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Performance Evaluation of An Automated Small-Scale Cocopeat Compaction Machine

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ABSTRACT:
Cocopeat blocks are a good soil substitute in horticultural farms. Since cocopeat is loose and bulky, cocopeat blocks offer cheap transportation costs comparing to transporting loose cocopeat. These blocks increase the amount of cocopeat transport and reduce loading, unloading and storage costs. The performance evaluation was done using a developed automated cocopeat block-making machine for small scale farmers which was developed to compact the loose cocopeat into uniform blocks.The purpose of the study was to determine optimum operating parameters of the developed automated cocopeat compacting machine. The results obtained showed that, a cocopeat block of 300 mm by 150 mm by 150 mm was obtained with a density of 400 kg/m^3 at a compacting pressure of 200 bar and a moisture content of 15%. The machine blocking capacity was found to be 48 blocks per hour. The compacting machine is important in compaction of cocopeat since more cocopeat is transported. Optimum values of moisture content and compacting pressure yield good density blocks that are suitable for transportation. It is recommended that cocopeat be transported in compacted form.

Key words: Cocopeat, Performance, Moisture, Density, Compaction.

I. INTRODUCTION

Huge heaps of coconut shells are produced during harvesting of coconuts in many developing countries. Coconut is a useful perennial plant. A coconut fruit is made up of an outer exocarp, a thick fibrous fruit coat known as the husk, underneath is the hard protective endocarp or shell. The various parts of a coconut fruit are shown in plate1.

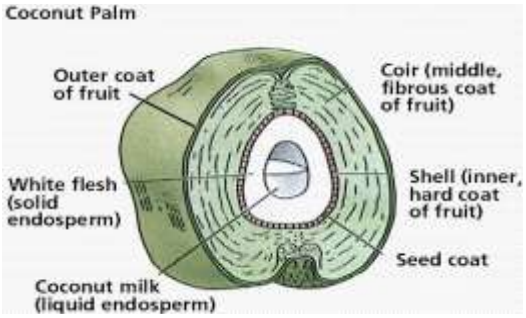

Plate **Error! No text of specified style in document.**-1 : Structure of a coconut fruit**[1]**

The size of the fruit varies from 147 to 196mm in diameter and 245 to 294mm in length. The nut is spherical. Inside the nut is a thin, white flesh layer of about 12mm thick which is refered to as the 'coconut meat'. The interior of the nut is hollow and is filled partially with a watery liquid refered to as the 'coconut milk'. Coconut meat is soft and jelly like when immature and becomes firm at maturity. Coconut milk is abundant in the unripe fruit but it is gradually absorped as the fruit ripening occurs . It's oil is used in making margarine and cooking oils.The coconut meat can be eaten fresh or used to make ice cream or even shredded to make livestock feed. Coconut shells are normally used as a fuel, mainly for cooking. Coconut husks yield fibers that are used in the manufacture of coir products such as coir carpets, coir boards, and coir composites and cocopeat. [2]. The coconut endosperm is used for human consumption whereas the by-products are used as raw materials for manufacture of several value added products including products used in the agricultural sector like cocopeat. [3].

Coconut husks and coconut shells are wastes that are obtained in the production of copra. They are further processed to coconut fibre and cocopeat.

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Figure 1.2 shows a general process of obtaining cocopeat.

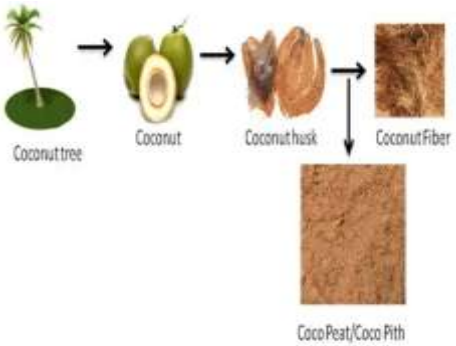

Plate **Error! No text of specified style in document.**-2: Flow chart of cocopeat extraction **[4]**

Plate 1-3 to plate 1-5 Shows the difference between the cocopeat, coir fibre and cocopeat blocks

Plate **Error! No text of specified style in document.**-3 : Cocopeat from coconut husks **[5]**

Plate **Error! No text of specified style in document.**-4: Coir fiber from coconut husks **[5]**

Plate **Error! No text of specified style in document.**-5: Cocopeat blocks from cocopeat dust**[6]**

Characteristics of cocopeat

Cocopeat extracted from dried coconut husks undergoes various processes to make it available for use in agriculture; it is an excellent growing medium for high value crops and in propagation of seedlings. It is considered an excellent growing medium component with acceptable electrical conductivity, pH value and other required chemical attributes necessary in floriculture industry, its high water holding capacity leads to low aeration within the medium, which affects the oxygen diffusion to the roots. This condition is improved by addition of coarser materials like sand into the cocopeat. The incorporation of these materials improves the physical and chemical properties of the cocopeat[8]. There has been a great deal of interest in cocopeat, arising from its potential and in accessibility of other organic manures such as the compost and green manure. Cocopeat is often used for manure and landfill purposes. Accumulation of cocopeat causes pollution problems for aquatic as well as terrestrial environments. It also becomes breeding grounds for snakes and mosquitoes. Inappropriate disposal of cocopeat in rainy seasons makes the chemicals in the cocopeat such as the polyphenols and organic matter leach out leading to environmental problems. Dumping of cocopeat in water bodies increases the concentration of hydrogen sulphite, carbon dioxide and methane, which are toxic gases [9].

Cocopeat utilization in Kenya

Cocopeat is used as a soil amendment, potting and planting medium and as soil culture medium in horticulture[10]. Soil amendments are the materials that if added to the soil, they modify the soil properties in a positive way to make it healthy for agricultural use. Since the cocopeat has a high moisture retention capacity, it is in very high

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demand for agricultural use especially in dry areas. The application of cocopeat as a soil amendment in long-term basis reduces the bulk density, improves the water holding capacity and improves the organic carbon content of the soil. In addition, cocopeat as a potting and planting medium offers a good source of nutrients and water, therefore giving support to the growing plants and replacing commercial substitutes in set ups for profits. In addition, it provides good consistency, low bulk density and very few risks in transportation. The soilless culture medium is very effective in enhancing water use and efficiency thereby improving the management of nutrients in crop cultivation for maximization of profits.

Further, cocopeat has a very good applicability in cultivation of crops, plant propagation and as plant culture. These humic substances have hormone like activity that simulate root and plant growth. Cocopeat advantages are its bio-degradability, it is environmentally safe, entirely organic, it has no harm to the environment when disposed, better aeration to the plants. It has uniform texture and consistency, it is reusable and recycled up to 4 times, it is good for both outdoor and indoor use, it retains and releases nutrients for a long period, it enhances organic content of soil if mixed with the soil, it is free from weed seed and it has a high water holding capacity. The cocopeat compaction process takes into consideration the condition of the cocopeat for it to produce the desired cocopeat blocks. These conditions include moisture content where high moisture content pose problems in grinding, compaction pressure force required in the compaction process and the density of the produced blocks. The density of the blocks is related to the volume reduction in block making process, moisture content and compaction force.

The purpose of this research is to carry out a performance evaluation of an automated cocopeat compacting machine used by small scale farmers. This will help to enhance productivity, transportation and performance improvements for the coconut value chain in the country thereby improving the livelihood coconut farmers in coconut growing areas.

The developed cocopeat block making machine was evaluated for performance to enhance the production of cocopeat blocks for agricultural use. The schematic diagram for the developed machine is as in figure 4. In order to do this, there was need to incorporate automation features in the design to obtain a machine with optimum productivity for small-scale farmers.

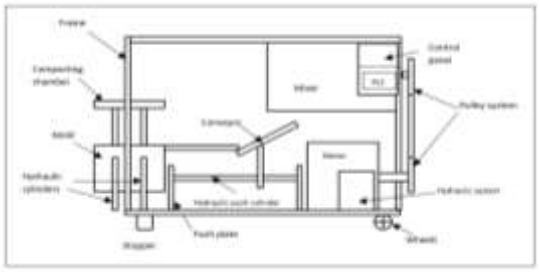

Figure 5: Designed cocopeat compacting Machine

Project objectives

The objective of this study was to carry out performance evaluation of a cocopeat block making machine

Research Materials, tools and equipment.

The raw materials was cocopeat from coco grow Ltd. The cocopeat was cleaned of impurities by floating technique, then mixed with water and compacted to produce cocopeat blocks using the developed compaction machine. The cocopeat blocks produced dilate if left in the open as a result of absorbing moisture from the air, therefore, the blocks were sealed in polythene bags to shield them from the environment and stored in readiness for transportation.

Main tools and equipment were universal drilling machine, lathe machine, welding machine, vertical band saw machine, surface grinding machine. Other pieces of equipment are ball pen hammer, cocopeat floating container, stirring rod, digital electronic balance, pressure gauge, vernier calliper, hand gloves and googles.

Coconut value chain

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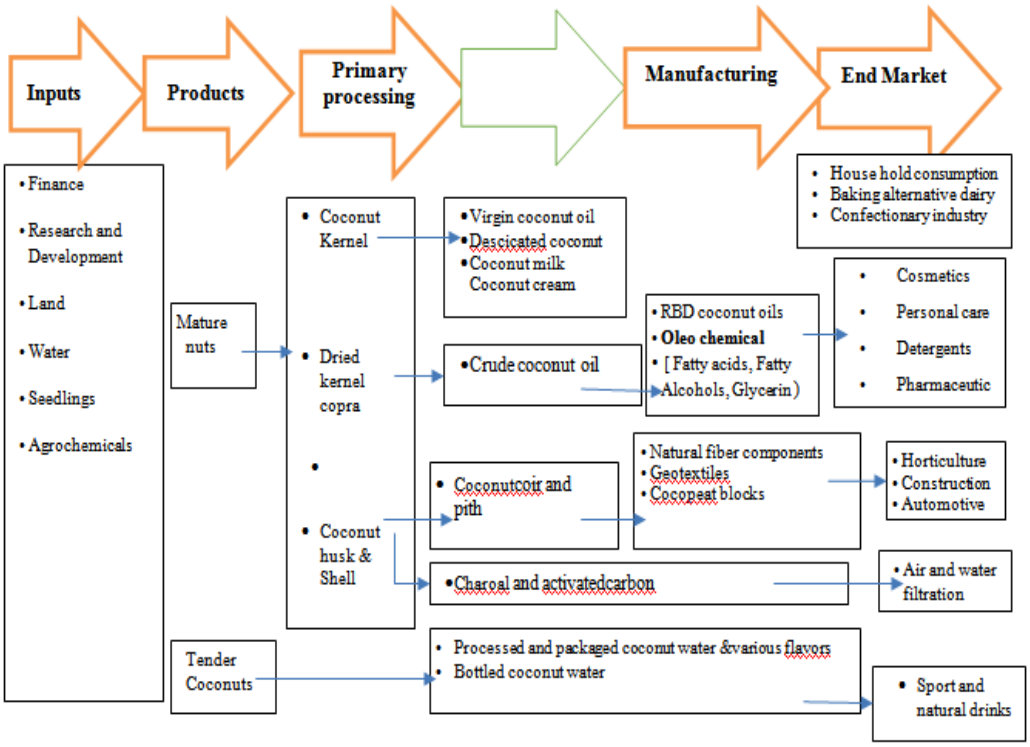

Figure 2 -1: Coconut value chain [17].

Machine Performance Evaluation

Cocopeat blocks production process

The cocopeat production process was a systematic sequence and if one-step were left out then the results obtained would be blocks of poor quality. After cocopeat preparation, it was compacted in the machine developed to get cocopeat blocks.The blocks produced were stored in polythene-bags to shield them from the effects of the environment in readiness for transportation. These blocks were then evaluated to determine the ability to be transported to agricultural areas.

Optimal moisture content

Optimal moisture content is the water content at which the cocopeat can be compacted to maximum dry unit mass by a given compacting effort. The electronic weigh scale was used to in determining moisture content. This was done by subtracting the dry weight from the initial weight and the moisture content percentage calculated by the formulae. Moisture content (MC) % = $\frac{Wi - Wf}{Wi} x\ 100$

W_i = initial mass of the cocopeat.

W_f = final mass of the cocopeat.

Optimal compaction force

Compaction force is critical in any compaction operation, therefore the determination of the optimal compaction force is essential in getting the best results. In this study, a pressure gauge was used to measure the pressure during compaction.

II. RESULTS AND DISCUSSION

The blocks obtained had straight edges and did not deform on moving from one point to another. Therefore, the blocks had a density that was required. The optimal compaction pressure was 90 bar at a density of 0.9 kg/m3 and 23% moisture content as plate 4-4. The graph below show the relationship between the compacting pressure block density and the moisture content. As the compacting pressure increased the density of the blocks increased likewise when the moisture content increased.

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Graph 1: Compacting pressure, Moisture content and Density

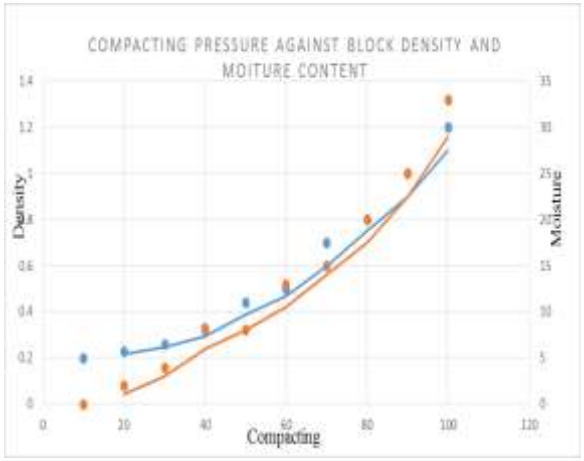

Plate **Error! No text of specified style in document.**-6: The blocks obtained using the developed compacting machine

Plate **Error! No text of specified style in document.**-7: Cocopeat blocks

Machine blocking capacity

The machine blocking capacity is a measure of the machine production rates. The blocking capacity for the machine was 48 blocks per hour.

III. CONCLUSION

In performance evaluation of the cocopeat machine, the optimum moisture was23%at 90bar. Cocopeat blocks of 300 mm by 150 mm by 150 mm and density 0.9 kg/m^3 were obtained with straight edges. The straight edges were a clear indication that stacking during transportation would be easy and minimum space will be required during transportation. The machine blocking capacity was found to be 48 blocks per hour

Recommendations

It was recommended that sensors for humidity levels and compacting force to be used to measure the moisture content for accurate measurements in machineperformance.

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