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ORIGINAL RESEARCH

Coconut coir dust as a waste on growth of Pothos (*Scindapsus aureum* L.)

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Abstract

Purpose Coir dust was utilized to manufacture soilless mixture for ornamental plant reproduction. Coconut coir provides more air and moisture to the root zone. Growing medium with coir does not shrink from container walls upon drying.

Method This study was performed in a greenhouse, Institute of Agricultural Research, University of Zabol during 2019-2020; the experiment carried out on a completely randomized design with 4 treatments, 8 months of measuring and 3 replications. Treatments had contained equal volume ratio of coco peat+ rice hull; coco peat + spent mushroom compost, cocopeat + leaf mold, coco peat + perlite. Measurable factors like plant height, stem diameter, number of new leaves**,** fresh and dry weight of leaves and the amount of chlorophyll were assessed for comparison of pothos growth, and finally plants had compared as stated by their general form and morphology too. Characteristics were analyzed with SPSS software and mean comparisons were represented by Duncan test in $P \leq 0.05$.

Results The findings showed that the variables such as substrate, months of measuring and their interplays had significant effects on all factors (except stem diameter). Mainly, media containing leaf-mold characteristics such as plant height, leaf number and leaf area were better than the others. The results of cocopeat + spent mushroom compost were nearly similar to cocopeat + leaf-mold, but two other media didn't show good growth after 8 months. On the other hand, growth rate of the plants improved by warming the air from autumn to summer and the most growth rate were related to July.

Keywords Cocopeat, Rice hull, Leaf compost, Mushroom compost, Perlite, Growing media

Introduction

Scindapsus aureus (Pothos) is discussed as the easiest plant of all household plants. It belongs to Araceae family. This plant is tolerant to low light situations (Saffari et al. 2013). Danger of environmental pollution, exclusively soil and groundwater has caused more significance of another method of soil agriculture because of application of pollutant source (Levy and Taylor 2003). The growth of plants such as ornamental plants are related to many parameters. The importance of potted culture mixture's quality is more than soil media because they have more limited space. Humidity, aeration and organic matter of the soilless mixture were the three parameters that affected development and blooming of gardenia plants. (Al-Menaie et al. 2008). The effect of different compositions of

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potting substrate having leaf compost or poultry manure as the principal sources on the nutrient uptake efficiency of pothos has been emphasized. There is an enormous possibility for using the waste material efficiently for propagation of ornamental plants (Iftikhar and Qasim 2003). As a good soilless culture, cocopeat has a good pH, Electrical conductivity and chemical elements, however its content of water is great that causes the poor air-water connection to be increased, and it leads to low aeration within the mixture. Therefore, it affects the distribution of oxygen to the roots. Addition of larger media into cocopeat improves the aeration condition of the media (Awang et al. 2009). Coconut coir dust is a substrate which is more appropriate than oil palm empty fruit bunch. Although the primary EC content of coconut coir dust was high, no sign of growth delay in hybrid cauliflower plant was observed. Under these situations, plant's dry weight and total leaf area were twice in plants grown in cocopeat compared to those grown in oil palm empty fruit bunch (Asiah et al. 2004). Larger materials such as rice hull, kenaf core fiber and perlite can be used to increase the air-water relationship of cocopeat (Tsakaldimi 2006; Sambo et al. 2008). The surface of a coir-based potted media will become dry more rapidly than the root zone. Greenhouse's owner must be careful not to overwater the ornamental plants in a peat-coir growing medium. The factors related to the quick drying will often help us to solve the problems of crop growth resulting from overwatering, especially in cold climates with high humidity or cloudy conditions (Londra et al. 2018). In a research, Dede et al. (2010) concluded that the most appropriate mixture for *ligustrum* was the mixture containing poultry fertilizer, whereas bio-solid is the most suitable mixture for *cypress*, irrespective of the main ingredients. The media containing 3:1 leaf mold/coconut coir dust had the higher number of leaves in pothos growth, but the number of shoot was better in the same ratio of leaf-mold: sand mixture (Khayyat et al. 2007).

Obvious differences in morphological traits were recorded among traditional substrates with considerable superiority of flower quality and plant growth. The results of this study showed that treatment containing silt, coconut coir and top soil had the highest Gerbera plants, while combination of silt, Lahore compost and top soil exhibit the most number of leaves per plant and maximum flower stalk thickness (Riaz et al. 2015). The use of fertilizers, especially vermin-compost not only improved the growth of pothos with 10% of soil, but also enhanced all growth parameters. The effect of granular sulfur compost on the number of new leaves in pothos plant was much more than vermin-compost (Saffari et al. 2013).Younis et al. (2010) concluded that mixture of sand: silt: leaf compost: spent compost (1:1:1:1) was the best mixture for propagation of croton plants followed by sand: silt: leaf compost: spent compost (oyster) (1:1:1:1). Through the compilation of burnt rice hull, we can enhance some chemical and physical attributes of cocopeat, and its positive effect was intelligibly reflected in the growth and development of *Celosia cristata* (Awang et al. 2009). A few studies have been reported on the effect of different substrates on pothos. The important point here is to introduce the suitable substrates for better growth of pothos plants, however, the wide application of the ornamental plants is the crucial point, because the results of this study and similar researches not only help the producer to detect a suitable medium for better growth in the shortest time, but also they help the consumers such as housewives to choose the most appropriate media for their plants. On the other hand, the use of recycling materials as a substrate for ornamental plants is not only beneficial for the environment, but the fruit fibers can be used as a substrate in most homes after consuming fruits such as coconut that it is also economically justifiable. The purpose of this study was to estimate different growing substrates and the effect of other substrates combined with cocopeat on the characteristics of growth of popular indoor plants, golden pothos, so the best and suitable

combination is introduced for the owner of greenhouse for economical and faster production of pothos.

Material and methods

The present research was carried out in a greenhouse in Institute of Agricultural Research, University of Zabol, Iran country, from December until July during 2019-2020. The experiment design was a completely randomized design with 4 treatments, 8 months of measuring and 3 replications. Various substrates consisted of M_1: cocopeat+ rice hull; M_2: cocopeat+ spent mushroom compost, M_3: cocopeat+ leaf mold, M_4: cocopeat+ perlite. All mixtures were prepared according to volume ratio rather than weight (v/v). The plastic pots with the height of 25 cm and head's diameter of 21 cm were filled by handy mixtures. Also, rice hull was used in the bottom of all pots for better drainage due to its weightless rather than gravel. 3 pothos plantlets of uniform growth were transplanted in each pot. Some morphological characteristics like: the height of pothos plant, stem diameter, number of new leaves, fresh and dry weight of leaves and chlorophyll amount were evaluated for estimation of pothos growth, and finally treatments were compared following their general observable outward (given them a score of 1 to 10 which 10 was the best). During the study, no fertilizer or nutrient materials were used. Irrigation and mist were carried out handy and uniformly. The plants were irrigated each 10 days in cool months and each 4-7 days in warm months. The pH of the potting mixtures were determined using a double distilled water suspension in all of substrates in the ratio of 1:10 (w:v) (Inbar et al. 1993) that had been shaken automatically for 2 h and filtered through Whatman no.1 filter paper. The same solution was prepared to measure Electrical Conductivity (EC) with a conductance meter that had been standardized with 0.01 and 0.1 M KCl (the irrigation water test showed pH: 6.55 and EC: 642 µs/cm). It was given a mark to each plant for grading and morphological evaluation at the end of the experiment by Amerin method (Amerin et al. 1965). For visual grading of plants, four characteristics were evaluated for photos plants such as: plant height, appearance color of leaves, uniformity in leaf growth and size of leaves, and each characteristic was given 2.5 scores. Then the addition of the scores were determined, and the treatments were compared to determine the best (10 scores) and worst (3 scores) scores of different substrates in terms of appearance. Twenty people were asked to rate the above characteristics in terms of appearance, the average score was considered for each characteristic. Collected data was analyzed by SPSS software in p value of 0.05 ($P \leq 0.05$) and mean comparisons were performed by Duncan test between different treatments.

Result and discussion

The measurement of temperature in the greenhouse showed that the minimum temperature was 7 ºC in cool months, and it increased to 12-14 ºC after using of heater in autumn and winter, but after winter, because of warm weather, the minimum temperatures were 17 ºC and 25 ºC in spring and summer respectively. The amount of humidity was retained 30-40% in greenhouse in all months comparatively. Some nutrient elements were determined by soil analysis in the used substrates as follows by (Table 1). Analysis of potted substrates indicated that substrates with low nutrients, organic substance and water-holding capacities, can be improved by different organic materials with various compositions at different ratios (Younis et al. 2010). This means, for example, adding the substrates with desirable aeration such as cocopeat or perlite to heavy substrates such as soil or loam can improve soil aeration, and it may lead to better growth of the plants. Also, substrates with low nutrients can be used to improve the growth of plant by adding fertilizer or substrates containing nutrients with suitable concentration.

Table 1 Results of analysis of main elements in the used substrates

Media	N %	Mg Mgkg^{1-}	K Mg.kg^{1-}	P Mg.kg^{1-}	Fe Mg.kg^{1-}
Perlite	0.039	140	182	11	4.4
Leaf mold	1.69	360	528	21	16.44
Rice husk	2.04	160	671	190	23.04
Cocopeat	3.04	880	917	21	42.88
Mushroom compost	1.11	680	880	250	2.64

Plant height

Analysis of data in this research showed the significant effect of media, months of measuring and their interactions on pothos.

Interaction effect of media and time on pothos' length in 8 measurement times showed that cocopeat+ leaf compost was the best media, whiles cocopeat+ rice hull and cocopeat+ perlite were the worst substrates, and their difference was not significant (Fig. 1).

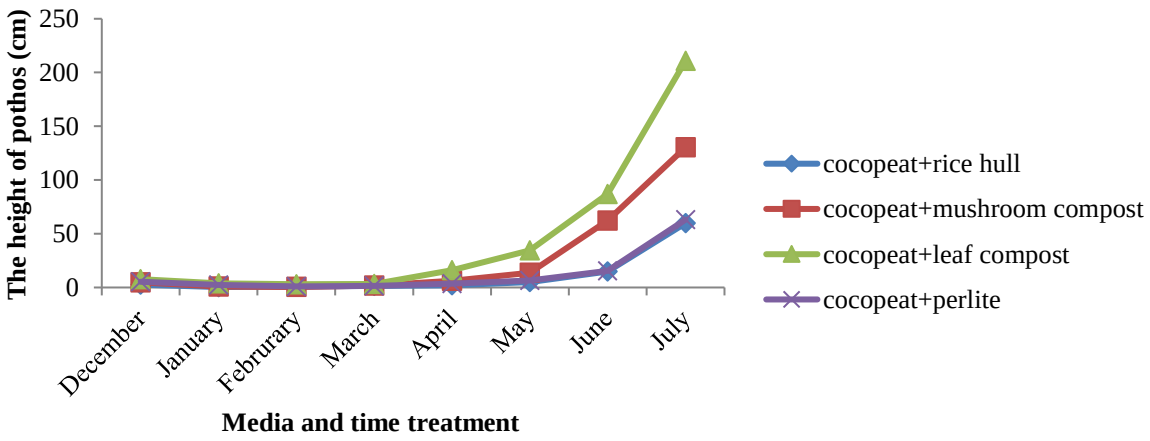

Fig. 1 The height of pothos in different media and months of measuring

Effect of media on pothos' height revealed that cocopeat+ leaf mold (a significant word) and cocopeat+ spent mushroom (b significant word) substrates had the most growth of length; while cocopeat+ rice hull and cocopeat+ perlite (c significant word) were the worst media (Fig. 2). Mean comparisons among different treatments were displayed according to the significant word on diagram. Addition of leaf compost to cocopeat had more significant effects on the height of plants, and then on the mushroom compost.

There were no significant differences in height between two other substrates. Fixed media in this trial (cocopeat) had the most nitrogen content than the others. In additive substrates, there were the most amount of nitrogen in rice hull, leaf compost, spent mushroom compost and perlite, respectively. But plant growth's diagram showed that the rice hull doesn't have a good effect on plant's height, whereas plants had maximum length in leaf mold and mushroom compost substrate when mixing with cocopeat. Perhaps its reason had been due to antagonistic behavior of the mixture of rice hull and cocopeat or inaccessibility of high levels of N for pothos plants.

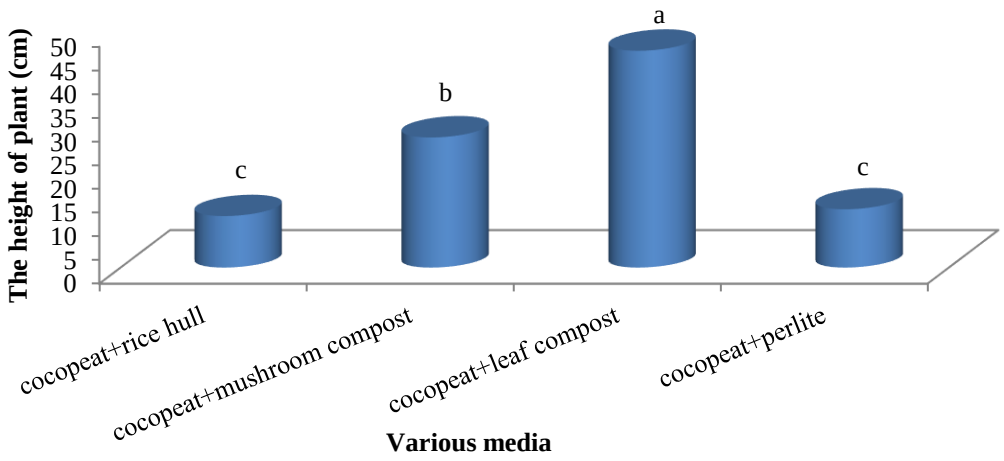

Fig.2 The height of pothos in different media containing cocopeat

Effect of measuring time on pothos' height was significant. The diagram shows that the additive amount of height was ascending from December 2019 until July 2020 (Fig. 3). But its amount was low in first stages (t_1-t_4). In four final stages, the length of plants increases quickly, as the weather grows warm in April. The reason of this theorem is clear, because the pothos is an arid and Semi-tropic native to southeastern Asia (Malaysia, Indonesia) and New Guinea (Abd-El-Hadi and Shanan 2010), so it is clear that it had slight growth in cool seasons but after April, plants' length increased quickly after the weather grew warm, and the greenhouse became lighter and sunny; insofar ss the plants' length increased nearly 116 cm just in July month.

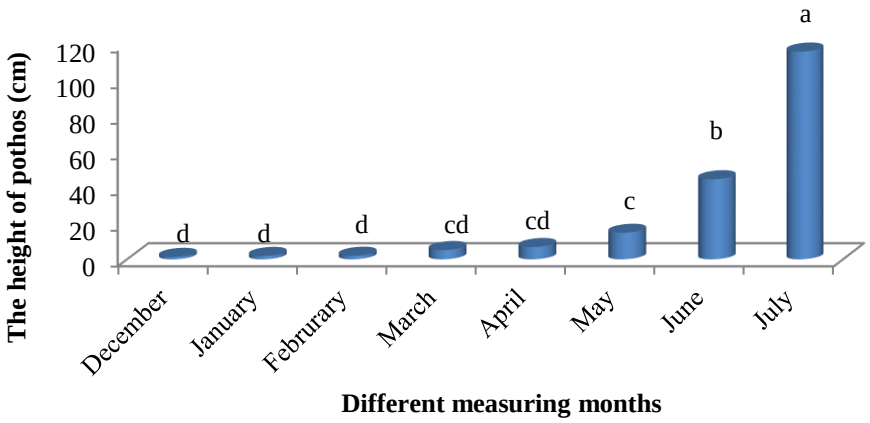

Fig. 3 The height of pothos in different months from autumn until summer
t1: December; t2: January; t3: February; t4: March; t5: April; t6: May; t7: June; t8: July

Leaf number

Statistical analysis showed that the interactions of media and time of measuring had significant effect on leaf number of pothos plant. After 8 months, it was revealed that the media containing cocopeat + leaf compost and cocopeat + spent mushroom compost had the most numbers of new leaves than others (Fig. 4). The new numbers of leaves are added to all of substrates' mixtures, and it was caused by increasing the air temperature.

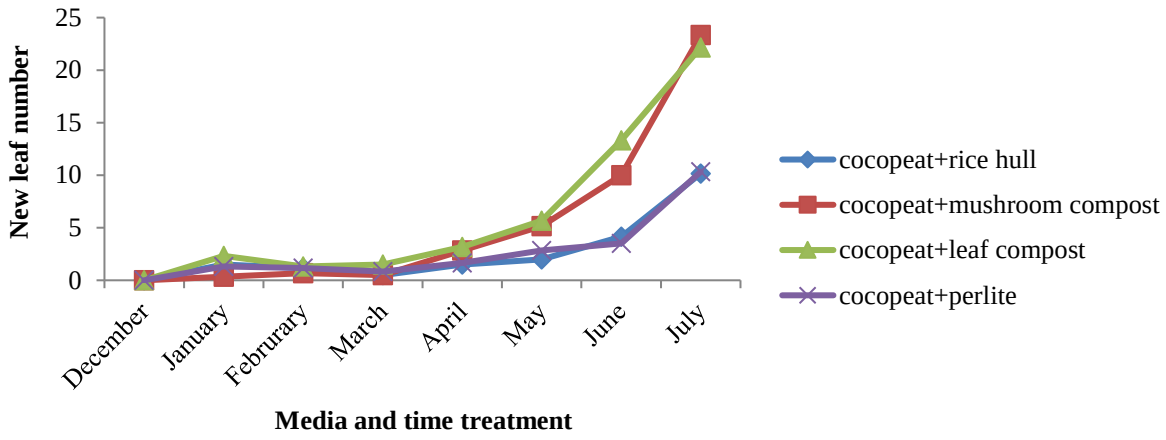

Fig. 4 Interaction of media and months on new leaf number of pothos

Content of nitrogen in Soil analyses showed that rice husk had the most content of nitrogen following the leaf mold, spent mushroom compost and perlite, respectively, but according to diagram, M3 substrate was better than M2, M4, and M1. So, rice husk couldn't use its high nitrogen for growth, or perhaps nitrogen of this media was inaccessible via drainage (Fig. 5). Presumably cohesion of ingredients in M3 and M2 causes less drainage, Thus, pothos plant could apply essential elements for its better growth and production of more numbers of new leaves on its branches. At the end of experiment, root development was very good in media containing rice husk, whiles media containing leaf-mold had lower root growth than rice husk. According to the result of this experiment, Khayyat et al. (2007) discussed that high leaf growth was observed in media including leaf compost, although root development was slight. Since the only reason for these events was not the differences in the water-air relationship with different rooting substrates, other parameters are probably involved. Root information can limited by decreased porosity.

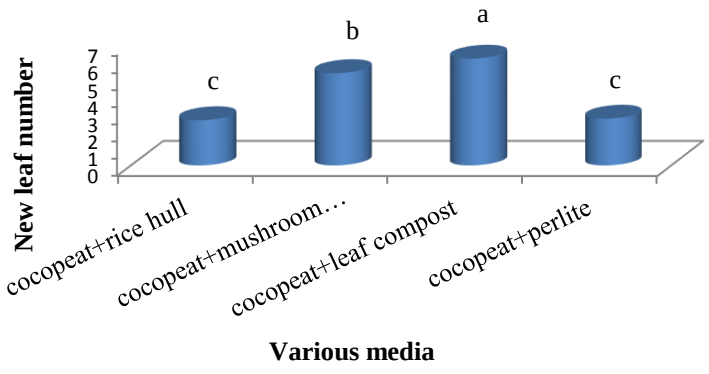

Fig. 5 Effect of additive substrate to cocopeat on new leaf number of pothos

Statistical analyses (Table 2) showed the significant effect of measuring times on the numbers of new leaves (Fig. 6). The effect of t_1 and t_2, t_2 and t_3 and t_4, t_4 and t_5 wasn't significant, but this effect was remarkable among other times. The results obtained at the end of this experiment showed that the number of new leaves was notably in four final stages; while in the first four stages, the number of leaves appeared on the plants was few. This phenomenon is due to gradual warming from December 2019 until July 2020. More sunshine causes more photosynthesis gradually, thus growing more numbers of new leaves is believable after winter. Two consecutive months had not significant differences together in cold months because of

slow growth rate, while after the weather getting warm in spring and summer, significant differences were observed between treatments by enhancing the growth rate with increasing the length and the number of new leaves. Due to the tropical origin of *Scindapsus aureus* plants and according to the result of this research, the highest output of growing characteristics was in the warm months of the year and the growth rate gradually increased by enhancing of the air temperature in the greenhouse.

Table 2 Statistical analysis (mean comparisons) in different treatments and measured factors

	Measured traits				
Source	Plant height	New leaf number	Stem diameter	Chlorophyll index	Leaf area
Substrate	12691.6^{**}	159.8^{**}	1266.8^{ns}	246.2	$(1.43\times10^{8})^{**}$
Time	38165.3^{**}	734.7^{**}	1075.6^{ns}	-	$(3.08\times10^{8})^{**}$
Substrate× Time	3813.9^{**}	45.3^{**}	1107.1^{ns}	-	$(7.16\times10^{7})^{**}$
Error	285.1	3.2	1109.6	14.4	6335143

^{ns} and **are non-significant and significant at $P\leq0.01$

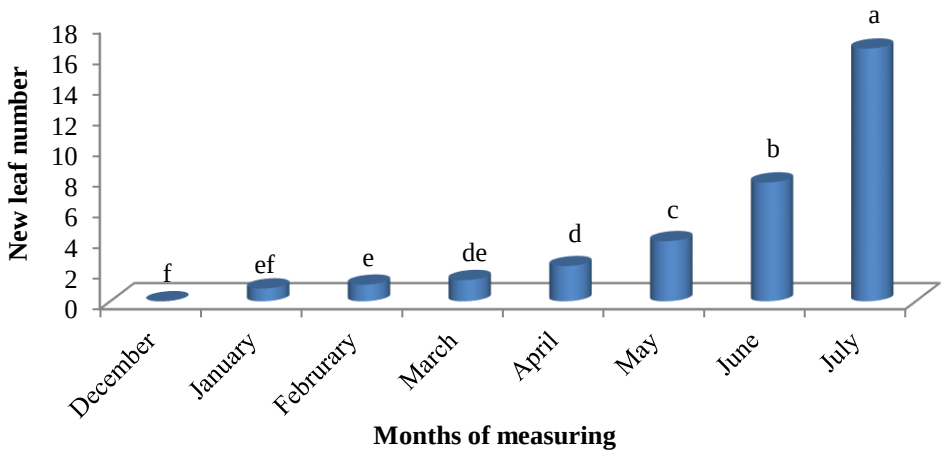

Fig. 6 New leaf number of pothos on different months

Stem diameter

This study revealed that the effect of potted substrate, different measured months and their interplay on stem diameter of pothos was not significant. The results of Benito et al. (2005) showed that the stem diameter in *cypress* wasn't affected by the growing media, too.

Chlorophyll Index

The amount of chlorophyll was measured at the end of experiment by measuring chlorophyll set (Fig. 7).

Fig. 7 Measuring of chlorophyll on pothos leaves

The results of chlorophyll amount in plants showed that M2 substrate had highest value, but there wasn't any significant difference between M2 and M3. On the other hand, M1 substrate that had less chlorophyll didn't have significant difference with M4 (Fig. 8).

One of the physiological reasons for growth decrease may be a disorder in the plant photosynthetic system. One of the ways to find out these disorders in photosynthesis is studying the chlorophyll fluorescence and the features related to it (Soltani 2004). According to Hasanpur Asil et al. (2009), the results on *Lilium* flower showed that the substrate doesn't have a significant effect on chlorophyll index, which is contradictory to the results of this experiment.

Also, the results of Ebrahimi et al. (2012)'s experiment showed that cocopeat + perlite substrate had the most effect on chlorophyll on strawberry leaves that it is discordant with the results of this experiment. Bidarnamani and Zarei (2014) concluded that different pot mixtures containing perlite had no significant effect on photos, that it is consistent with the results of this study.

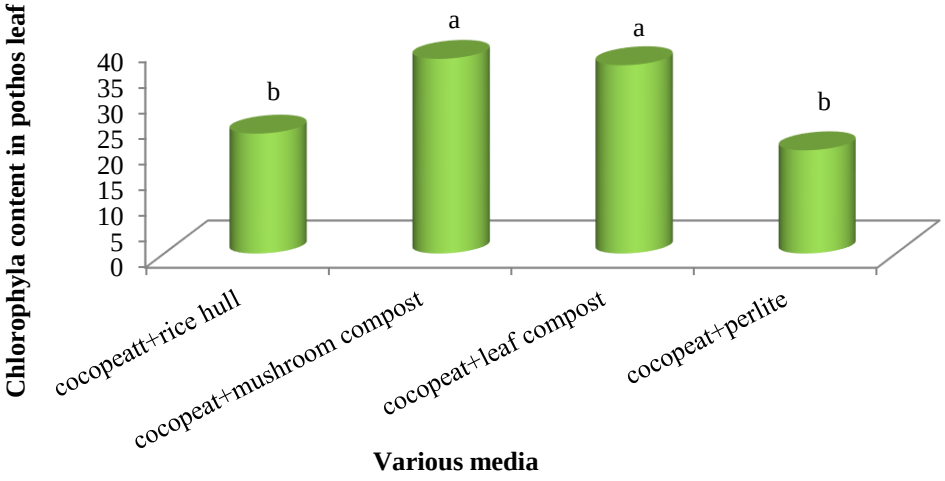

Fig. 8 Chlorophyll of pothos leaves in different media containing cocopeat

Leaf area

For calculation of fresh and dry weight of the leaves and the area of leaves, the models of leaf length and width data and also prediction models are used. Due to the correspondences between these characteristics and measuring data of leaves' length and width, it was represented a diagram of interaction of media and measuring time on leaf area only. The best formula (with comparison of R^2, CV etc.) was selected for calculation of leaf area (Bidarnamani 2011).

$$LA = 37.24F^{0.8685} \qquad R^2 = 0.9329$$

In this formula LA is Leaf Area and F is leaf's Fresh weight. Substrate, months of measuring and their interplay had significant effect on leaf area, fresh and dry weight of the leaf (Fig. 9). Cocopeat + mushroom compost had more leaf area than media containing leaf compost, perlite and rice husk, respectively (Fig. 10). Almost two latter media were similar; while cocopeat+ leaf compost had better leaf area than cocopeat+ mushroom compost from 6th stage to 7th. The reason for this theorem was distinguished only when there was an obvious comparison between this diagram and a diagram of new leaves' numbers, because media containing leaf compost had more numbers of new leaves than mushroom-compost ones in these stages. So, total leaves' area was maximum.Effect of media on total leaf area in pothos plant showed that although coconut+ mushroom compost and coconut+ leaf compost didn’t have significant effect on each other, they had more leaf area than coconut+ rice hull and coconut+ perlite (coconut+ rice hull and coconut+ perlite didn’t have significant effect on each other, too).

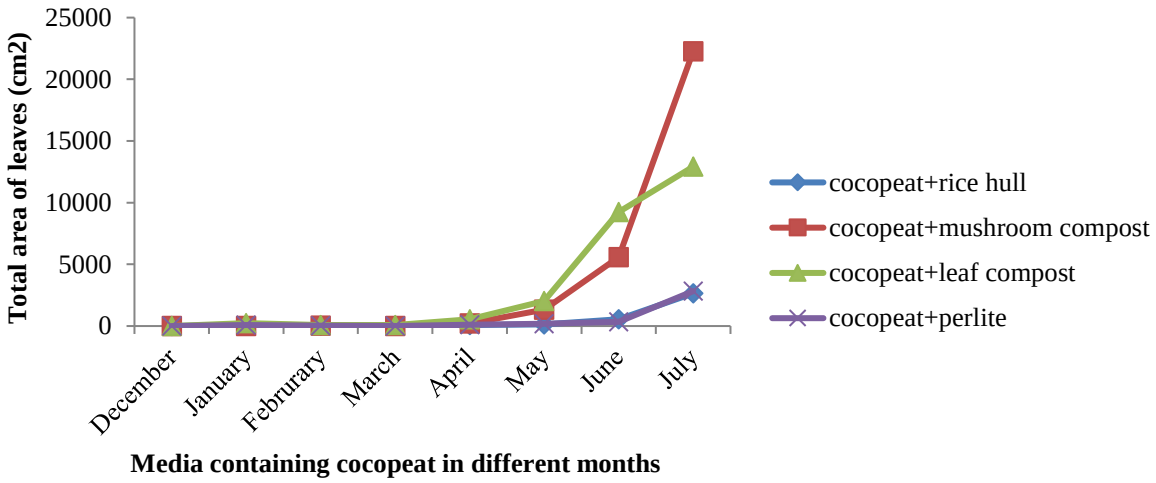

Fig. 9 Total area of leaves in different media

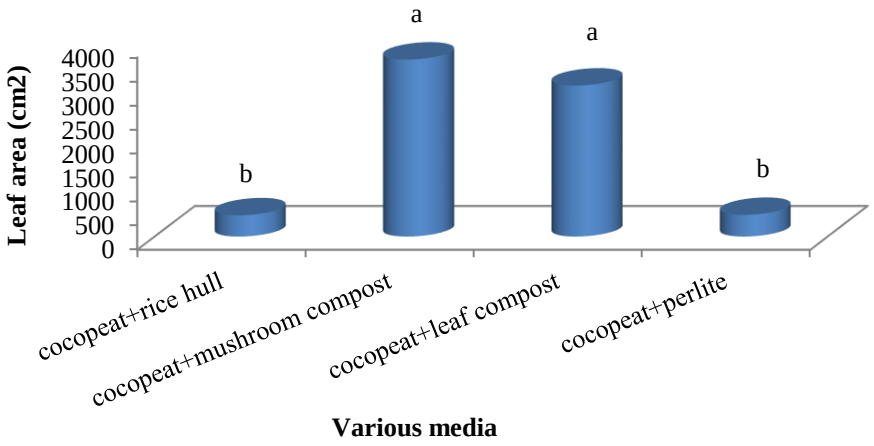

Fig. 10 Leaf area of pothos in media containing cocopeat

In Khayyat et al. (2007)'s report, higher leaf area in pothos plants was observed in peat moss/cocopeat (1:3) compared to the other pot media. But no significant variation was shown among recent media and cocopeat/peat moss (1:1) and also cocopeat mixtures. In other similar diagrams on various times (except stem diameter), the effect of various times on total leaf area in pothos plant was significant, too (Fig. 11). The variation on two final months was significant only, and it is because of warm weather in final stages and generating more new numbers of leaves in pothos plants.

Morphological evaluation

Based on all measured and analyzed growth characteristics, among four substrates containing cocopeat, the order of media was M3>M2>M4>M1 after eight months (Fig. 12). Thus, M3 and M2 substrates can be introduced to greenhouse's owner, and everybody can use the results of this experiment for better growth of the ornamental plant pothos.

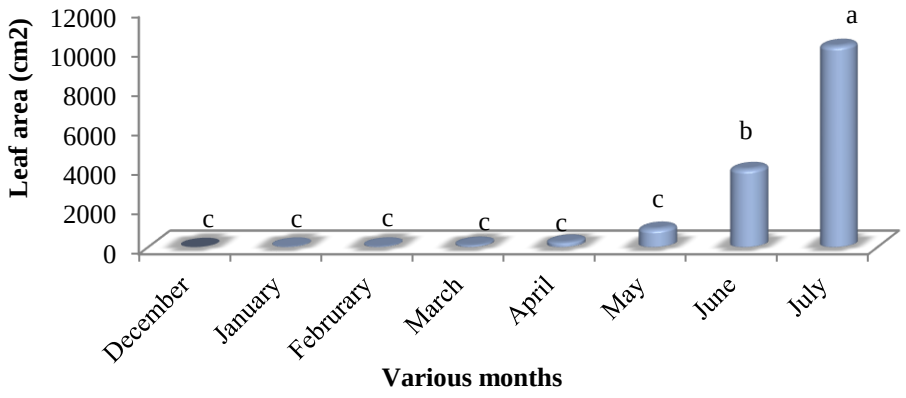

Fig. 11 Leaf area of pothos in different months

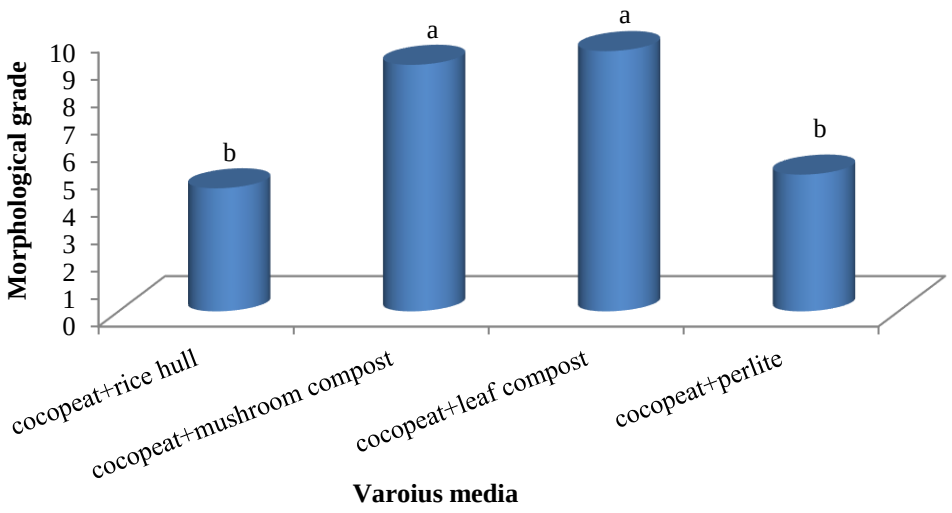

Fig. 12 Morphological score of plants in different media

Conclusion

During different months of study on pothos plants, the growth can be increased by enhancing the temperature; that means, temperature is a stimulus for the growth of the ornamental plants, especially for the plants with tropical origin. Substrates such as perlite, cocopeat, vermiculite etc., can increase media's space by addition of its amount in the substrate. The production of leaves on cuttings displayed earlier growth of root system in plants; however the other environmental agents can also be involved. Content of main elements in Table 1 showed that nitrogen is higher in rice husk, after cocopeat media, but growth rate in cocopeat+ rice husk was less than cocopeat+ leaf mold and cocopeat+ mushroom compost. So other factors can affect the growth rate besides nutrition and aeration, such as water maintenance capability. On the other hand, the interaction of two substrates, increasing or decreasing their positive and negative effects on growth is very important. For example, plants' root may have more aeration in separate usage of perlite or cocopeat, but aeration was decreased in their combination duo to enhancing the water maintenance capability. The addition of coconut fiber as a residue from the consumption of coconut fruit with other compounds showed that the best combination for the

growth of pothos plant was leaf mold and mushroom compost, respectively. Therefore, recycling of the waste of the forest trees, mushroom compost and coconut can be a very suitable factor for the growth of the ornamental plants. Also achieving the best time for propagation of pothos plant and estimating the costs of keeping flowers in the greenhouse indicated that it is not economical to propagate this plant in the months with low temperature due to the lack of developmental traits of plants in low temperature in cold seasons. Instead, it can be seen multiplier growth factors in the warmer months in the short period, which reduces propagation and maintenance costs many times over. The addition of coir to a soilless growing medium can be beneficial in many ways: it helps root's aeration in soil media, it supplies water to the potting media due to its high water absorption, and it keeps the plants in the hydroponic culture system.

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Compliance with ethical standards

Conflict of interest The authors declare that there are no conflicts of interest associated with this study.

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