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Research Article
Nutritional Efficacy of Various Growing Substrates for Potted *Ravenea rivularis* Palm Production

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Abstract
Background and Objective: *Ravenea* palm (*Ravenea rivularis*) is the most popular grown interior potted plant. Present study was carried out to assess the effect of different potting substrates in various compositions on growth and development of *Ravenea* plants. **Materials and Methods:** In total, ten treatment combinations were used to compare with control treatment (garden soil) and treatment was consisted of 16 plants with four replications. Various potting substrates: Garden soil, silt, farmyard manure, peat moss, leaf compost and coconut compost in various combinations were added. The experiment was carried out in Completely Randomized Design (CRD). The collected data for plant growth and development were subjected to Duncan's Multiple Range (DMR) test whereas for chemical and physical characteristics of potting substrate and means was compared. **Results:** The results depicted that the T_{10} that is the combination of farmyard manure, silt, coconut compost, peat moss and leaf compost (1:1:1:1:1) exhibited best results for the growth and production of potted *Ravenea* plants. The treatment T_{10} substrate is considered excellent due to its density, saturation percentage, structure, texture, consistency and Organic Matter (OM) as well as nitrogen, phosphorus and potassium concentration. **Conclusion:** It can be concluded that to get quality pot production a mixture of substrates proved to be best as it delivers a combination of properties and nutrients. The new potting mix will provide a stable, organic, sustainable, environmental friendly and cost effective alternatives to nurserymen.

Key words: Bulk density, leaf compost, organic matter, peat moss, potting mix, palms

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Most of the farmers in Pakistan have fragmented and small land holdings and these conditions mostly permit to grow floricultural crops to enhance the farmer's net return. Net profit of floricultural crops against its investment is much greater, compared to conventional cropping pattern. Unfortunately, Pakistan has almost negligible share towards international flowers' trade. Recently, there is an increase in demand of floricultural plants, potted plants, cut flowers and other value added products derived from flowers. The recompenses of potted ornamental plants' production are: Tranquil marketing package, prolong marketing/planting season, easy transport and early returns[1].

Ravenea belongs to sub-family Ceroxyloideae and tribe Ceroxyleae which is a genus of dioecious and solitary palms. *Ravenea* has 15 species are confined to Madagascar and 2 species are limited in Comoro islands[2]. The varsity of habitats of these species are varied, ranged from xerophytic bushlands to low-land rain-forest, montane forest and ericoid scrub. *Ravenea* palm has tremendous potential to be grown as accent plant and for indoor beautification. This palm demand in market is growing at rapid due to its versatile usage in landscape and interior-scape.

The selection of suitable growing substrate is one of the most important factor in growth and production of quality ornamental plant production[3]. For optimal quality growth of potted palms, growing substrates must have characteristics such as: Capable of water retention, provide nutrients, porous for gaseous exchange and offer mechanical support for root anchorage[4]. Nonetheless, depends on the plant type, plant growth stage, age of the plant will justify the uses of these substrates. Combination of various substrates is more popular among nurseryman for production of ornamental plants[5]. However, there are noteworthy variations in quality of plants produced in various substrate combinations. Many studies about various potting substrates and nutrients were conducted worldwide to quality potted ornamental plants[6,7].

Mostly in potted ornamental plant production and growing substrates have 6-8% of the total cost of production. It is therefore, essential to figure out the appropriate potting substrate or combinations for quality plants' production in pots[8,9]. Plant growers emphasized that the selection of growing substrates should be done with great care as in pots plants has limited space for its root development and nutrient uptake[10]. Recently, various organic/inorganic potting media with different brand names are available in market[11]. Most of organic growing substrates contained peat moss, pine-bark, wood shaves, sludge, agricultural wastes or by-products, farmyard manure (FYM), poultry manure and composts while, the inorganic media components contained styrofoam, perlite, rock wool, sand and vermiculite depending on plant requirements[12]. Local existing materials compost, kitchen waste compost, sludge, coconut coir/fiber, rice hull, spent mushroom compost and cotton gin trash aren't evaluated as potential potting substrate for potted plant production in Pakistan. Therefore, this study was planned to evaluate various potential substrates such as peat moss, leaf compost, farmyard manure, garden soil, silt and coconut compost alone and in combination for quality growth of *Ravenea* palm.

MATERIALS AND METHODS

Ravenea palm is considered among one of popular palm species used as ornamental. In this study estimation of various potting substrates was carried out in Floriculture Research Area, Institute of Horticultural Sciences, Faisalabad. *Ravenea rivularis* plants were purchased locally from a well reputed nursery. In this study, 6 basic types of potting substrates were used and then different combination treatments were made to check the growth performance of *Ravenea* plants. The cultural and management practices such as watering, weeding and hoeing were kept same in all treatments under this study. The treatments combinations were as:

T_0 = Control
T_1 = Farmyard manure
T_2 = Coconut compost
T_3 = Leaf compost
T_4 = Peat moss
T_5 = Silt
T_6 = Silt+farmyard manure (1:1)
T_7 = Silt+leaf compost (1:1)
T_8 = Silt+coconut compost (1:1)
T_9 = Silt+peat moss (1:1)
T_{10} = Farmyard manure+leaf compost+coconut compost +peat moss+silt (1:1:1:1:1)

Collection of data: Data were collected during research period for following parameters using standard procedures; plant height (cm), plant weight (g), dry weight of plant (g), fresh and dry weight ratio, No. of leaves, No. of side shoots per plant, leaf area (cm^2), root length and mortality rate.

One-year-old plants with uniform size and shape were selected. Plants were shifted in 12 inches' pots filled with different substrate's treatments. Plant were kept in Floriculture Research Area, Institute of Horticultural Sciences, University of Agriculture, Faisalabad.

Total nitrogen (N), available phosphorus (P), available potassium (K), electrical conductivity (dS m^{-1}) and pH of substrates used in this study were determined in Ayub Agriculture Research Institute, (AARI), Faisalabad. The experiment was carried out in Completely Randomized Design (CRD). Each treatment was consisted of four plants with four replications. The collected data for plant growth and development were subjected to Duncan's Multiple Range (DMR) test whereas for chemical and physical characteristics of potting substrate and means was compared[13] at 5% probability.

Analysis of media: Following data was obtained in relation to each substrate used in this study.

pH: The pH of each substrate was calculated through pH digital ion analyzer. Saturated soil paste was prepared with distil water and allowed to stand for 60 min. The electrodes were injected in substrate paste and raised and lowered repeatedly to get a consistent pH reading.

Total Nitrogen (TN): For determination of TN, Kjeldahl's digestion methodology was adopted. In short, the nitrogen in the medium sample was transformed into NH_4^+ by digestion with digestion mixture and concentrated H_2SO_4. After cooling the contents was shifted into 100 mL volumetric flask and made up the final volume. The distillation was proceeded in micro Kjeldahl's apparatus (Timberline instruments) (Boulder, Colorado, USA) and methyl red and boric acid were used as indicator. The titration process was carried out with standard H_2SO_4 to determine TN in medium sample.

Available Phosphorus (AP): To estimate AP, 1.25 g of substrate was weighed and then 25 mL of extracting solvent was added and shacked for 30 min. Filter this solution and 1 mL of this filtered material was taken in glass beaker and 3 mL of distilled water was added. Finally, 1 mL of color dye was added and stirred for 2-3 min. Place filtered material for 15-20 min visualized on spectrophotometer (UV-1700, Shimadzu, Kyoto, Japan). The AP was calculated by using Eq. 1:

$$\text{ppm from curve} \times 25\text{ mL}/1.25\text{ g} \times 5\text{ mL}/1\text{ mL} = \text{ppm of P} \quad (1)$$

Available potassium (AK): The available potassium was calculated by using flame photometer by using Eq. 2:

$$\text{mEq L}^{-1}\text{ of K}^{+} = \left[\frac{\text{mEq L}^{-1}\text{ of K}^{+}\text{ by calibration}}{\text{curve} \times 50\text{ mL of sample}}\right] \quad (2)$$

Electrical Conductivity (EC) (dS m^{-1}): Electrical conductivity was recorded by using conductivity meter (Model CM-1 Mark V) (Eugene, Oregon, USA).

Organic Matter (OM): For determination of Loss on Ignition (LOI) was used. This method contained the devastation of all OM in the sample through heat. For estimation, 1 g of sample was kept in ceramic crucible, which is then heated between 350-440°C overnight. The sample was refrigerated put in a desiccator and weighed. The OM was calculated by using Eq. 3:

$$\text{OM} = \frac{\text{Initial weight} - \text{Final weight}}{\text{Initial weight}} \times 100 \quad (3)$$

Saturation percentage: The saturation percentage was calculated by adopting procedure as described. The sample was oven dried at 100°C until constant oven dried weight was attained. Saturation percentage was estimated by Eq. 4:

$$\text{Saturation (\%)} = \frac{\text{Loss in weight of soil}}{\text{Oven dry weight of soil}} \times 100 \quad (4)$$

RESULTS AND DISCUSSION

Data pertaining to electrical conductivity of the medium was analyzed statistically and results are shown in Table 1. The analysis of variance of EC had revealed significant results at 5% level of probability. The mean values for treatments were subjected to DMR test (Table 1). The results revealed that garden soil (T_0) attained the maximum EC value 3.47 dS m^{-1}, followed by farmyard manure. Peat moss had the minimum EC value 2.22 dS m^{-1}. The results showed that EC had a negative correlation with No. of leaves per plant, root length, leaf area, No. of side shoots, fresh and dry weight of plant but it had a positive but non-significant correlation with fresh/dry weight ratio.

It is important to note that there is a direct impact of EC on nutrients' uptake. The nutrients' uptake increased with the increase in EC up to some extent and then there is decrease in uptake. The EC of substrate having leaf compost, farmyard manure, coconut compost, peat moss and silt (1:1:1: 1:1) (T_{10}) was 3.40 dS m^{-1} which is best for *Ravenea* palm production. The EC of the potted, medium can be enhanced with the addition of vermicompost in the substrate[14], higher EC might be assessed from higher contents of K, N, Ca, Na, S and other soluble elements in the compost[15].

The amount of soil alkalinity and acidity is stated "Soil pH" that effects the physical, chemical and biological

Table 1: Evaluation of growing media Electrical Conductivity (EC) of *Ravenea* palm

	Original order		Ranked order	
Treatments combination	Treatments	p-value	Treatments	p-value
Garden soil	T_0	3.47^{a}	T_0	3.47^{a}
Farmyard manure	T_1	3.40^{ab}	T_1	3.40^{ab}
Coconut compost	T_2	3.31^{abc}	T_6	3.35^{ab}
Leaf compost	T_3	3.00^{d}	T_2	3.31^{abc}
Peat moss	T_4	2.22^{f}	T_8	3.26^{bc}
Silt	T_5	3.22^{bc}	T_5	3.22^{bc}
Silt+farmyard manure (1:1)	T_6	3.35^{ab}	T_8	3.16^{cd}
Silt+leaf compost (1:1)	T_7	3.16^{cd}	T_3	3.00^{d}
Silt+coconut compost (1:1)	T_8	3.26^{bc}	T_9	3.00^{d}
Silt+peat moss (1:1)	T_9	3.00^{d}	T_{10}	2.57^{f}
Farmyard manure+leaf compost+coconut compost+peat moss+silt (1:1:1:1:1)	T_{10}	2.57^{f}	T_4	2.22^{f}

Any two mean not sharing a letter differ significantly from each other at 5% level of probability

Table 2: Comparison of treatment means for pH of media

	Original order		Ranked order	
Treatments combination	Treatments	p-value	Treatments	p-value
Garden soil	T_0	7.94^{a}	T_0	7.94^{a}
Farmyard manure	T_1	6.67^{b}	T_1	6.67^{b}
Coconut compost	T_2	6.60^{b}	T_6	6.61^{b}
Leaf compost	T_3	6.00^{d}	T_2	6.60^{b}
Peat moss	T_4	5.56^{e}	T_8	6.58^{bc}
Silt	T_5	6.57^{bc}	T_5	6.57^{bc}
Silt+farmyard manure (1:1)	T_6	6.61^{b}	T_7	6.28^{cd}
Silt+leaf compost (1:1)	T_7	6.28^{cd}	T_9	6.23^{cd}
Silt+coconut compost (1:1)	T_8	6.58^{bc}	T_{10}	6.06^{d}
Silt+peat moss (1:1)	T_9	6.23^{cd}	T_3	6.00^{d}
Farmyard manure+leaf compost+coconut compost+peat moss+silt (1:1:1:1:1)	T_{10}	6.06^{d}	T_4	5.56^{e}

Any two mean not sharing a letter differ significantly from each other at 5% level of probability

properties of substrates. Soil pH critically effects the nutrients' availability for plants root uptake. It also regulates the soil microorganisms activities; therefore, it is considered one of the chief determination factor for quality production of potted ornamental plants.

Present study results demonstrated that garden soil exhibits the maximum pH (7.94), while, peat moss had the minimum pH (5.5) (Table 2). Correlation analysis revealed that pH had a negative correlation with plant morphological characteristics such as plant height, No. of leaves per plant, leaf area, root length, fresh and dry weight of plant while, it had a positive as well as significant relationship with fresh and dry weight ratio.

The basic factor for nutrients' uptake is the chemical solubility of ions which plants needs and its solubility is correlated with soil pH. In this study, the maximum nutrients' uptake was detected in substrate combinations of farmyard manure, leaf compost, peat moss, coconut compost and silt in equal ratio (6.7 pH).

Productive fertile media is the prerequisite of better growth and development of plants as they are dependent on it for Organic Matter (OM), minerals, gaseous exchange and water. The animal and plant residues contribute for the organic matter status in soil and after decomposition of OM, organic components converted into humus, that rises the soil fertility that in turns enhances the plant growth.

Mean value for present study treatments were subjected to DMR test and presented in Table 3. Present results showed that substrate combination having farmyard manure, peat moss, leaf compost, coconut compost and silt had 0.96% OM that is followed peat moss with 0.90% OM. The minimum OM contents were recorded in silt substrate (Fig. 1a). In depth analysis depicted that OM had a positive correlation with plant morphological characters such as; plant height, No. of leaves per plant, leaf area, No. of side shoots, root length and plant fresh and dry weight but it had a negative and non-significant association with plant fresh and dry weight ratio. The OM had a direct as well as indirect influence on the nutrients' availability. Eaton *et al.*[16] and Hawkins[17] described that OM mixed with soil had positive influence on plant growth and development as OM contributed for soil improvement by releasing essential nutrients. The OM is the key micro nutrients' source that is supportive for optimal plant growth. Addition of animal manure contributes to OM rich in carbohydrate in any substrate. The addition of carbohydrate contents revealed better growth impact on various plants.

Phosphorus (P) meant for plant metabolism and enlargement and have an explanatory role in energy metabolism, membranous photosynthesis, formation of nucleic acid, respiration, enzyme regulation and N_2 fixation[18]. The optimum application of P positive correlates with many processes of plant growth such as flowering, fruit formation and root growth and development.

Data pertaining to mean values for substrate treatments were studied using DMR test results are presented in Fig. 1b. The results showed that farmyard manure, peat moss, leaf compost, coconut compost and silt had the maximum 28.93 mg L^{-1} available phosphorus whereas, the minimum 2.47 mg L^{-1} available phosphorus was found in substrate having farmyard manure only. Present results revealed that phosphorus had a positive significant relationship with No. of leaves per plant, leaf area, No. of side shoots, root length and dry weight while, it had a negative association with plant height, fresh dry weight ratio. In present results leaf area had a positive correlation with P contents in substrate. A rapid growth trend in *Cyclamen* with maximum plant height, leaf length and leaf number when with 160 mg phosphorus application. Growth factors such as shoot root growth, canopy developments and nutrient contents in leaf tissues displayed the maximum in plants growing in substrates having optimal P contents.

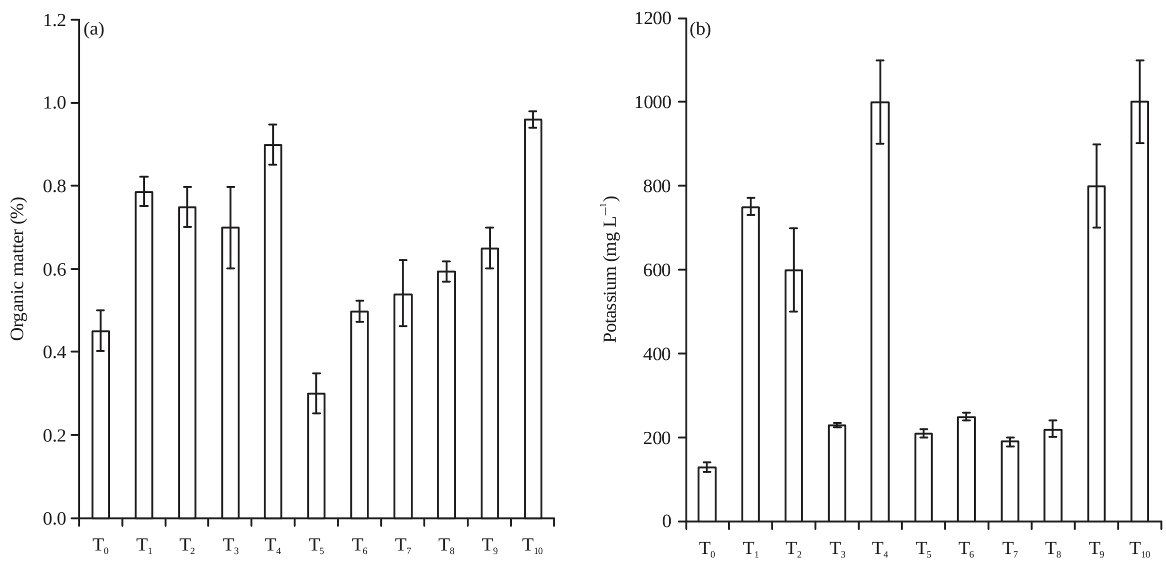

Fig. 1(a-b): Evaluation of potting media (a) Organic matter and (b) Available potassium of *Ravenea* palm

T_0: Garden soil, T_1: Farmyard manure, T_2: Coconut compost, T_3: Leaf compost, T_4: Peat moss, T_5: Silt, T_6: Silt+Farmyard manure (1:1), T_7: Silt+leaf compost (1:1), T_8: Silt+coconut compost (1:1), T_9: Silt+peat moss (1:1) and T_{10}: Farmyard manure+leaf compost+coconut compost+peat moss+silt (1:1:1:1:1)

Table 3: Comparison of treatment means of organic matter (%)

	Original order		Ranked order	
Treatments combination	Treatments	p-value	Treatments	p-value
Garden soil	T_0	0.45^{fg}	T_{10}	0.96^{a}
Farmyard manure	T_1	0.79^{bc}	T_4	0.90^{ab}
Coconut compost	T_2	0.75^{bcd}	T_1	0.79^{bc}
Leaf compost	T_3	0.70^{cd}	T_2	0.75^{bcd}
Peat moss	T_4	0.90^{ab}	T_3	0.70^{cd}
Silt	T_5	0.30^{c}	T_9	0.65^{cde}
Silt+farmyard manure (1:1)	T_6	0.50^{ef}	T_8	0.59^{def}
Silt+leaf compost (1:1)	T_7	0.54^{ef}	T_7	0.54^{ef}
Silt+coconut compost (1:1)	T_8	0.59^{def}	T_6	0.50^{ef}
Silt+peat moss (1:1)	T_9	0.65^{cde}	T_0	0.45^{fg}
Farmyard manure+leaf compost+coconut compost+peat moss+silt (1:1:1:1:1)	T_{10}	0.96^{a}	T_5	0.30^{c}

Any two mean not sharing a letter differ significantly from each other at 5% level of probability

Potassium (K) is among one of major plant nutrient essential for plant development as it contributes carbohydrates' synthesis, lipid and protein contents in plants. The K availability to plant fluctuates with factors, such as clay contents in substrate (texture) and clay composition (structure) of substrate. The results showed that substrate having peat moss only and substrate having composition of farmyard manure, leaf compost, peat moss, coconut compost and silt exhibited the maximum 1000.00 mg L^{-1} potassium, while, the minimum 130.00 mg L^{-1} available potassium was observed in substrate having garden soil only. Potassium proved a positive correlation with morphological features such as plant height, No. of leaves, leaf area, No. of side shoots, root length, fresh and dry weight, while, it had a negative correlation with fresh dry weight ratio. Increase K contents facilitated increase carbohydrate translocation to roots that enhanced the plant growth and development in different ornamental potted plants[19]. The leaf compost significantly increased the K uptake compared to other mineral fertilizer application. Hence, leaf compost is proven important resource of plants' nutrition.

Nitrogen (N) being the major element is constituting of many organic composites in plants such as amino acids, protein and chlorophyll. Comparison of substrates' treatment shown superiority of treatment T_{10} having equal proportion of farmyard manure, leaf compost, peat moss, coconut compost and silt with nitrogen ratio (2.40), which is followed by treatment T_7 (2.15) having silt and leaf compost as their components. The minimum nitrogen level (0.21) was observed in garden soil (Table 4). Nitrogen proved a positive and significant growth enhance as recorded in this study. The root shoot growing, canopy development is influenced by nitrogen availability, foliage plants that receive more nitrogen had a higher shoot per root growth[4]. Plant and animal residues/wastes are valuable and important source of nitrogen and other major and minor elements essential for plant growth and development.

The data regarding plant height were subjected to statistical analysis and results are presented in Table 5. For plant height, the present results demonstrated significant plant height increase ($p<0.05$) in substrate combination of farmyard manure, silt, coconut compost, peat moss and leaf

Table 4: Comparison of treatment means of total nitrogen

	Original order		Ranked order	
Treatments combination	Treatments	p-value	Treatments	p-value
Garden soil	T_0	0.21[g]	T_{10}	2.40[a]
Farmyard manure	T_1	0.31[fg]	T_7	2.15[b]
Coconut compost	T_2	0.39[fg]	T_6	1.80[c]
Leaf compost	T_3	0.40[fg]	T_8	1.27[d]
Peat moss	T_4	0.52[f]	T_9	0.91[e]
Silt	T_5	0.20[g]	T_4	0.52[f]
Silt+farmyard manure (1:1)	T_6	1.80[c]	T_1	0.31[fg]
Silt+leaf compost (1:1)	T_7	2.15[b]	T_2	0.39[fg]
Silt+coconut compost (1:1)	T_8	1.27[d]	T_3	0.40[fg]
Silt+peat moss (1:1)	T_9	0.91[e]	T_5	0.20[g]
Farmyard manure+leaf compost +coconut compost+peat moss+silt (1:1:1:1:1)	T_{10}	2.40[a]	T_0	0.21[g]

Any two mean not sharing a letter differ significantly from each other at 5% level of probability

Table 5: Comparison of treatment means for plant height

	Original order		Ranked order	
Treatments combination	Treatments	p-value	Treatments	p-value
Garden soil	T_0	70.03[k]	T_{10}	91.79[a]
Farmyard manure	T_1	75.16[g]	T_9	90.06[b]
Coconut compost	T_2	71.56[i]	T_7	89.97[c]
Leaf compost	T_3	78.45[g]	T_6	85.18[d]
Peat moss	T_4	83.14[f]	T_8	84.13[e]
Silt	T_5	72.85[h]	T_4	83.14[f]
Silt+farmyard manure (1:1)	T_6	85.18[d]	T_3	78.45[g]
Silt+leaf compost (1:1)	T_7	89.97[c]	T_1	75.16[g]
Silt+coconut compost (1:1)	T_8	84.13[e]	T_5	72.85[h]
Silt+peat moss (1:1)	T_9	90.06[b]	T_2	71.56[i]
Farmyard manure+leaf compost+coconut compost+peat moss+silt (1:1:1:1:1)	T_{10}	91.79[a]	T_0	70.03[k]

Any two mean not sharing a letter differ significantly from each other at 5% level of probability

Table 6: Comparison of treatment means for No. of leaves per plant

Treatments combination	Original order		Ranked order	
	Treatments	p-value	Treatments	p-value
Garden soil	T_0	3.53[h]	T_{10}	6.76[a]
Farmyard manure	T_1	6.26[c]	T_4	6.53[b]
Coconut compost	T_2	3.75[g]	T_6	6.53[b]
Leaf compost	T_3	4.76[f]	T_1	6.26[c]
Peat moss	T_4	6.53[b]	T_9	5.76[d]
Silt	T_5	3.55[h]	T_7	5.53[e]
Silt+farmyard manure (1:1)	T_6	6.53[b]	T_3	4.76[f]
Silt+leaf compost (1:1)	T_7	5.53[e]	T_8	4.75[f]
Silt+coconut compost (1:1)	T_8	4.75[f]	T_2	3.75[g]
Silt+peat moss (1:1)	T_9	5.76[d]	T_5	3.55[h]
Farmyard manure+leaf compost+coconut compost+peat moss+silt (1:1:1:1:1)	T_{10}	6.76[a]	T_0	3.53[h]

Any two mean not sharing a letter differ significantly from each other at 5% level of probability

compost (1:1:1:1:1) among various potting substrate treatments. In depth analysis means were subjected to compared using DMR test and results are presented in Table 5. A perusal of the substrates showed significant results and substrate containing farmyard manure, peat moss, leaf compost, coconut compost and silt exhibited the maximum plant height 91.79 cm followed by 90.06 cm substrate having silt and peat moss. Under present study circumstances garden soil as a substrate exhibited the minimum 70.03 cm plant height. Plant height is critically influenced by its environment such as root medium. To attain optimal plant height a balanced root medium is essential for adequate nutrients, supply[7]. Present results exhibited that nutritional level was maximum in substrate having components of farmyard manure, leaf compost, peat moss , coconut compost and silt, such as nitrogen 2.40%, phosphorous 28.93 mg L^{-1} and potassium 1000.00 mg L^{-1} that facilitate plants to achieve the maximum height in this study.

Mattson[20] studied on substrates fertilizer amendments for bedding plants and provided various combinations for quality plants in beds. Kiran *et al.*[21] revealed that substrate having silt and leaf compost showed the maximum plant height in *Dahlia*. The probable cause for more plant height could be related to compost decomposition yielded biological inputs, such as plant growth hormones and release of macro and micro elements responsible for better plant growth[22]. Chen *et al.*[23] working on *Eucalyptus* got the highest plant height when peat moss, vermiculite and sand was used as potting substrate.

In plants, leaves are the main food production zone as leaf organelles converts the solar energy into chemical energy. Data pertaining to No. of leaves per plant were exposed for statistical analysis. The results illustrated noteworthy differences in substrate having combination of farmyard manure, silt, coconut compost, peat moss and leaf compost (1:1:1:1:1) at 5% among various substrates studied. The means were compared by using DMR test and results are shown in Table 6 and 7, which depicted significant more No. of leaves in substrate combination of farmyard manure, silt, coconut compost, peat moss and leaf compost. The maximum leaf number 6.76 were recorded in substrate having in farmyard manure, leaf compost, peat moss, coconut compost and silt which is followed by 6.53 peat moss substrate. The minimum No. of leaves per plant 3.53 were recorded substrate having garden soil only. In depth correlation analysis revealed that No. of leaves is positive correlated with OM contents, P, K, N and saturation percentage. However, it exhibited a negative correlation effect with pH and EC of the substrate. The No. of leaves in any plant species is an indicator of its good growth and development and also reveals appropriateness of environmental conditions under which they are grown as reported by Westerman and Bicudo[24].

The higher leaf number in composted substrates might be attributed to its optimal water holding capacity, proper gaseous exchange and nutrients' status of substrates[25]. The findings of Cardenas-Mendez *et al.*[26] showed the *Dianthus* (carnation) grown in substrate having 65 and 35% burned rice husk amended with coconut coir revealed the maximum leaf area and leaf number. Also, Scagel[27], observed higher leaf number grown in substrate with composted fir bark (80%), peat (20%), coir (20%) or coir (10%) and peat (10%). Grassotti *et al.*[28], got higher leaf in *Lilium* in substrate having coconut compost and perlite. Whereas, Mehmood *et al.*[29] experiential more leaf number and quality growth in *Antirrhinum majus* in substrate having peat moss.

In plants, leaves are the food synthesis zone, therefore, leaf area and No. of leaves overall effect the growth of any plant species. The leaf area is dependent on plant growth and its retention on the stem. Present study data regarding leaf area were estimated after statistical analysis that

Table 7: Comparison of treatment means of leaf area (cm^2)

	Original order		Ranked order	
Treatments combination	Treatments	p-value	Treatments	p-value
Garden soil	T_0	25.58[j]	T_9	33.12[a]
Farmyard manure	T_1	27.17[h]	T_{10}	32.92[b]
Coconut compost	T_2	26.81[i]	T_6	31.18[c]
Leaf compost	T_3	28.24[g]	T_7	30.43[d]
Peat moss	T_4	30.32[e]	T_4	30.32[e]
Silt	T_5	24.16[k]	T_8	29.56[e]
Silt+farmyard manure (1:1)	T_6	31.18[c]	T_3	28.24[g]
Silt+leaf compost (1:1)	T_7	30.43[d]	T_1	27.17[h]
Silt+coconut compost (1:1)	T_8	29.56[e]	T_2	26.81[i]
Silt+peat moss (1:1)	T_9	33.12[a]	T_0	25.58[j]
Farmyard manure+leaf compost+coconut compost+peat moss+silt (1:1:1:1:1)	T_{10}	32.92[b]	T_5	24.16[k]

Any two mean not sharing a letter differ significantly from each other at 5% level of probability

demonstrated significantly maximum leaf area in substrate (Silt+peat moss) ($p<0.05$). The mean values are presented in Table 3. Present results depicted that the maximum leaf area 33.12 cm^2 was recorded in peat moss substrate followed by 32.92 cm^2 in substrate having farmyard manure, leaf compost, peat moss, coconut compost and silt, while, the minimum leaf area 24.16 cm^2 was experiential in silt substrate. In depth correlation analysis exhibited that leaf area had a positive correlation with OM, N, P, K and saturation percentage. Nonetheless leaf area had a negative non-significant association with substrate EC and pH.

In *Dianthus* (carnation), Cardenas-Mendez *et al.*[26] observed higher No. of leaves and greater leaf area in substrate having burnt and composted rice husk amended with coconut coir. In *Dahlia variabilis* cv., Redskin efficient nutrition management effected the vegetative and reproductive growth was observed by Younis *et al.*[30]. In *Amaranthus*, plants grown in manure showed the maximum leaf area as reported by Akparobi[31]. Whereas, Asciutto *et al.*[32] and Bachman and Metzger[33] reported vermicompost best in case of leaf area in *Impatiens* and ornamental bedding plants. Though, substrates having vermicompost had greater growth potential[14]. Many researchers such as Eaton *et al.*[16], Hawkins[17], Riaz *et al.*[34], Younis *et al.*[35] and Hussain *et al.*[36] reported increase in morphological characteristics in various ornamental plants.

This study proved to helpful for the nurserymen to opt the substrate containing farmyard manure, silt, coconut compost, peat moss and leaf compost for potted palm plant production. But for other ornamental potted production the suited potting substrate should be explored. Nurserymen should be vigilant when shifting alternative potting mixes or trying to find new media components. Using the local alternative substrate components are viable options as it will reduce the cost and maintains a suitable growing substrate quality.

CONCLUSION AND FUTURE RECOMMENDATIONS

The results related with plant growth characteristics revealed that the maximum plant height, leaf area, leaf number, side shoots, fresh dry weight of plant and root length were observed in substrate having farmyard manure, leaf compost, peat moss, coconut compost and silt followed by substrate having silt and peat moss in equal proportion. Also, the maximum N, P, K, saturation percentage and OM contents were recorded in substrate having farmyard manure, leaf compost, peat moss, coconut compost and silt. This substrate proved to be the best under present experimental conditions and could be use as potential substrate for growing of *Ravenea* palm.

Seeing the significant increase in growth of *Ravenea* palm it is recommended to use combination of farmyard manure, silt, coconut compost, peat moss and leaf compost as it has the ability to improve the substrate's physical and chemical properties greatly. Furthermore, from results it was observed that mixture of potting substrates offers necessary plant nutrients, improves its porosity, increase water holding capacity and makes the media lighter and with lesser bulk density.

SIGNIFICANT STATEMENT

This study discovers the quality of potting substrates is one of the most important factor that effects the growth and development of potted plants. A quality substrate possesses both the physical and chemical properties that encourage vigorous and healthy plant growth. Combination of farmyard manure, silt, coconut compost, peat moss and leaf compost is recommended as it has the ability to improve the substrate's physical and chemical properties greatly. Mixture of potting substrates offers necessary plant nutrients, improves its porosity, increase water holding capacity and makes the media lighter and with lesser bulk density.

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