florist greenery market because of their beautiful and varied foliage long post-harvest life, low cost, low investment, year-round availability and versatile design qualities in form, texture and colour.

The potting media play important role in the growth and development of foliage plants. And awareness of using these foliage plants is increasing day by day. These are mainly grown in inside and outside showrooms, hotels, houses, institutional buildings, bungalows *etc*. There is a huge demand in the international market for foliage plants. Hence standardized media will help the landscapers and other stake holders in the utilization of *Nephrolepis undulate* J. Sm more efficiently.

With this perspective, the present experiment was carried out during the year 2018-19 at experimental block of Department of Floriculture and Landscape Architecture, College of Horticulture, Mudigere. The investigations were made as an attempt to standardize the potting media for *Nephrolepis undulate* J. Sm under protected condition. The results of the experiment are discussed in this chapter with the supporting data and available literature.

5.1 Growth parameters

The potting media showed significant differences with respect to plant height at various growth stages (60, 90, 120, 150 and 180 days). The maximum plant height (95.30 cm) was observed in the media containing soil + cocopeat + FYM + vermicompost (2:1:1:1) which was significantly superior over other potting media whereas, the minimum plant height (55.63 cm) was observed in the media having soil + sand + FYM (2:1:1) which is represented in Figure 2. The variation in plant height was may be due to the vermicompost, which is rich in humus and contains valuable vitamins, enzymes and hormones like auxins, gibberellins, *etc*. helpful for better growth and development and high nitrogen content available to plants which are grown in cocopeat. These results are in conformity with the reports of Sandeep *et al*. (2018) in *Nephrolepis* fern, Swetha *et al*. (2014) in aglaonema and Dhiman *et al*. (2010) in chrysanthemum.

The plant spread varied significantly maximum plant spread in both East-West and North- South direction (72.00 and 73.67 cm respectively) was recorded in the media having soil + cocopeat + FYM + vermicompost (2:1:1:1) superior over other treatments whereas, the minimum spread (56.67 and 57.33 cm respectively) was observed in the media containing soil + sand + FYM (2:1:1). This may be due to the

FYM and vermicompost containing various minerals and nutrients that are required for the efficient growth of the plant and better physical properties of the substrate media which influences the absorption of nutrients by the plants which was observed previously in Abid *et al*. (2017) in dracaena, Ikram *et al*. (2012) in chrysanthemum, Chauhan *et al*. (2014) in gerbera and Muraleedharan and Karuppaiah (2015) in anthurium.

Significant differences with respect to number of shoots (suckers) was noticed. The maximum number of shoots (6.17) was observed in the media having soil + cocopeat + FYM + vermicompost (2:1:1:1) superior over other treatments whereas, minimum number of shoots (3.53) was observed in the media soil + sand + FYM (2:1:1).The variation in number of shoots was may be due to the vermicompost, which is rich in humus and contains valuable vitamins, enzymes and hormones like auxins, gibberellins *etc*. helpful for better growth and development This was in-line with the conclusions of Singh and Nair (2003) in diffenbhachia, Jawaharlal *et al*. (2001) in anthurium, Dhananjaya and Sulladmath (2003) in anthurium.

The number of croziers is one of the important character of fern which influences the number of fronds. The media having soil + cocopeat + FYM + vermicompost (2:1:1:1) recorded maximum number of croziers (3.10) whereas, the minimum number of croziers (1.60) was recorded in soil + sand + FYM (2:1:1). The variation in the number of croziers due to improve in the physical properties of substrate, such as bulk density, container capacity, electrical conductivity, microbial activity and nitrate concentrations which are helpful for increasing the number of croziers. Similar results are obtained earlier by Nair *et al*. (2015) in leather leaf fern.

The number of fronds per plant is one of the important character in *Nephrolepis* fern, as they play a key role in deciding the ultimate yield of cut foliages. The number of fronds varied significantly the maximum number of fronds (12.00) was noted in media soil + cocopeat + FYM + vermicompost (2:1:1:1) while, the minimum number of fronds (8.63) was noticed in soil + sand + FYM (2:1:1). This may be due to the vermicompost, in appropriate quantities to potting media has synergistic effectsand cocopeat was found to improve the physical properties of the substrate, decrease compaction and enable better growth and production which was beneficial for increasing the number of fronds. These results are in conformity with earlier by Nair *et al*. (2015) in leather leaf fern and Sandeep *et al*. (2018) in *Nephrolepis* fern.

The treatment media having soil + cocopeat + FYM + vermicompost (2:1:1:1) significantly recorded the maximum length of crozier (4.93 cm) while, minimum length of crozier (2.43 cm) was noted in soil + sand + FYM (2:1:1). The variation in the length of crozier is due to the vermicompost contains microorganisms.The microbial activities also promote plant growth, including production of antibiotics,

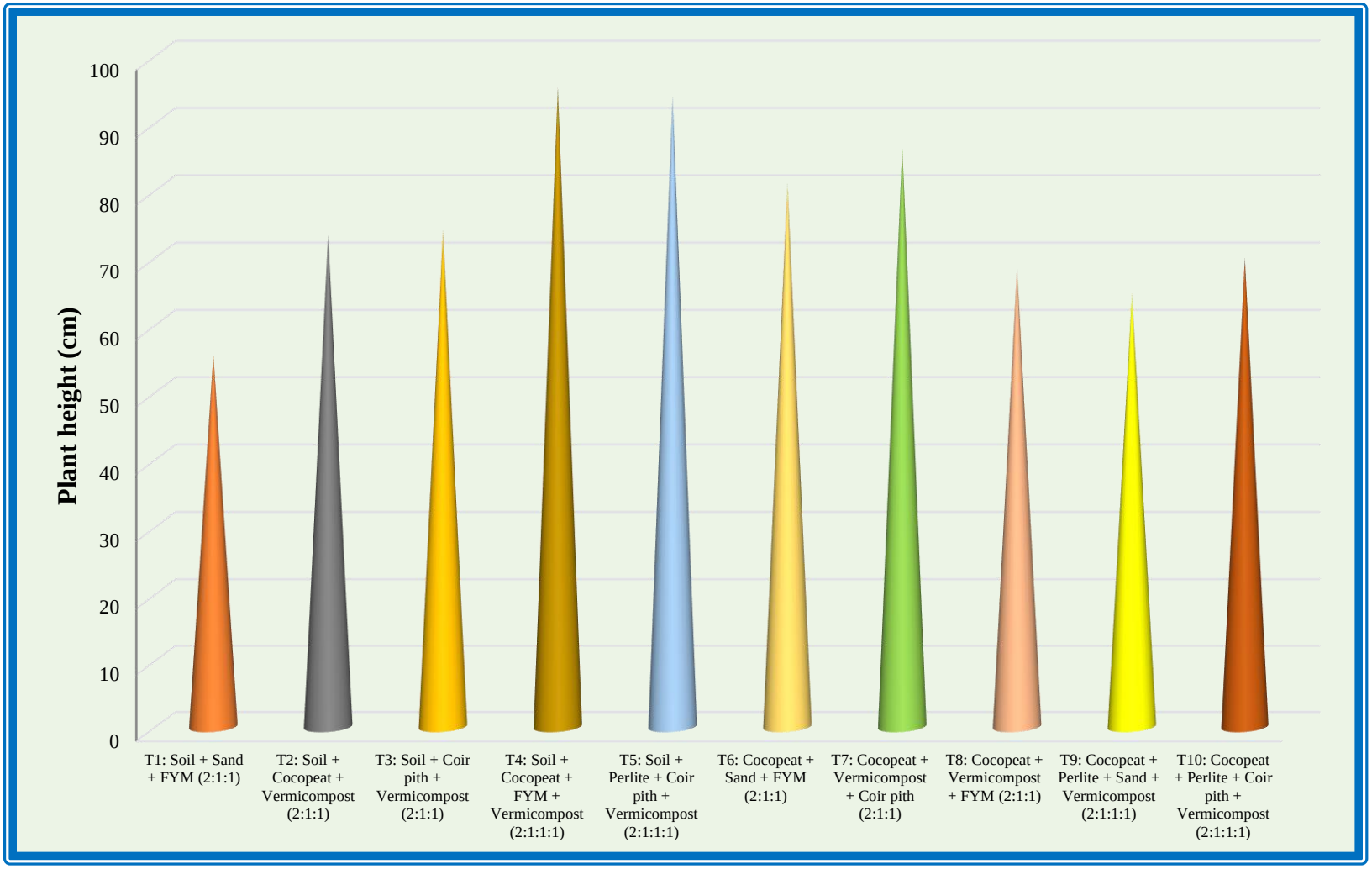


Figure 2. Effect of potting media on plant height of *Nephrolepis undulate* J. Sm at 180 days after planting under protected condition

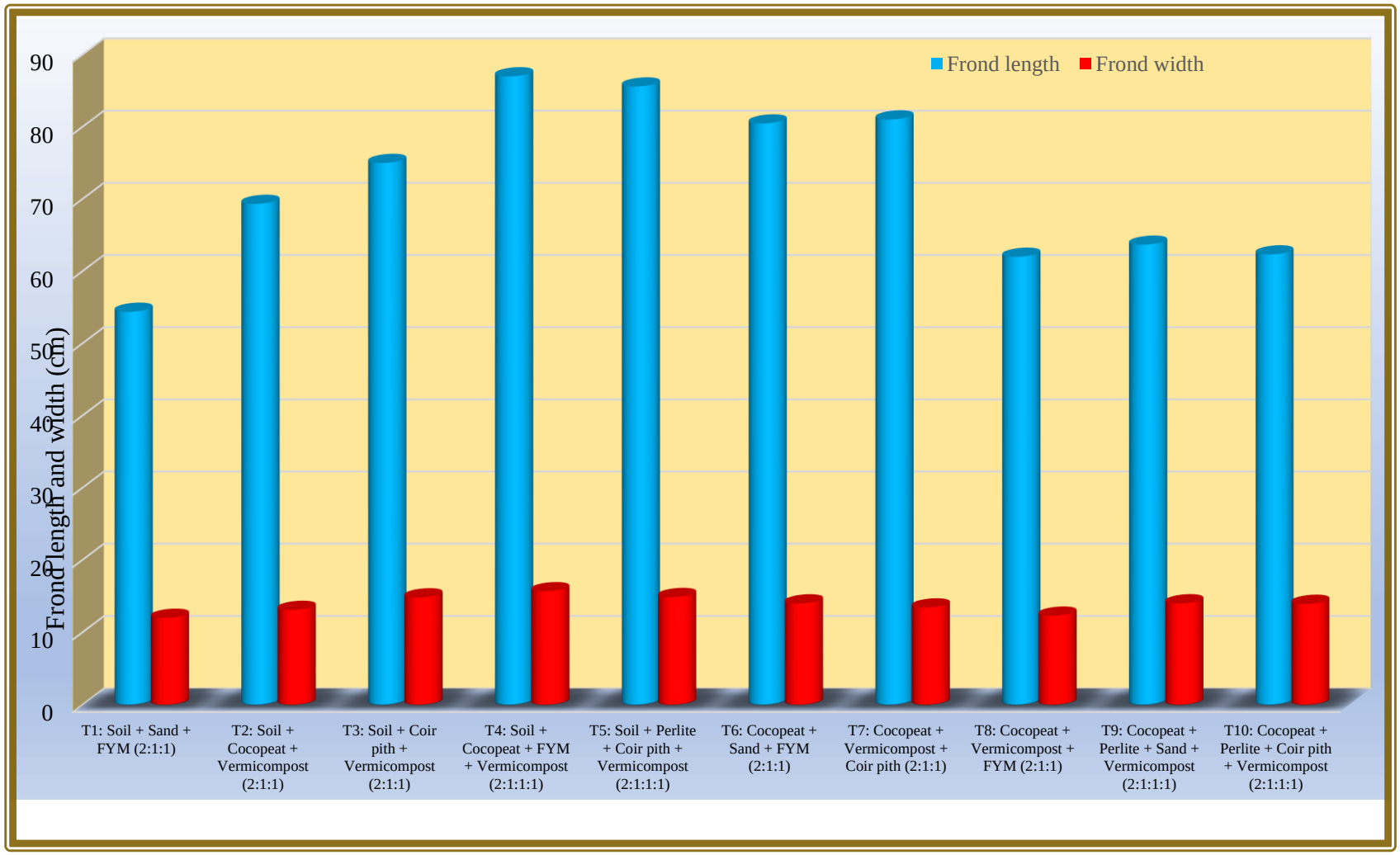
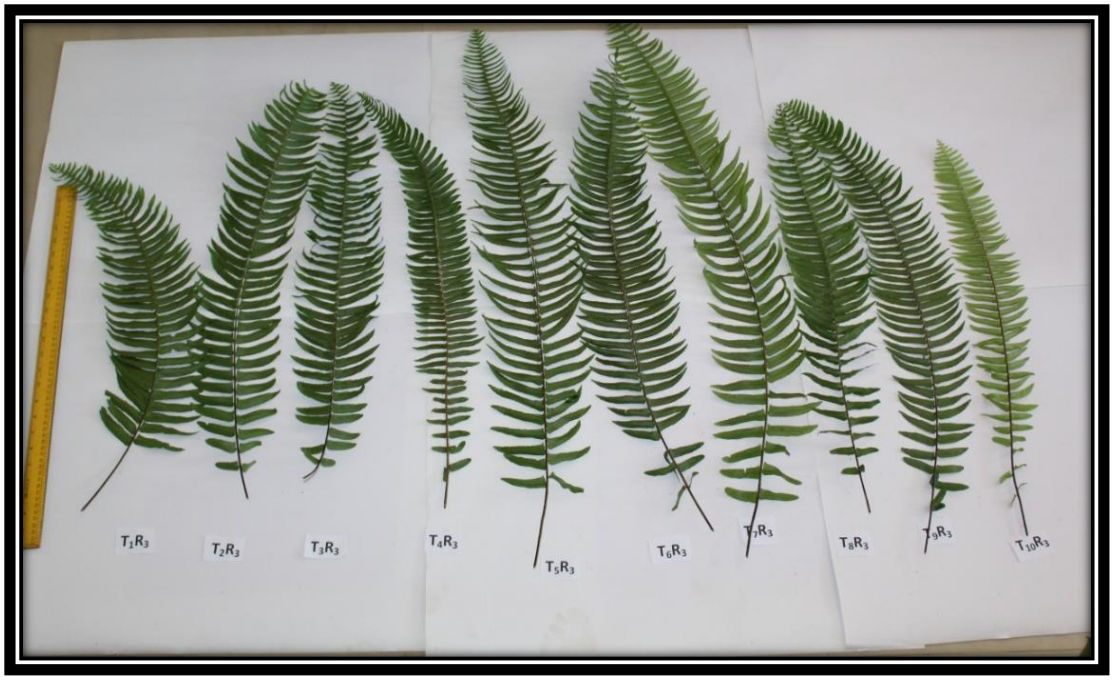
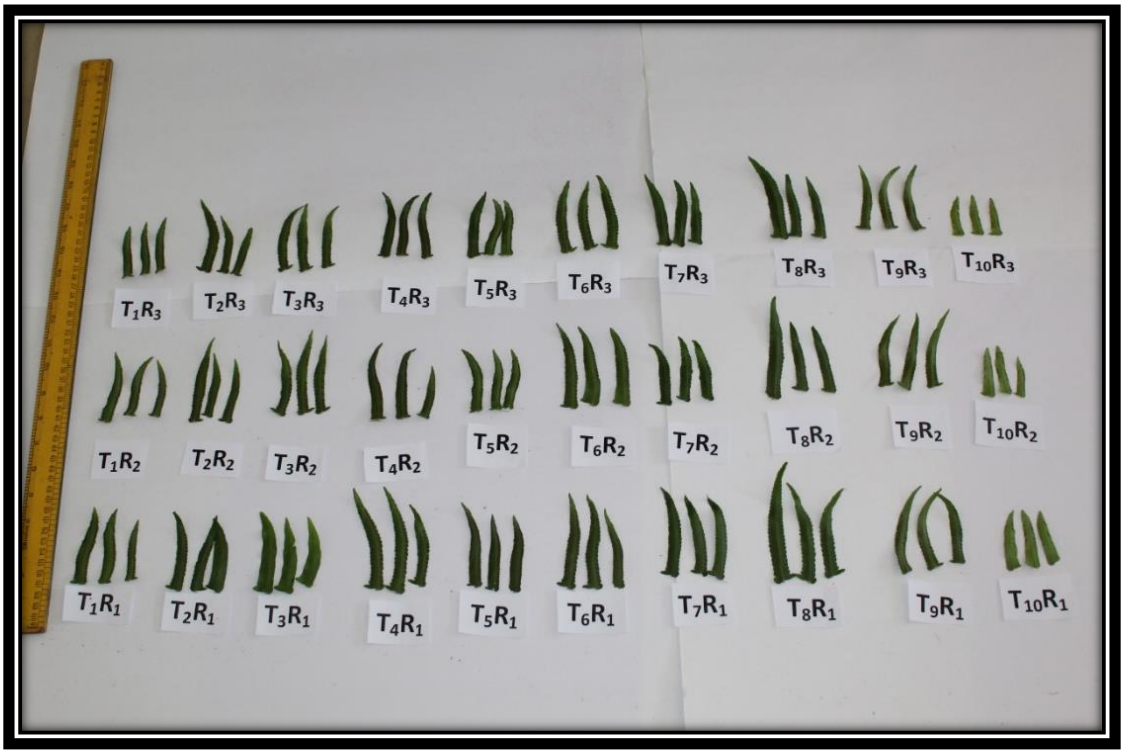


Figure 3. Effect of potting media on frond length and width of *Nephrolepis undulate* J. Sm at 180 days after planting under protected condition



(a)



(b)

Plate 3. Variation in the frond length (a) and leaflet length (b)

disease antagonists and plant growth influencing substances such as hormones and humates, presence of such substances could alsoincrease the crozier length. These results are reported earlier by Sandeep *et al*. (2018) in *Nephrolepis* fern.

During all the stages of plant growth the frond length showed significant variation. Significantly the maximum frond length (87.00 cm) was noticed in the media soil + cocopeat + FYM + vermicompost (2:1:1:1) whereas, the minimum frond length (54.38 cm) was recorded in soil + sand + FYM (2:1:1) which is represented in Figure 3. This is because of that vermicompost contains microorganisms which can form synergistic relationships in plant rhizospheres, thereby increasing the capacity of plants to utilize soil moisture and nutrients. Similarly, variation in the frond length was also reported earlier by Nair *et al*. (2015) in leather leaf fern and Sandeep *et al*. (2018) in *Nephrolepis* fern.

The width of the fronds also plays a vital role in making the fern for standard cut foliage. It is one of the parameters that decide the significance of suitability of fern for commercial cultivation. Significant differences were observed among the different treatments for frond width. The maximum width of frond (15.67 cm) was recorded in media havingsoil + cocopeat + FYM + vermicompost (2:1:1:1) whereas, the minimum frond width (12.00 cm) was recorded in soil + sand + FYM (2:1:1) which is represented in Figure 3. The variation in width of frond is due to the vermicompost, which contains microorganisms.The microbial activities also promote plant growth, including production of antibiotics, disease antagonists and plant growth influencing substances such as hormones and humates. Presence of such substances could also increase the growth and yield that occurred even at the lowest rate of vermicompost applications. These findings are in conformity with Sandeep *et al*. (2018) in *Nephrolepis* fern and Nair *et al*. (2015) in leather leaf fern.

The frond width was influenced by leaflet length. Significant influence in the length of the leaflet is due to the higher water-holding capacity of cocopeat and high nutrient content of vermicompost may have been responsible for maximum leaflet length. Among the treatments the maximum leaflet length (8.30 cm) was recorded in the media soil + cocopeat + FYM + vermicompost (2:1:1:1) whereas, the minimum frond width (5.60 cm) was recorded in soil + sand + FYM (2:1:1) which is represented in Figure 4. These results are in accordance with earlier reports of Swetha *et al*. (2014) in aglaonema, Kayalvizhi *et al*. (2013) in asparagus and Nair *et al*. (2015) in leather leaf fern.

The media containingsoil + cocopeat + FYM + vermicompost (2:1:1:1) recorded significantly (2.10 cm) maximum breadth of leaflet whereas, the minimum leaflet breadth (1.37 cm) was recorded in soil + sand + FYM (2:1:1) which is represented in Figure 4. This variation due to effects of cocopeat has the ability to store and release nutrients to plants for an extended period of time, vermicompost has

considerable amounts of humic substances and improves plant nutrition and that FYM provide the nutrients for the growth of the plant. Similarly, variation in leaflet breadth was also noticed earlier by Kayalvizhi *et al*. (2013) in asparagus and Swetha *et al*. (2014) in aglaonema.

The treatment having mediasoil + cocopeat + FYM + vermicompost (2:1:1:1) significantly recorded the maximum diameter of the shoot (0.95 mm) while, minimum shoot diameter (0.62 mm) was noted in soil + sand + FYM (2:1:1).This is because media contains minerals and nutrients that are required for the efficient growth of the plant and that increases the size (diameter) of the plant. These results are in conformity with Khayyat *et al.* (2007) in pothos.

The number of leaflets is also one of the important character of *Nephrolepis* fern which influences the frond length. Significantly maximum number of leaflets (135.00) was observed in the media having soil + cocopeat + FYM + vermicompost (2:1:1:1) whereas, the minimum number of leaflets (65.78) was recorded in soil + sand + FYM (2:1:1). This may be due to FYM provides all the nutrients for growth, cocopeat affords higher total pore space (TPS) and water holding capacity (WHC) and vermicompost is richer in humic compounds which might have helped to increase the number of leaflets. This was in- line with conclusions of Kayalvizhi *et al*. (2013) in asparagus and Swetha *et al*. (2014) in aglaonema and Khayyat *et al.* (2007) in pothos.

The number of spores is one of reproductive character of *Nephrolepis* fern which increases the multiplication of ferns. The number of sori per leaflet, number of sporangia per sori and number of sori per sporangia varied significantly among the treatments. The maximum number of sori per leaflet, number of sporangia per sori and number of spores per sporangia (63.00, 35.56 and 54.33) was noted in the treatment havingsoil + cocopeat + FYM + vermicompost (2:1:1:1) whereas, the minimum number of sori per leaflet, number of sporangia per sori and number of sori per sporangia (27.67, 21.22 and 35.22) was recorded in treatment soil + sand + FYM (2:1:1) which is represented in Figure 5. The maximum number of sori per leaflet was due to maximum number of leaflets and frond length. This is because of that vermicompost contains microorganisms which can form synergistic relationships in plant rhizospheres, thereby increasing the capacity of plants to utilize soil moisture and nutrients. This was reported earlier by Nair *et al*. (2015) in leather leaf fern and Sandeep *et al*. (2018) in *Nephrolepis* fern.

5.2 Qualitative parameters

The shelf life decides the ability of the plant. Shelf life of *Nephrolepis* fern varied significantly among the treatments. The maximum shelf life (8.00 days) was recorded in thetreatment having soil + cocopeat + FYM + vermicompost (2:1:1:1) whereas, the minimum shelf life (6.00 days) was recorded in soil + sand + FYM

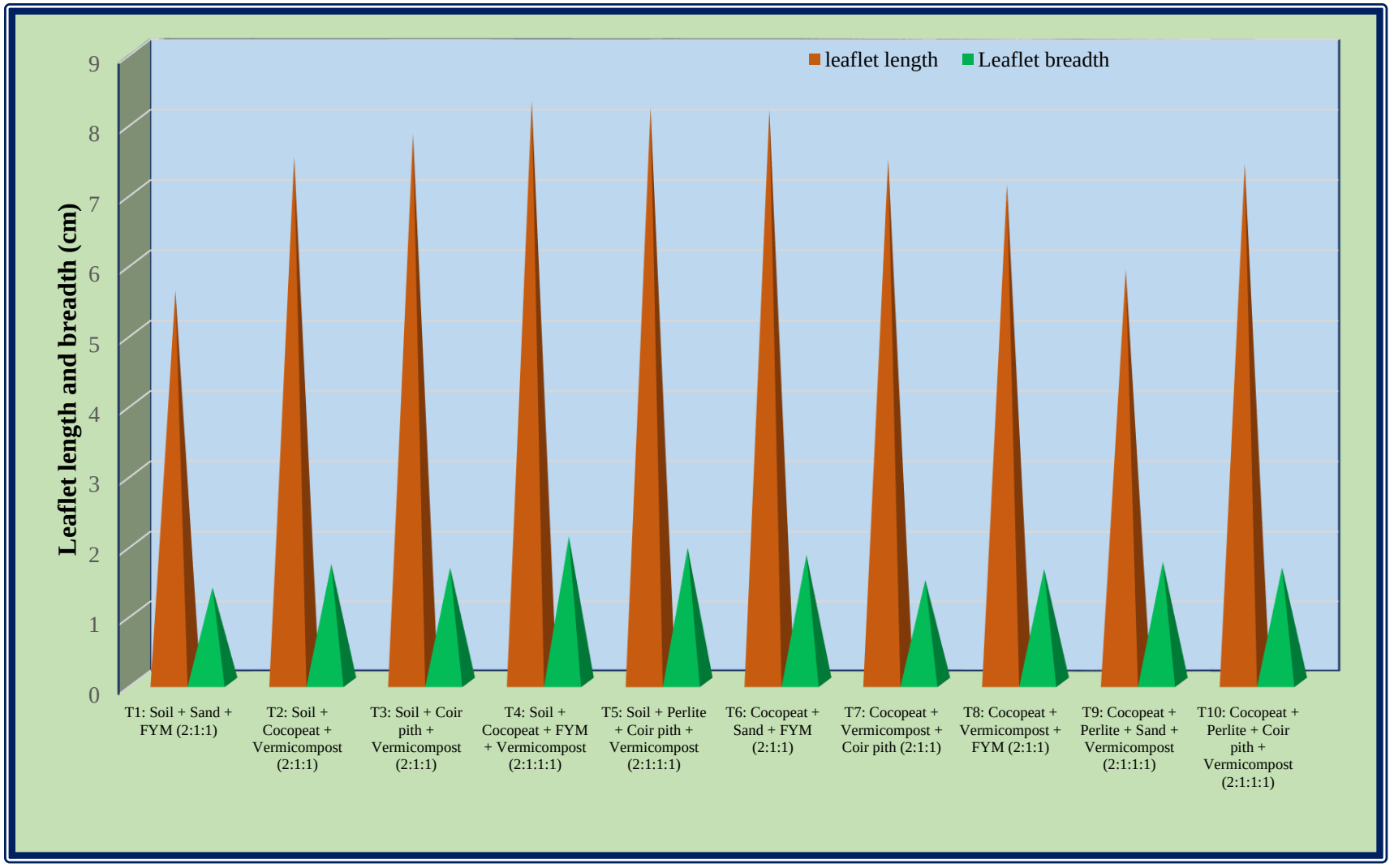


Figure 4. Effect of potting media on leaflet length and breadth of *Nephrolepis undulate* J. Sm at 180 days after planting under protected condition

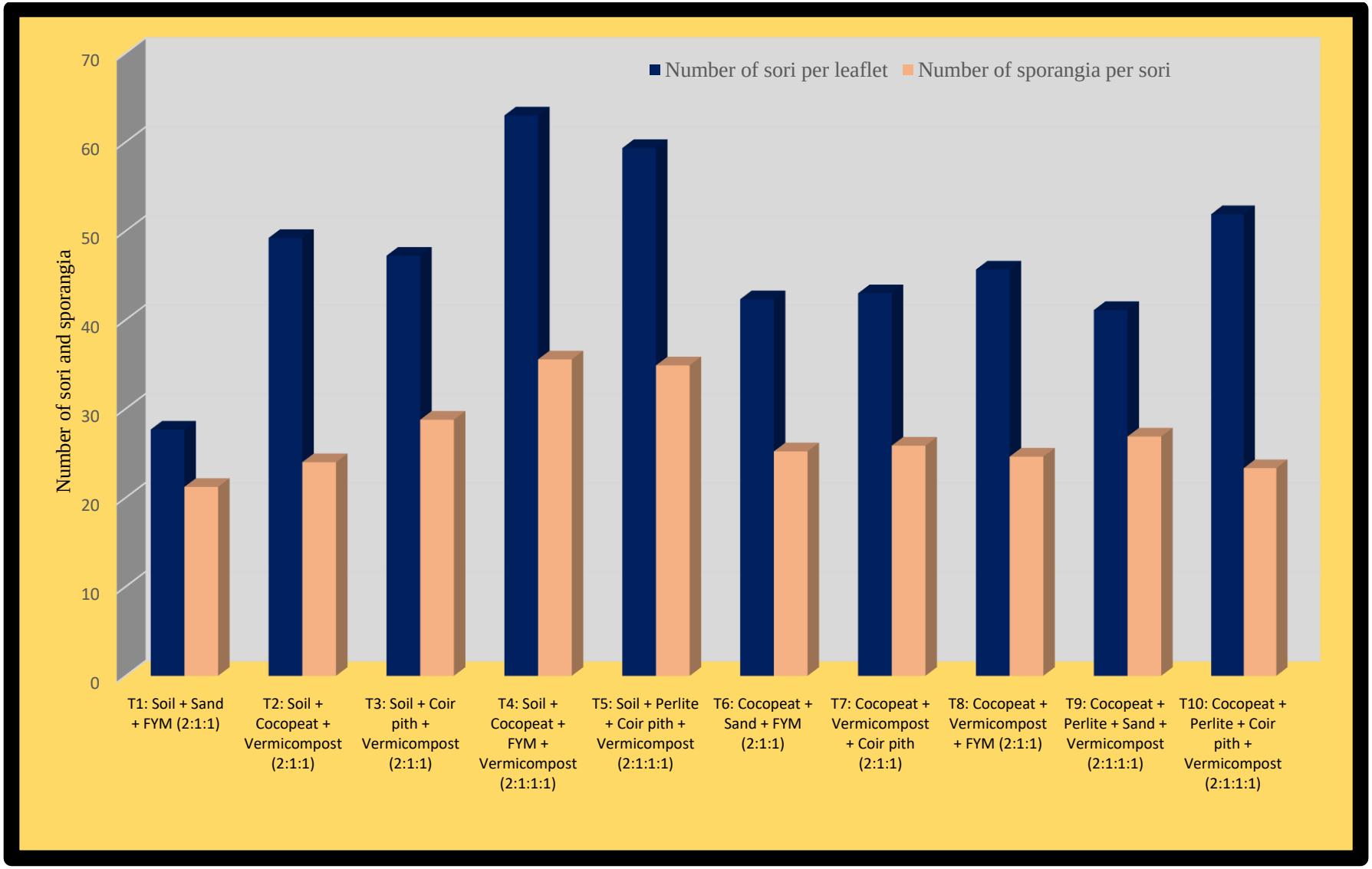


Figure 5. Effect of potting media on number of sori and sporangia of *Nephrolepis undulate* J. Sm under protected condition

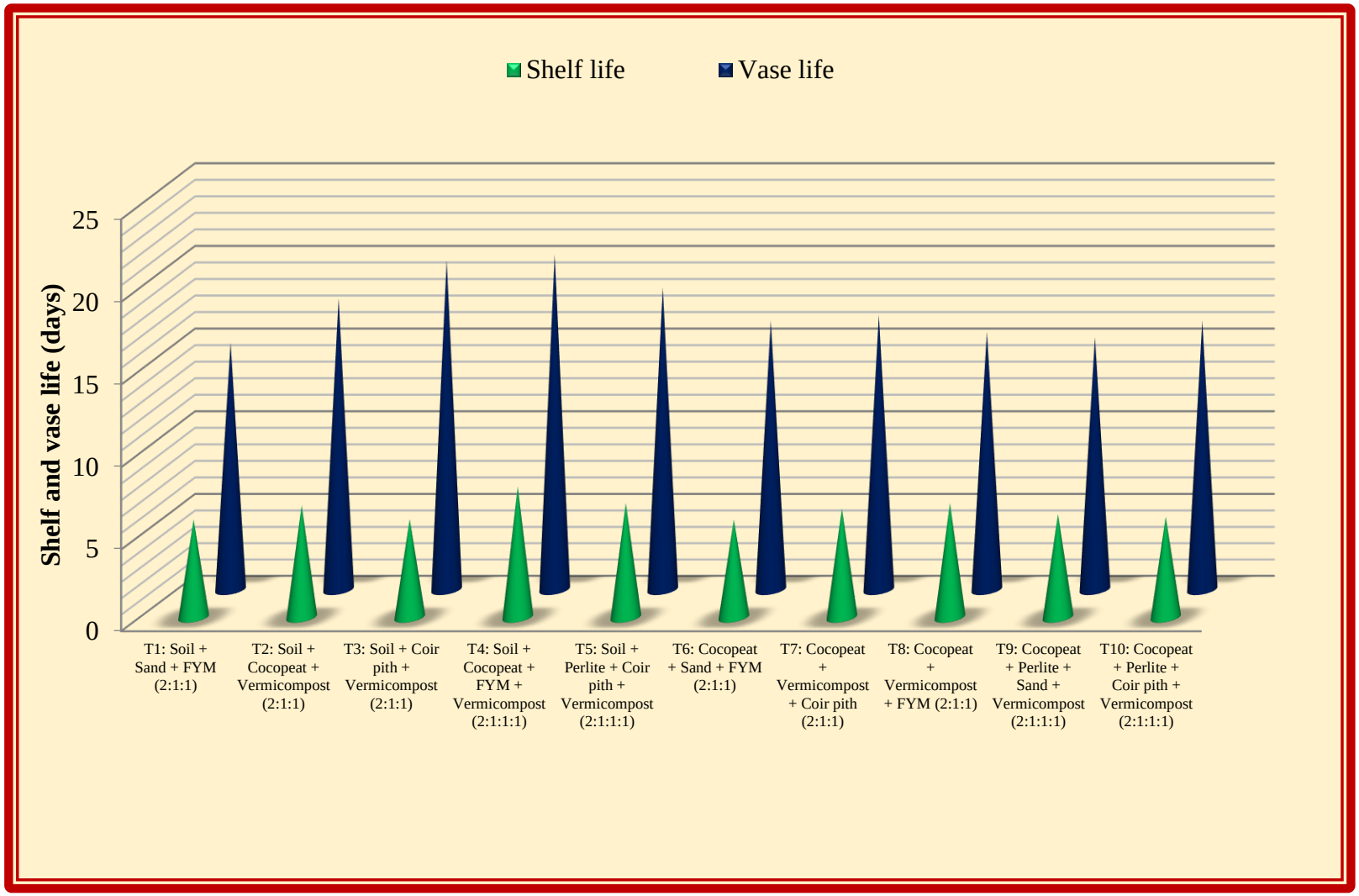


Figure 6. Effect of potting media on shelf and vase life of *Nephrolepis undulate* J. Sm at under protected condition

(2:1:1) which is represented in Figure 6. This is because of substrate having better physical properties, which influence the absorption of nutrients by the plants which ultimately produce long frond which increases the ability of the plant. These results are in accordance with Chavada *et al*. (2017) in rose and Ikram *et al*. (2012) in tuberose.

The vase life of fronds significantly differed among different treatments. The maximum vase life (20.33 days) was recorded in soil + cocopeat + FYM + vermicompost (2:1:1:1) whereas, the minimum vase life (15.00 days) was recorded in the treatment soil + sand + FYM (2:1:1) which is represented in Figure 6. The variation in vase life was due to the vermicompost, which is rich in humus and contains valuable vitamins, enzymes and hormones like auxins, gibberellins *etc.* which helps to reserve and also increases synthesis of carbohydrates which helps to extending the keeping quality of fronds, and also due to trigger in the metabolic activity due to narrowing C: N ratio by significant accumulation of carbohydrates. Similar results were observed in Kayalvizhi *et al*. (2013) in asparagus, Rajera *et al.* (2017) in lily and Ikram *et al*. (2012) in tuberose.

The potting media treatments varied significantly on visual plant grade of *Nephrolepis* fern significantly maximum visual plant grade (4.85) was recorded in the media containing soil + cocopeat + FYM + vermicompost (2:1:1:1) whereas, the minimum visual plant grade (3.08) was recorded in soil + sand + FYM (2:1:1). Higher production or accumulation of total protein and amino acids in their fronds than plants grown in other medium and that protein and amino acid composition of different plant parts has been related to energy storage for future growth which might be the reason for maximum visual plant grade. These results are found earlier by Swetha *et al*. (2014) in aglaonema and Nazari *et al*. (2011) in hyacinth.

The amount of chlorophyll decides the quality of foliage. Significantly maximum chlorophyll “a”, chlorophyll “b” and total chlorophyll content (1.99, 0.97 and 2.96 mg/g of fresh weight) was noted in treatment having soil + cocopeat + FYM + vermicompost (2:1:1:1) whereas, the minimum chlorophyll “a”, chlorophyll “b” and total chlorophyll content (0.98, 0.33 and 1.35 mg/g of fresh weight) was recorded in soil + sand + FYM (2:1:1). This may be due to the superiority of vermicompost and FYM, which having ability to supply nutrients like N, P, K, Ca and Mg in available form. As N and Mg are the important constituents of chlorophyll, higher availability and uptake of these nutrients resulted in higher chlorophyll synthesis in turn leading to higher photosynthesis and growth. These results are in conformity with Scagel (2003) in rhododendron, Naggar and Nasharty (2009) in amaryllis and Olosunde *et al*. (2014) in dracaena and cordyline.

5.3 Shoot and root parameters

The fresh and dry weight of shoots was significantly maximum (178.11 and 81.77 g)in the media combination of soil + cocopeat + FYM + vermicompost (2:1:1:1) whereas, the minimum fresh and dry weight of shoots (135.78 and 60.89 g) was recorded in soil + sand + FYM (2:1:1). The composition of media (vermicompost and FYM) made efficient use of nutrients especially nitrogen containing compounds to develop proteins buildup leading to accelerated growth and development of structural parts. This feature resulted in proliferation of meristematic cells destined to form new shoots and leaves. This can be attributed to more number of fronds and leaflets which increases the shoot biomass. The plant dry mass reveals the actual quantity of organic compounds like carbohydrates, proteins and fats that plant has acquisitioned to build its structures excluding the water contents. Similar views were held by Merrow (1995) in anthurium, Khelikuzzaman (2007) in tradescantia and Akparobi (2007) in amaranthus.

Significantly the maximum length of the root (36.11 cm) was noted in treatment soil + cocopeat + FYM + vermicompost (2:1:1:1) whereas, the minimum root length (27.89 cm) was recorded in soil + sand + FYM (2:1:1). The increased root length might be attributed to the better texture and porosity of cocopeat and vermicompost which probably facilitated easy penetration of roots and also being a well-drained media, it promoted better root characters. These results are in conformity with Kayalvizhi *et al*. (2013) in asparagus and Olosunde *et al*. (2014) in dracaena and cordyline.

The root diameter was significantly maximum (0.35 mm) in treatment soil + cocopeat + FYM + vermicompost (2:1:1:1) whereas, the minimumroot diameter (0.20 mm) was recorded in soil + sand + FYM (2:1:1). This may be due to the better texture and porosity of cocopeat and vermicompost which probably facilitated easy penetration of roots and increases its size and also being a well-drained media, it promoted better root characters. These results are in conformity with Olosunde *et al*. (2014) in dracaena and cordyline.

The root volume was significantly maximum (85.33 cc) in the treatment containingsoil + cocopeat + FYM + vermicompost (2:1:1:1) whereas, the minimum root volume (53.38 cc) was recorded in mediasoil + sand + FYM (2:1:1).This might be due the combined effect of the media components like soil and cocopeat that gives better porosity to the media and allows good root penetration apart from having good water absorption capacity. The FYM in the media also helped in good root development in terms of number and length of the roots that together might be responsible for increased root volume. These results are found earlier by Saha *et al*. (2017) in gerbera.

(a) **(b)**

Plate 4. Shoot and root parameter analysis, (a) - (T_4) Soil + Cocopeat + FYM + Vermicompost (2:1:1:1) and (b) - (T_1) Soil + Sand + FYM (2:1:1) (control)

The fresh and dry weight of roots was significantly maximum (353.67 and 132.56 g) with the media combination of soil + cocopeat + FYM + vermicompost (2:1:1:1) whereas, the minimum fresh and dry weight of shoots (95.11 and 62.11 g) was recorded in soil + sand + FYM (2:1:1). This can be attributed to more number and length of the roots. These results are in conformity with earlier findings by Swetha *et al*. (2014) in aglaonema, Abid *et a*l. (2017) in dracaena, Muhammed *et al*. (2017) in dracaena and Kumar and Ahmed (2015) in geranium.

5. 4 Media analysis

The media was analysed for pH, EC, N, P and K content before and after planting. The results were significantly varied among the treatments. The treatments containing different media *i.e*. soil + cocopeat + vermicompost (2:1:1), soil + cocopeat + FYM + vermicompost (2:1:1:1) andsoil + perlite + coir pith + vermicompost (2:1:1:1) soil condition (6.47, 6.13 and 6.20) was acidic and EC was also lowest (0.24) in the media soil + cocopeat + FYM + vermicompost (2:1:1:1) while media containing soil + sand + FYM (2:1:1) was alkaline (7.60) condition and having maximum EC (0.76), and also OC, N, P and K content significantly varies the maximum (0.78, 1.19, 1.41 and 1.43 %) in the treatment havingsoil + cocopeat + FYM + vermicompost (2:1:1:1) and minimum (0.54, 0.50, 0.52 and 0.56 %) in soil + sand + FYM (2:1:1). Usually ferns require acidic condition for their growth and also due to effect of media combination, if there is increase in pH and EC, there is induced reduction in N, K and P contents of potting media. These results are in conformity with earlier findings *i.e*. Mehmood *et al*. (2013) in antirrhinum, Handrek (1992) in ferns, and Naggar and Nasharty (2009) in hippeastrum.

5. 5 Plant analysis

Significantly maximum (5.10, 0.59 and 2.65 %) amount of N, P and K (%) content was noticed in the media soil + cocopeat + FYM + vermicompost (2:1:1:1) while, the minimum (1.80, 0.29 and 0.78 %) amount of N, P and K content was recorded in soil + sand + FYM (2:1:1). This might be due to high nutrient provided by the vermicompost, media amended with cocopeat had higher nitrogen, phosphorous and potassium content which increases the N, K uptake and availability of P could be result of more P exchange sites or higher activity of P- solubilizing organisms. These findings are in conformity with Scagel (2003) in Rhododendron and Swetha *et al*. (2014) in aglaonema.

5.6 Incidence of pest and diseases

In present investigation there is no incidence of pest and diseases on *Nephrolepis* fern under protected condition. This was reported earlier by Nair *et al*. (2015) in leather leaf fern.

5.7 Economics of *Nehprolepis undulate* J. Sm (cost of cultivation)

The maximum benefit cost ratio was recorded in the treatment containing soil + cocopeat + FYM + vermicompost (2:1:1:1) (1: 2.15) whereas, the lowest was recorded in soil + sand + FYM (2:1:1) (control) (1: 1.56) which is represented in Figure 7. The total cost of cultivation and the market price for the produce plays a vital role on the net returns. The plant quality is maximum in plants which are grown in media soil + cocopeat + FYM + vermicompost (2:1:1:1) which may fetch higher price in the market. These results are in conformity with Gupta *et al*. (2004) in gerbera and Padhiyar (2017) in chrysanthemum.

Conclusion

The results of the experiment have clearly confirmed that, the treatment containing soil + cocopeat + FYM + vermicompost (2:1:1:1) found to be superior with respect to most of traits such as vegetative, quality, root and shoot parameters. Hence, this media combination can be commercially used for the cultivation of *Nephrolepis* fern.

Future line of work

With the results obtained from the present study, the following future line of works could be taken up.

1. Results indicate that, there is a need for further study on the long-term effects of growth regulators on *Nephrolepis* fern.
2. Studies on the effect of N, P and K fertilizers on the growth and development of the *Nephrolepis* fern.
3. Studies on the effect of spacing and various light intensities on the plant growth.

(a)

(b)

Plate 5. The best treatment and control, (a) - (T_4) Soil + Cocopeat + FYM + Vermicompost (2:1:1:1) and (b) - (T_1) Soil + Sand + FYM (2:1:1) (control)

(a)

(b)

Plate 6. Vase life of *Nephrolepis undulate* J. Sm at initial (a) and 15th day (b)

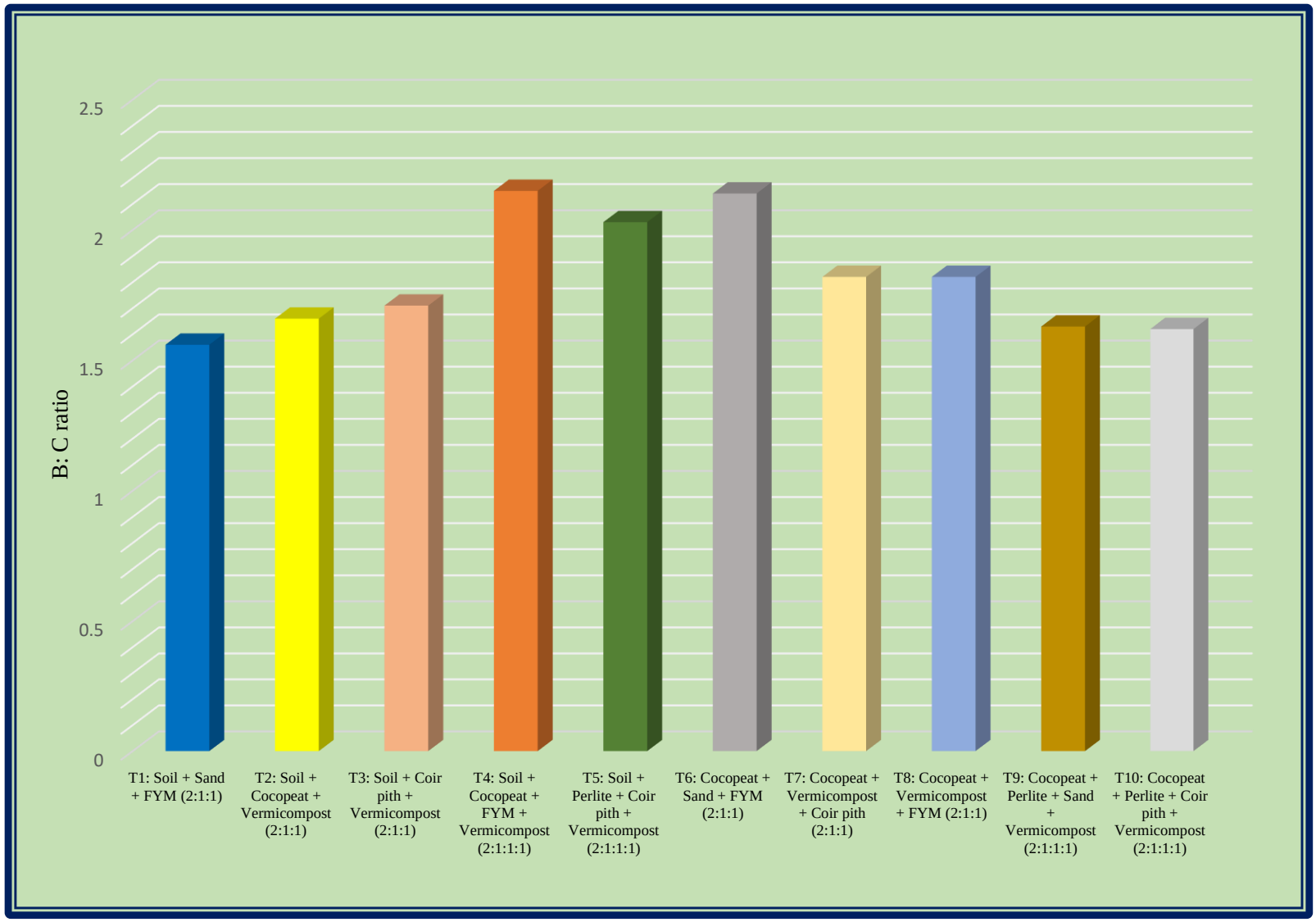


Figure 7. Benefit Cost ratio of *Nephrolepis undulate* J. Sm under protected condition

SUMMARY

VI SUMMARY

The present investigation on " Standardization of potting media for *Nephrolepis undulate* J. Sm under protected condition " was carried out under naturally ventilated poly house in the experimental field of Department of Floriculture and Landscape Architecture, College of Horticulture Mudigere, University of Agricultural and Horticultural Sciences, Shivamogga during the period from 2018- 19. The salient findings of the investigation are summarized in this chapter.

The plants raised in the media comprising soil + cocopeat + FYM + vermicompost (2:1:1:1) significantly recorded maximum plant height. Whereas, the plants raised in the media containing soil + sand + FYM (2:1:1).

Significant variation was observed among the treatments for plant spread. The maximum plant spread was observed in soil + cocopeat + FYM + vermicompost (2:1:1:1) while, the minimum plant spread was noted in media soil + sand + FYM (2:1:1).

Among different combination of media, significantly maximum number of shoots was noted in treatment having soil + cocopeat + FYM + vermicompost (2:1:1:1) whereas, minimum was recorded in soil + sand + FYM (2:1:1).

Compared to other medium, the media having soil + cocopeat + FYM + vermicompost (2:1:1:1) recorded maximum number of croziers while, the minimum number of croziers was noted in media soil + sand + FYM (2:1:1).

Significantly maximum number of fronds per plant was observed in the media soil + cocopeat + FYM + vermicompost (2:1:1:1) whereas, minimum number of fronds per plant was recorded in soil + sand + FYM (2:1:1).

The treatment containing soil + cocopeat + FYM + vermicompost (2:1:1:1) recorded maximum length of the crozier while, the minimum length of crozier was noted in media soil + sand + FYM (2:1:1).

Significantly maximum frond length was recorded in the media soil + cocopeat + FYM + vermicompost (2:1:1:1) while, the minimum length of frond was noted in media soil + sand + FYM (2:1:1).

All the treatments showed significant differences with respect to frond width. The media comprising soil + cocopeat + FYM + vermicompost (T_4) (2:1:1:1) significantly recorded maximum frond width. Whereas, the plants raised in the media T_1- soil + sand + FYM (2:1:1) recorded minimum frond width.

At peak plant growth stage significantly the maximum number of leaflets per was recorded in soil + cocopeat + FYM + vermicompost (2:1:1:1) while, the minimum number of leaflets per frond was noted in soil + sand + FYM (2:1:1).

The media comprising soil + cocopeat + FYM + vermicompost (2:1:1:1) significantly recorded maximum leaflet length. Whereas, the plants raised in the media having soil + sand + FYM (2:1:1) recorded minimum leaflet length.

The maximum leaflet breadth significantly observed in soil + cocopeat + FYM + vermicompost (2:1:1:1) while, the minimum leaflet breadth was noted in soil + sand + FYM (2:1:1).

Significantly maximum shoot diameter was observed in the media soil + cocopeat + FYM + vermicompost (2:1:1:1) while, the minimum diameter of the shoot was noted in soil + sand + FYM (2:1:1).

The number of sori per leaflet, number of sporangia per sori and number of spores per sporangia was significantly maximum in the plants which are grown in the media soil + cocopeat + FYM + vermicompost (2:1:1:1) while, the minimum number of sori per leaflet, number of sporangia per sori and number of spores per sporangia was noted in soil + sand + FYM (2:1:1).

In different combination of media, the plants which grown in the media having soil + cocopeat + FYM + vermicompost (2:1:1:1) significantly recorded maximum shelf life while, the minimum shelf life was noted in soil + sand + FYM (2:1:1).

The plants which grown in the media containing soil + cocopeat + FYM + vermicompost (2:1:1:1) significantly recorded maximum vase life while, the minimum vase life was noted in soil + sand + FYM (2:1:1).

The quality of the plants was analysed through visual plant grade, among that the plants which grown in the media having soil + cocopeat + FYM + vermicompost (2:1:1:1) significantly recorded maximum visual plant grade while, the minimum visual plant grade was noted in soil + sand + FYM (2:1:1).

Chlorophyll content was significantly maximum in media soil + cocopeat + FYM + vermicompost (2:1:1:1) whereas, the minimum chlorophyll content was noted in soil + sand + FYM (2:1:1).

The shoot biomass *i.e.* both fresh and dry weight was recorded in the media soil + cocopeat + FYM + vermicompost (2:1:1:1) while, the minimum fresh and dry weight of the shoot was observed in T_1- soil + sand + FYM (2:1:1).

Similarly, the root parameters such as root length, root diameter and root volume were observed in T_4 - soil + cocopeat + FYM + vermicompost (2:1:1:1) while, the minimum root length, root diameter and root volume were noted in soil + sand + FYM (2:1:1).

The root biomass *i.e.* both fresh and dry weight was recorded in the media soil + cocopeat + FYM + vermicompost (2:1:1:1) while, the minimum fresh and dry weight of the root was observed in soil + sand + FYM (2:1:1).

In different treatments, media was analysed for the estimation of pH EC, N, P and K content. Significantly minimum pH and EC and maximum amount of OC, N, P and K content was recorded in the media soil + cocopeat + FYM + vermicompost (2:1:1:1) while, maximum pH and EC and minimum amount of OC, N, P and K content was noted in soil + sand + FYM (2:1:1).

The nutrient content of leaves varied significantly. Among that maximum amount of N, P and K was recorded in the media soil + cocopeat + FYM + vermicompost (2:1:1:1) while, minimum amount of N, P and K was noted in soil + sand + FYM (2:1:1).

The treatment containing soil + cocopeat + FYM + vermicompost (2:1:1:1) recorded maximum net returns and benefit to cost (B: C) ratio followed by cocopeat + sand + FYM (2:1:1) compared to all other treatments.

In the present investigation, an attempt was made to standardize the potting media for *Nephrolepis undulate* J. Sm under protected condition. Among the different combination of medium, the media comprising of soil + cocopeat + FYM + vermicompost (2:1:1:1) recorded maximum growth and quality parameters. Hence, the media *i.e.* T_1- soil + cocopeat + FYM + vermicompost (2:1:1:1) might be recommended for commercial cultivation.

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VII REFERENCES

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APPENDICES

VIII APPENDICES

APPENDIX I

Monthly mean meteorological data recorded during the experimental year 2018–19 recorded at the ZAHRS, Mudigere.

Months	Rainfall (mm)	Relative Humidity (%)	Temperature (°C)	
			Maximum	Minimum
May	289.20	84.80	27.41	19.96
June	700.10	82.06	24.16	20.76
July	602.50	84.67	22.83	19.51
August	497.50	84.70	23.16	18.38
September	120.00	84.33	25.73	18.60
October	113.60	84.54	27.06	18.54
November	23.40	84.80	29.46	24.03
December	12.10	81.74	27.80	18.35
January	00	80.45	28.90	18.12
February	9.30	82.28	30.75	18.71
March	00	80.45	34.16	19.51
April	52.30	80.73	32.00	18.50
Total	**2420**	**995.55**	**333.42**	**322.97**
Mean	**201.66**	**82.96**	**27.78**	**19.41**

Total rainfall – 2420 mm

APPENDIX II

Cost of cultivation of *Nephrolephis undulate* J. Sm by using different potting media under protected condition (1000m^2)

Sl. No.	Particulars	Total cost (₹)	Depreciation cost (₹/1yr)
I.	**Non- recurring contingency (NRC) (for a life span of 10 years)**		
	Construction of polyhouse @ ₹ 800/m^2 Top: UV stabilized polyfilm Side: shade net	8,00,000	80,000
a)	Irrigation system	15,000	1500
	Total of NRC	8,15,000	81,500
II	**Recurring contingency (ORC) for a life span of one year (1000m^2)**		
1.	Inputs		
a)	Planting materials (plants/1000m^2 @ 1₹/plant)	4000	
b)	Different potting media		
	T_1: soil + sand + FYM (2:1:1)	12,000	
	T_2: soil + cocopeat + vermicompost (2:1:1)	18,000	
	T_3: soil + coir pith + vermicompost (2:1:1)	16,000	
	T_4: soil + coco peat + FYM + vermicompost (2:1:1:1)	22,000	
	T_5: soil + perlite + coir pith + vermicompost (2:1:1:1)	24,000	
	T_6: cocopeat + sand + FYM (2:1:1)	20,000	
	T_7: cocopeat + vermicompost + coir pith (2:1:1)	24,000	
	T_8: cocopeat + vermicompost + FYM (2:1:1)	24,000	
	T_9: cocopeat + perlite + sand + vermicompost (2:1:1:1)	32,000	
	T_{10}: cocopeat + perlite + coir pith + vermicompost (2:1:1:1)	32,000	
2.	**Labour charges**		
	Planting and weeding	1000	
	Total	86,500	

APPENDIX III

List of abbreviations and symbols

%	Per cent
°C	Degree centigrade
CD	Critical Difference
cm	Centimeter
cc	Cubic centimeter
mm	Millimeter
DAP	Days After Planting
g	Gram
Kg	Kilogram
i.e.	That is
S. Em.	Standard Error of Mean
viz.	Namely
et al	And other
@	At
pH	Potential hydrogen
EC	Electrical conductivity
ds/m	Deci siemens per meter
cv.	Cultivar
Var.	Variety