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The Study on the Growth Rate and Peat Characteristics of Chilli Plantation Utilising Coconut Husk and Peanut Shell as Sustainable Alternative to Soil Cultivation

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Abstract: Soilless media, method of growing plants without the use of soil as a rooting medium, is the most intensive and effective production method in the modern agriculture industry. Soilless cultivation has been observed to be an effective way to improve product quality. Thus, this research used agriculture waste of Cocopeat and Peanut Shell as an alternative to soil cultivation. The main objective of this study was to observed the chilli plantation growing rate by using coconut and peanut husk as a peat and identified physical and chemical characteristics of growing media. The 5 different treatment media was used in this study with different ratios. All the treatments were characterised in the aspects of pH, electrical conductivity, bulk density, particle density, moisture content and water holding capacity. For the observation of growth rate number of chilies, leaves, flowers and height of plants were determined after harvesting. The treatment with mixing ratios at T4 (50%: 50%) and T5 (60%: 40%) of cocopeat and peanut shell showed a better performing than 100% of soil, cocopeat and peanut shell. It exhibited appropriate values for the physical properties of T4 and T5 which are for the pH (6.11, 5.51), EC (0.0089, 0.0091), BD (0.194, 0.2) g/cm^3, PD (0.587, 0.554) g/cm^3, MC (48.66, 53.08)%, WHC (59.75, 64.79)% which was very close to the standard of soilless medium. It is observed that the growth rate of plant was achieved in T4 and T5 with the number of 6 and 7 chillies produced. The recommended usage of peanut shell was below 50% due to its undesirable physical properties. Other organic matter and properties of medium produced can be further investigated in future.

Keywords: Cocopeat, Peanut Shell, Soil, Media, Agriculture Waste, Growth Rate

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1. Introduction

Soilless media, defined as any method of growing plants without the use of soil as a rooting medium, is the most intensive and effective production method in the modern agriculture industry [1]. Nowadays, soilless cropping is carried out to produce vegetable and ornamental plants in greenhouses and nurseries [2]. Researcher Rouphael mentioned that, soilless cultivation has been observed to be an effective way to improve product quality, as in the case of food biofortification, which is even more important than yield, per se, to increase farm competitiveness in modern horticulture. Biofortification refers to the process of increasing the nutritional value of crops by enhancing the concentration of essential nutrients in their edible parts [3].

The main advantage of soilless over soil-based cultivation is represented by the more accurate control of plant nutrition and irrigation and other environmental conditions of the rhizosphere for example root zone temperature. To reduce of the environmental impact of plant production via the selection of more eco-friendly substrates. Substrates id1ntified by environmental drivers are mainly composed of organic components [4]. Reasons are to be found among their general low cost and widespread availability, together with their renewability and easier disposal that make them an environmentally sustainable option. In present study, the organic materials used in soilless cultivation are coconut husk and peanut shell which suitable for the plantation. Hence, the aim of this study is to observed the chilli plantation growing rate by using coconut and peanut husk as a peat and identify characteristics of growing media.

The main objective of this study are to produce peat medium from coconut husk and peanut shell as a replacement as soil in chilli plantation. Besides this study was to identify the physical and chemical characteristics of coconut husk and peanut shell. Lastly, it was carried out to measure the effectiveness of growth rate chilli plantation by using coconut husk and peanut shell.

The study was carried out as laboratory-based research by using acidity pH meter, electrical conductivity, bulk and particle density measurements, moisture content, water holding capacity and in order to analyse chemical and physical characteristic of coconut and peanut husk. Moreover, chilli plantation was used to identify the effectiveness of coconut and peanut peat by measuring the length of plant, number of leaves, flowers and chillies grown on plant.

1.1 Cocopeat

Coconuts (Cocos nucifera L.) produce a fibrous material called coconut coir, often known as coco coir or coco fibres as shown in Figure 1[5]. A ripened coconut's brown coco fibers contain 43% cellulose, 45% lignin and less than 1% hemicellulose [6]. The husk retains 8 to 9 times its weight in water and contains 20% to 30% fiber of varied length. It has a maximum four-year shelf life [7]. Mostly, coconut fiber has been used to create ropes, yarns, brushes, rugs, and geotextiles because of its high lignin concentration (45%), which naturally makes these fibres tough and long-lasting. Additionally, due to its ability to promote soil water retention and pore size, this undervalued substance has become widely employed as a soil supplement in horticulture. A substantial amount of coco peat from the coconut industry is frequently dumped into the environment as waste following the collection of the coconut meat and coconut water because significant washing and treatment of coco peat is necessary to prepare these fibres for use in horticulture.

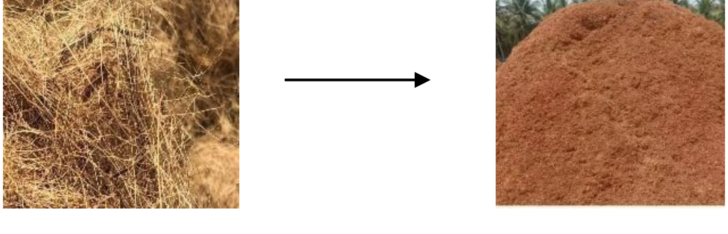

Figure 1: Coconut fibre and Cocopeat

1.2 Peanut Shell

The peanut plant is a significant crop that is planted all over the world. In terms of planting area, it is second only to rapeseed among oil plants. It is a prevalent practice in many populous nations, where peanuts are a significant food crop. As a species of the Fabaceae family of plants, which also includes chickpeas, lentils, beans, and peas, peanuts in Figure 2 [8]. The organic amendment of peanut shells raises nutrient levels, such as carbon, nitrogen, phosphorus, and calcium structure, and lowers the salinity of the soil. As the usage of peanut shells it is mostly used in food preparation, confectionary items, or as a nut; it is also used to make cereals, cookies, breads, candies, and salad dressings. Additionally, peanuts are used to make industrial items like oils, flours, inks, lotions, lipsticks, because of their high fat content [9]. Thus, as a result, peanut shell is a useful growth medium due to the substance's advantageous characteristics and high porosity.

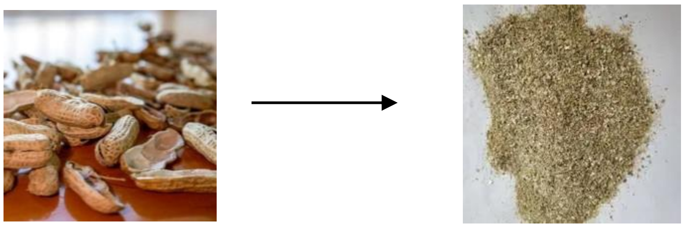

Figure 2: Peanut Shell and Peanut Peat

2. Materials and Methods

2.1 Materials

The material used in the research were cocopeat, peanut shell and sandy soil. Besides, the chemical substances used were medium, distilled water and standard solutions for calibration methods. The equipment used were pH meter, EC meter and drying oven. Moreover, this study used peanut shell and cocopeat as soil substitutes in order to reduce salt-affected regions in agriculture. There are numerous parameters for characterisation of the peat medium, including pH value, electrical conductivity value, bulk density, particle density, moisture content and water holding capacity. In addition, the pace of growth of the chilli plant also was measured.

2.2 Collection of Media

The coconut husk and peanut shell was collected and kept in a safe place. The fibres must be removed from the coconut husk and allowed to dry. The leftover portions were next being chopped or cut into little bits using a good pair of scissors or cutters. Furthermore, the chopped sections were ground in a mixer grinder until the peat type of the cocopeat and peanut shell is separated as fluff. The fibres was next be removed from the medium using a sieve. The resulting peat was then being rinsed with water to eliminate any excessive salts. For about an hour, the peat was immersed in water. The excess water was squeezed out using the hands. The peat was next being dried in bright sunlight for a day.

2.3 Characterization of Physiochemical properties

All the media samples were characterized based on pH value, EC value, particle density, bulk density, moisture content and water holding capacity. pH meter was calibrated before use. Volumes and weights of media samples were measured to calculate the bulk and particle density. Moisture content and water holding capacity were evaluated the maximum amount of water stored in the soil. Value of treatment with different media used were recorded to calculate their respective values with loss. Eventually, the plant growth rate was determined by measuring the plant's height from the medium line to the top. Furthermore, to assess the growth performance of the chilli plantation using different peat media, number of leaves, number of flowers, and number of the chillies was measured. The growth rate of plants being evaluated in 60 days of harvesting. The general process flow involved in characterization of physiochemical properties of media samples is as shown in Figure 3.

2.3.1 Bulk Density

The sample was collected using core ring and it's been transferred into beaker. Then, the beaker with collected sample has been placed into the oven at 105°C for 24h. The oven dried medium sample was poured into a beaker. The mass of the medium sample been calculated by subtracting the loss. The density of the sample then been determined using the formula below in equation 1 using the data collected. All of the preceding processes was repeated by substituting the other four mediums.

$$Density, \rho = \frac{mass\ (g)}{volume\ (ml)} \qquad Eq.1$$

2.3.2 Particle Density

The density of solid particles collectively is referred to as particle density of media. The particle density of a medium sample is computed using two measurable quantities which are the sample's mass and volume. The mass is calculated by weighing the sample, and the volume is calculated by calculating the mass and density of the water displaced by the sample. This method has been used for a long time. The density of the sample then been determined using the formula below in equation 2 using the data collected. It is simple, direct, and accurate if done carefully. In this study, pycnometer was used to determine particle density of the medium.

$$D_p = \frac{d_w(W_2 - W_1)}{(W_2 - W_1) - (W_3 - W_4)} \qquad Eq.2$$

d_w= density of water in grams per cubic centimeter

W1 = weight of pycnometer filled with air,

W2 = weight of pycnometer with medium sample,

W3 = weight of pycnometer filled with medium and water,

W4 = weight of pycnometer filled with water.

2.3.3 Moisture Content

All the medium was utilised in this study to assess the moisture content utilising the oven drying technique at temperature 105°C for 24h. It is expressed as the weight of water divided by the dry weight of solid particles multiplied by 100 percent as shown in equation 3. This practical requires the use of a petridish, weighing scale, drying oven, desiccator, and medium samples. The procedure was repeated until the oven dried medium has a uniform weight, and the weight of the dry medium petridish was recorded. Finally, the moisture content was calculated using the loss.

$$Moisture\ Content, \% = \frac{W_w}{W_d} \times 100\% \qquad Eq.3$$

Ww= Weight of water,

Wd = Dry weight of solid particles

2.3.4 Water Holding Capacity

The purpose of this study is to determine the water retaining capacity of all of the media involved in this investigation. This experiment was required a retort stand, a petridish with water, a weighing scale, a crucible, and medium. The wetness of the medium was being measured. Next, the crucible with the wet media was weighed and recorded once absorbed with distilled water. Finally, the loss was used to compute the water holding capacity, as demonstrated below.

$$Water\ Holding\ Capacity, \% = \frac{W_w - W_s}{W_w} \times 100\% \qquad Eq.4$$

Ww= Weight of wet soil sample

Ws = Weight of soil sample

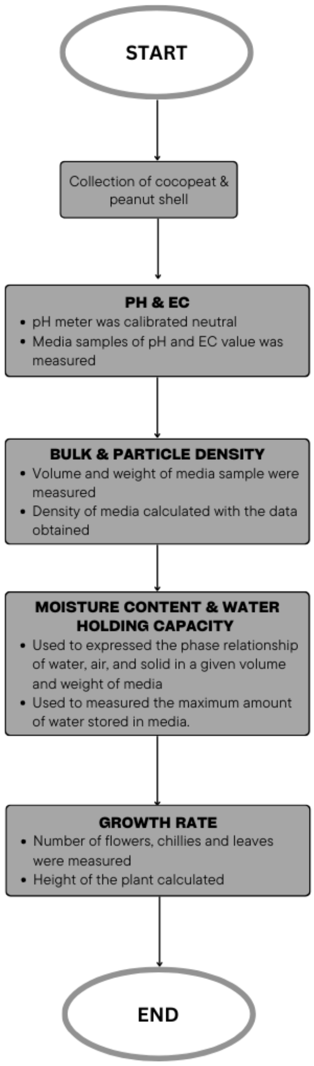

Figure 3: Process flow involved in characterization of physiochemical properties

3. Result and Discussion

3.1 Growth Rate of Chilli Plantation

Below Table 1 shows the weightage of media used in this study and some plant growth factors of the chilli plant cultivated in various mediums are represented by the data in Table 2. The investigated materials and mixing ratios had a substantial impact on number of leaves (LN), number of flowers (FN), number of chillies (CN) and height of the plant (H).

Table 1: Media Treatment with its Weightage

Media Treatment	Weightage Treatment, (%)	Weightage (g)
Cocopeat, T1	100	300
Peanut shell, T2	100	300
Soil, T3	100	300
Cocopeat: Peanut shell, T4	50:50	150:150
Cocopeat: Peanut shell, T5	60:40	180:120

Table 2: Effect of Pure Media and Mixing Ratio on Some Growth Parameters of Chili Plant

Media Treatment	Number of Leaves	Number of Flowers	Number of Chilies	Height of Plant, (cm)
T1	72	2	3	23.5
T2	118	5	0	28
T3	156	8	0	32
T4	93	2	6	36.5
T5	108	3	7	32.5

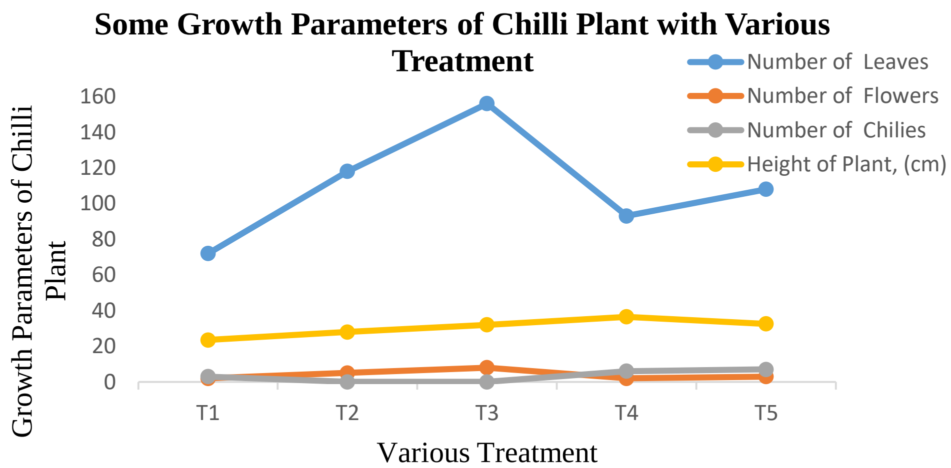

Figure 4: Comparison of Some Growth Parameters of Chili Plant with Various Media Treatment

The height of the chili plants from the top of the biocomposites to the center of the poly bag and the total number of leaves, chilies, and flowers were measured in order to determine the pace of plant growth. The criteria for plant growth for the chili plants are listed in Table 2 and comparison graph plotted in (Figure 4). Based on the graph the compost treatment T4 compost had a total number of 93 with 2 flowers and 6 chilies on it while T5 compost had a total number of 108 leaves with 3 flowers and 7 chilies at the end of the 60-day growth period. According to prior studies of the observed growth rate and parameters of the chili plant in compost medium were similar to the results of previous studies of the hydroponic growth of red radish plant [10]. In contrast, the found growth rate of the treatment plant T2 and T3 changed into slower than that of the T4 and T5 as obvious with the aid of the information describing the wide variety of chilies received in records and the root system.

On Day-60 of the growth period, the peak of the T1, T2 and T3 plant became 23.5cm, 28cm and 34cm and was lots shorter than that of the T4 and T5 plant 36.5cm and 32.5cm. Moreover, the number of chilies obtained in T2 and T3 was 0 due to its texture and structure of the growing medium can also play a crucial role. As was already mentioned, T1 is light, drains well, and provides good aeration to the plant roots while T2 may eventually compact, limiting root growth and nutrient uptake, and regular soil may not have adequate drainage, resulting in waterlogged conditions that are unfavorable for chili plants.

However, the overall wide variety of leaves of the T1 plant become 72, which was lesser to that of different treatments but it nonetheless gave the chilies on the end of day harvesting. This is because, after harvesting the chilies, the leaves turn yellowish and droop. This is mainly due to factor, such as senescence, in which leaves age naturally and eventually die over the development of the plant's life cycle. This diversion of resources leads to yellowing and shedding of older leaves. Thus, it's worth addressing that each growth medium has its unique properties, and with right modifications and care, it may be feasible to plant chilies in peanut shells or soil.

3.2 Peat media characteristics

All of the medium samples from T1 to T5 had their pH and EC values collected. The pH value was obtained both before and after the treatment, however only the initial reading of the EC meter was recorded. The findings of the analysis are shown in Table 2.

Table 3: Data obtained Mean Values of pH Before and After Cultivation and Initial EC Values of Media Treatments

Media Treatment	pH Before	pH After	Initia EC, *dS/m*
T1	6.53	5.67	0.0078
T2	6.79	6.51	0.0093
T3	6.49	4.23	0.0088
T4	6.48	6.11	0.0089
T5	6.38	5.51	0.0091

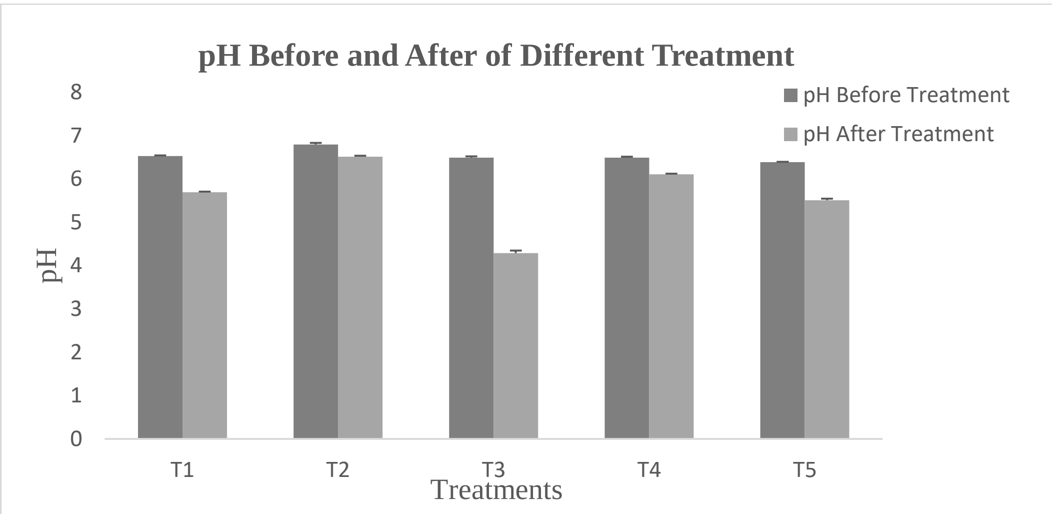

Figure 5: Comparison of pH values Before and After Cultivation by Soaking 24hours in Distilled Water

Based on the Table 3 the information mentioned above clearly demonstrates that both pH before and after culture, as well as the reading from the EC meter, were within the acceptable ranges, which, as the researcher had previously said, but with the exception of the pH value for T3 after cultivation, seems to be acidic at 4.23 can be clearly seen in Figure 5.

The T3 plantation, which was a soil-based plantation, was the only one where it was demonstrated that the pH was not within the range. This is because sandy soil was used for this investigation. As pointed out previously, sandy soil was frequently low in fertility and vulnerable to drought. The major cause of pH reduction in organic based media is the inability of soilless substrates to act as a buffer against the medium's being acidified by plant roots, which causes a change in pH. The ideal pH of soilless media for excellent availability of important nutrients is about 6.0, despite the fact that different medium cultivation has varying pH ranges for optimal development. Despite the low final pH's of all the medium, observation showed that plant development was normal and that there were no signs of fundamental lacking or toxicity. Thus, it indicates that the medium made from agricultural waste has been successfully used as a culture medium for ornamental plantations.

Next, from the Figure 6 below the EC values of all media differed between treatments ($p<0.001$), with T2 possessed the highest EC 0.0096ds/m while T1 had the lowest EC 0.0079 ds/m. The ECs for other media were still in the range. The EC values reflect the total inorganic ion concentration in the media extracts. Low EC value indicates that media did not contain excessive salt that could cause salinity injury to the plant but, at the same time contains insufficient amount of nutrients to support healthy plant growth. Higher EC of T2 reflects that peanut shell contains relatively high concentration of soluble salts which could be beneficial for plant growth.

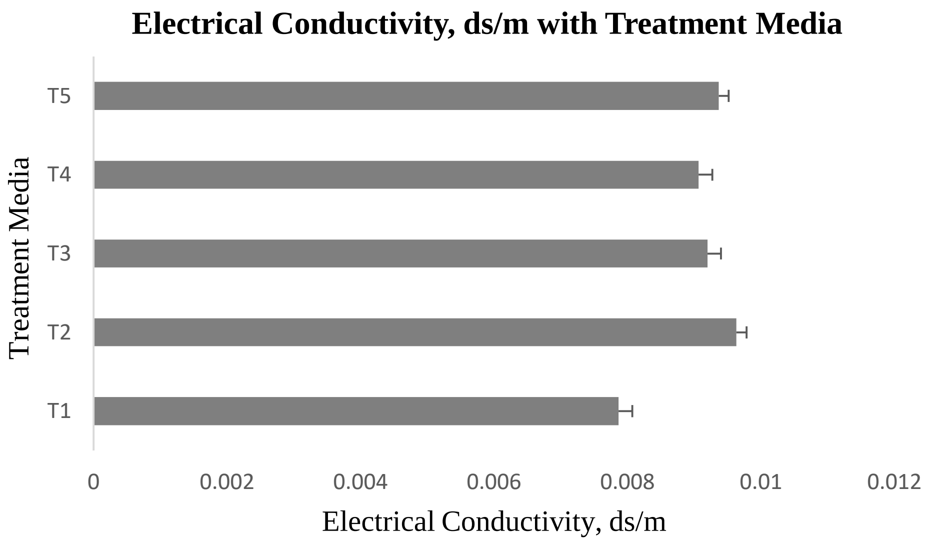

Figure 6: Electrical Conductivity, (ds/m) Variation Across Different Treatment Media After Soaking for 1 hour

Table 4: Some Physical Properties with Mean Values of Various Growth Media Treatment

Media Treatment	Bulk Density, (g/ cm^3)	Particle Density, (g/ cm^3)	Moisture Content, (%)	Water Holding Capacity, %
T1	0.132	0.465	55.16	68.87
T2	0.164	0.817	37.87	32.33
T3	1.078	0.639	23.51	54.88
T4	0.194	0.587	48.66	59.75
T5	0.200	0.554	53.08	64.79

3.3 Characterization of physiochemical properties

The need for cocopeat and peanut shell replacement substrates in nurseries developed because those organic resources are in short supply, agricultural waste generation is under increasing pressure, and employing locally generated waste products was economically necessary. The organic wastes utilised as a growth medium must possess a few qualities that promote ideal development circumstances. Apart from pH and EC, other physical characteristics examined in this study were bulk density, particle density, moisture content, and water holding capacity. Thus, those findings of the analysis are shown in Table 4.

3.3.1 Bulk and particle density

The bulk density of the treatment T1 was 0.132 g/ cm^3 Table 4 which is less than 1 g/ cm^3 and all other treatments thus can be categorized as light media and it causes the particle density lower also due to high level of cocopeat available in T1 in Figure 7. According to researcher Jawaharlal, the ideal bulk density of the growth media is 0.19-0.70g/ cm^3 except for the soil treatment the bulk density was 1.078g/ cm^3 which is higher compared to the other treatments [11]. The bulk density of the soil can be affected by its moisture content. Water fills the pore spaces between soil particles when it is wet, lowering the bulk density. It's crucial to remember that hale a greater bulk density might suggest compacted or thick soil, a bulk density that is too high can be harmful to plant growth. However, the other treatments all were within the ideal range.

It is a crucial characteristic to take into consideration while contrasting various plant culture growth media. The particle densities of soil, cocopeat, peanut shell and compost of both as growth media have been compared in the Table 4. From the data above, the highest particle density was obtained in 100% of peanut shell 0.817g/ cm^3, which seems that the appearance of high particle density, which reduced the bulk density Figure 7 compared to the others, was caused by the cellulose tissue of peanut shells and the size of the medium particles. Next, according to researcher Flint, depending on the composition, soil particle density can vary, but typically it ranges between 2.5 to 2.7g/ cm^3 [12]. But unfortunately, in this research the particle density of soil was seems to have low value with 0.639 g/ cm^3. This is due to the fact that elements including mineral content, moisture content, and compaction level can have an impact on density. Sandy soils have a lower particle density than soils with finer textures because of the density of particles.

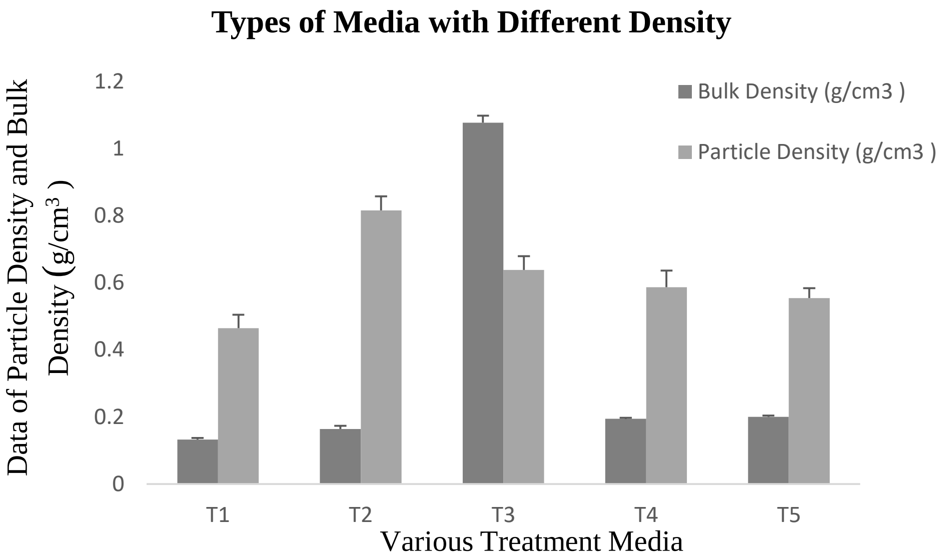

Figure 7: Comparison of Treatments with Particle Density, (g/ cm^3) and Bulk Density, (g/ cm^3) after Drying Media at 105°C for 24h

Furthermore, this cocopeat also has low particle density with 0.465g/ cm^3 compared to all medium. This low density generates a light-weight environment for plant development while allowing for optimal aeration and water retention. Lastly, the compost treatment shows the best result in particle density as T4 was 0.587g/ cm^3 and T5, 0.554g/ cm^3 which was within the range from 0.4 to 0.6g/ cm^3 as mentioned earlier by researcher Topcuoglu [13]. Therefore, it's crucial to maintain that particle density is simply one aspect to take into consideration when selecting a growth media.

3.3.2 Moisture content

The moisture content was determined in raw medium in consecutive time as a function of absorbed water. The percentage of moisture content was increasing in all particles. Highest percentage of moisture content was observed and tabulated in Table 4 where the treatment T1 (55.16%), followed by T5 (53.08%) and T4 (48.66%). The lowest moisture content was observed in T3 (23.51%) and followed by T2 (37.87%) which is still within the range. Because of this, it is likely that soil was had a reduced moisture content when compared to cocopeat and peanut shell medium. In comparison to both soil and cocopeat in Figure 8, cocopeat better retains water, whereas peanut shell medium has less effective water absorption. The primary constituents of peanut shells are cellulose and lignin, neither of which are as good at storing moisture as soil or cocopeat. As a result, compared to both soil and cocopeat, peanut shell medium usually has a lesser capacity to store moisture. The choice of a growth medium should take into account the particular requirements of the plants being grown because various plants have varied moisture requirements. Thus, it showed that cocopeat and high level of cocopeat in mixed ratio gives the best result in moisture content characteristics.

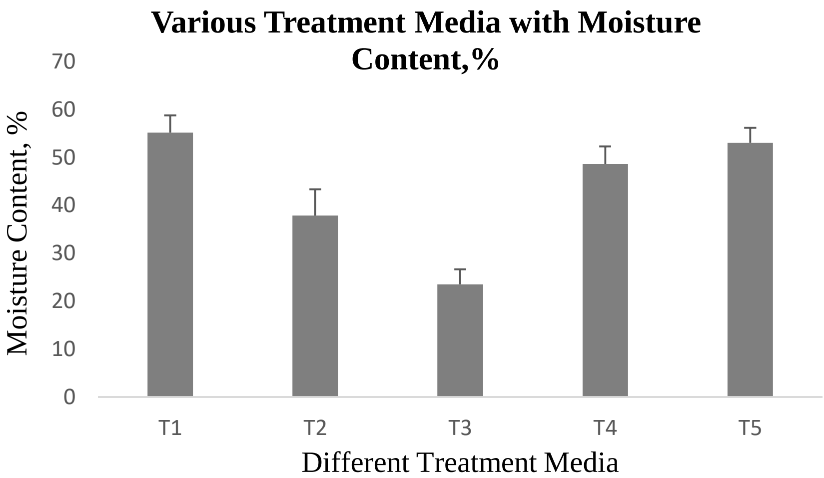

Figure 8: Comparison of Moisture Content of Different Treatment Media after Drying Oven for 24h at 105°C

3.3.3 Water holding capacity

The above Table 4 displays the ability of different medium to store water capacity. In this research, the T1, 100% cocopeat medium had a maximum water retention capacity of 68.87% of dry weight. This is due to the high moisture retention capacity of coco peat, which aids in water conserving. This causes greater root fresh weight, heights, and shoot fresh weights of ornamental plants were the results of a higher water holding capacity. Furthermore, T5, a compost made of cocopeat and peanut shell, had the second-highest percentage of water retention capacity, at 64.79%. This is due to the medium has a ratio of 60% of cocopeat with 40% of peanut shell, this T5 was to be highlighted as the highest. As a result, adding more cocopeat to a growth medium mix will enhance its ability to store water.

Additionally, the study clearly demonstrates that T2, which is 100% peanut shell, has the lowest water holding capacity which was 32.33%. This is because peanut shell compost may be used as a replacement for peat in the growing media because of its advantageous qualities and high porosity when combined with low-porosity substrates. Therefore, increasing the peanut compost content by 60 or 100% is not advised. Next, the water holding capacity for soil cultivation T3, was then still in the range of 54.88%, which was greater than 100% peanut shell but lower than cocopeat and compost of other media.

However, after mixing cocopeat and peanut shells in an equally ratios, the compost in T4 only has a 59.75% water-holding capacity, which is a little lower than the range mentioned researcher Both [14]. This results in the composting of peanut shell since it has a lower capacity to absorb water than soil and cocopeat. As a result, this study on the water-holding ability of agricultural waste such cocopeat and peanut shells with compost as an alternative to soil has shown to be an excellent culture medium for ornament planting. Figure 9 shows the differentiation of WHC in percentage and its error by finding its standard deviation.

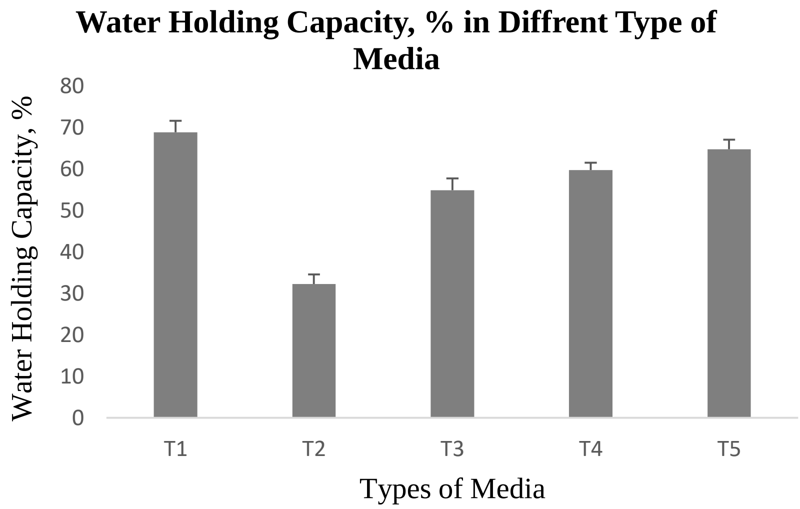

Figure 9: Comparison of Water Holding Capacity, % under Various Treatment Conditions from T1 to T5

4. Conclusion

In a nutshell, the concept of this study used of peat medium made from coconut husk and peanut shell to compare the development rate of chilli plantations with soil cultivation has been successfully developed. In the present study, all the media shown more or less good physical characteristics required for plant growth. Hence, organic amendments were found to provide good structural support to the soilless cocopeat and compost media. The rate of growth was measured at the end of this experiment was showed that the chilli plant was able to grow well in organic agriculture waste by producing chilli at the end of harvesting compared to the soil. Therefore, I strongly recommend using loam soil for better plant growth since loam is considered to be the best form of soil for plant growth because it has an equal proportion of sand, silt, and clay particles. While it still allowing for sufficient drainage, loamy soil effectively traps water. Thus, the accomplishment of the research objective study was achieved with the compost of cocopeat and peanut shells. Therefore, the re-use of cocopeat and peanut shells as a growing medium can not only reduce soil consumption and though minimize the accumulation of these wastes in the environment but it can also have economic benefits because they are more inexpensive than other common growth media.

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