PRELIMINARY STUDY OF COFFEE HARVESTING TOOL FOR LIBERICA VARIETY COFFEE

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ABSTRACT

Coffea Liberica, which is primarily grown in Southeast Asia. It is currently the most significant Coffea species cultivated in Malaysia and the Philippines. The major problem in harvesting Liberica coffee is that the mature growth isn't even and the higher strength of coffee cherry stem on tree branches. The coffee cherry can't be picked by shaking the tree because they don't fall off easily. Twisting and stripping coffee cherry is a harvesting technique which encourages the development of new coffee bud seeds. In this study, a tool for harvesting coffee cherry is used to pick coffee cherry from the tree branch by using rotating and stripping technique. This is a tool that already exists on the market and has been modified to suit the Liberica variety of coffee. It has two arms that rotate in opposite directions and are covered with Thermoplastic Polyurethane (TPU) material with the shape of a drill to protect the branch of the coffee tree from injured. The concept and designs of the covered TPU drill shape were made using computer-aided design software in the third dimension (3D), which simulated the functions. The covered was then made using a 3D printer machine. Actual experiment were conducted by establishing the mechanism of the concept and observing its actual function. It has been determined the physical parameters of Liberica cherry, the strength of coffee cherry stem on tree branches, and the comparative performance of conventional harvesting and harvesting with tools. The results indicate that the strength of mature Liberica coffee cherry stem on tree branches is stronger than that of unripe stem; therefore, the concept of shaking cannot be utilized in the design of harvesting machinery. Results also show that using tool to harvest coffee cherry is more productive than harvesting by hand. Extensive research, development, and improvement are required.

Keywords: Liberica, Coffee cherry, Mechanical harvesting tool, Manual harvesting, Performance Evaluation

INTRODUCTION

Coffee is a plant of the family Rubiaceae and genus Coffea, whose seeds are called coffee beans and processed into drinks (Noor Auni and Khairol, 1988; Muhammad Ghawas and Rubiah, 1991). It is a group of plants that can survive for over 25 years and reach heights between 5 and 15 meters. It is believed to have originated in Ethiopia before spreading to Egypt, Yemen, Italy, the entire continent of Europe, and the United States. As of today, coffee has acquired a foothold throughout the globe, including Malaysia, which cultivated coffee as a cash crop. Three of the 66 species in this genus are commercially cultivated and extensively traded on international markets. These species are Coffea Arabica (70%), Coffea Canephora or known as Robusta (28%), and Coffea Liberica (2%). There are two varieties of coffee that are commercially grown in Malaysia: The Liberica (90%) and Robusta (10%). Coffea Arabica is recognized as the most traditional coffee with the highest quality in terms of flavor and aroma, whereas Robusta coffee has a higher caffeine content, which has led to its use as a less expensive substitute for Arabica. Robusta coffee is typically more astringent and acidic than Arabica coffee. It is often used as an ingredient in some espresso blends to add more flavors at a lower cost. Among these three varieties, Robusta coffee is the cheapest with a price range of RM6 to RM10 per kilogram (kg), followed by Liberica, RM10 to RM16 per kg and Arabica, RM20 to RM25 per kg.

In Malaysia, the Liberica variety has two peaks' seasons per year, during which the coffee's maturity index reaches 90%. The main issue with harvesting Liberica cherry is that mature growth is not uniform, except during peak season, and the coffee cherry cannot be harvested using the shaking concept because it is difficult to fall from the tree branches. The harvesting of coffee cherry is accomplished manually, by twisting only the mature coffee cherry by hand. While the unripe cherry is left of the tree, to be reassessed a few weeks later. This process is repeated until every viable coffee cherry is harvested. It is an exceedingly labor-intensive method in which pickers set out and fill waist-hung baskets. Then these baskets are emptied into larger collection bags where at the end of the day, the harvest is spread out and any foreign debris and overripe cherry is removed. Strip harvesting is another way of harvesting that can be used. The term "strip harvesting" refers to the practice of removing all of the coffee cherry from the trees in a single mechanical motion. This results in harvests with different levels of maturity but is far less labor intensive and costly than conventional methods. The workers will place canvas on the ground, grasp the branch of the tree, and draw outward, knocking the coffee cherry onto the canvas. The coffee is then placed in sacks and transported to a scale, where the workers are compensated based on weight or volume. Since hand picking requires a lot of work, farms need a lot of people who are willing to work for minimal pay.

As a result, mechanization is expected to increase coffee bean harvesting production. To address this issue, Malaysian Agriculture Research and Development Institute (MARDI) developed a prototype of a comprehensive hand tool mechanized coffee harvesting kit. The concepts of rotation and striping were utilized. This tool is an existing tool on the market, which has been modified to accommodate the Liberica coffee variety. The concept designs were developed using 3D computer-aided design software, which simulated the functions. A preliminary experiment was conducted based on the performance evaluation. The purpose of this study is to evaluate the enhanced coffee cherry harvesting tool and its applicability to Liberica variety, as well as to compare mechanical harvesting to conventional methods. Based on these two activities, enhancements were proposed.

MATERIALS AND METHOD

I. Physical Parameters of Liberica cherry

Physical parameter data Coffee beans were collected from MARDI Kluang, Johor. There were two grades has been determined that is Large (A), and Medium (B) with 80 samples each. Physical parameters of all the coffee cherry, such as weight (grams) and diameter (cm), were measured (Figure 1). There were considerable

variances between grades and the major factors influenced the design of the clearing between branch and hand tool been measure. Data analysis using independent sample T-test.

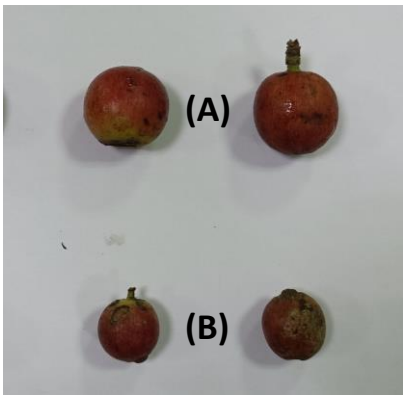

Figure 1. Physical parameters of the coffee cherry grade

II. Strength of coffee stem

Coffee bean stem on tree branches have different strengths depending on the variety. For Arabica, it was also found that a force of 1.2 N was required to detach unripe cherry and 0.9 N for ripe and heavier cherry. The method of shake can be used for arabica. The force required to shake one coffee tree is 12.8 N (D. O. Mbuge and P. K. Langat 2008). Liberica is in a different scenario since its stem are so firm on the tree branches that shaking harvesting is not an option. Using a force gauge and weight scales, a study has been done at MARDI Kluang to determine the force load for three types of index coffee beans that are ripe, unripe and overripe at the branch. (Figure 2). This study seeks to identify the maximum force required to harvest each bean of the Liberica variety. Data samples of 100 coffee cherry each type been measures.



Figure 2. Measuring force load and strength using force gauge and weight scales

III. Coffee harvesting tool

Coffee cherry harvesting tool (Figure 3) is used for picking the coffee cherry from the coffee tree. It also can pick olive, Chinese chestnut and soybean. Using an electronic card controls frequency stabilization, short-circuit protection and overload restriction. It is attached with 3m-long cable and 12V battery 100ah (rechargeable) with autonomy of about approximately 100 hours working time. This machine uses the concept of rotation and stripping to harvest coffee cherry. It has two counter-rotating limbs that come into contact with the tree's branches when a special button is pressed and a powerful electric motor that enables the machine to operate with a low power consumption of 1.0 amperage. This tool light weight and simple handling make it possible to collect directly from the tree, even in extremely challenging circumstances. The two counter rotating arms were covered with Thermoplastic Polyurethane (TPU) material shape of a drill to prevent the branches of the coffee tree from being injured. The concept designs of were developed using 3D computer-aided design software (Figure 4), which simulated the functions dan were develop using 3D printer machine (Figure 5). Actual experiments were undertaken by establishing the idea mechanism and seeing the actual function. This method of harvesting coffee is accomplished by stripping all the cherry from the branches at the same time. Strip picking is often used on dry processed coffees (beans are dried while surrounded by the pulp); it's really important to evaluate the right time to perform the stripping and determine the stage of the cherry maturation (Figure 6). Canvas size 3meter x 5meter were placed on the ground to easily collect the coffee cherry. Performance evaluation for this tool has been conducted at MARDI Serdang, Selangor and MARDI Kluang, Johor. The harvest data was compared between using a harvesting tool and the conventional method. Ten tree per-each method and been given 15 minute to harvest during that time. The data has been weighted and analyzed.



Figure 3. Coffee cherry harvesting tool with 12V battery 100ah

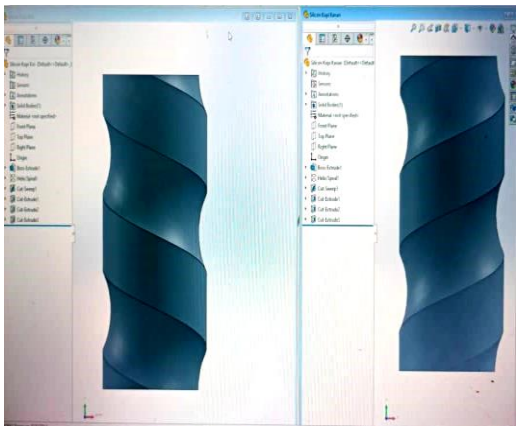

Figure 4. Covered for rotation arm using Thermoplastic Polyurethane (TPU) material shape of a drill

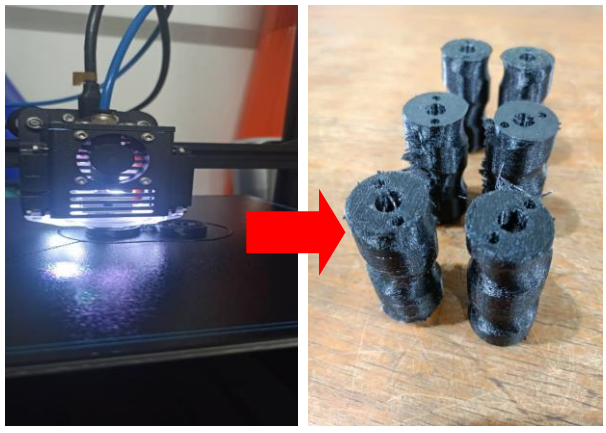

Figure 5. Development of arm rotating covered using 3D-printing machine

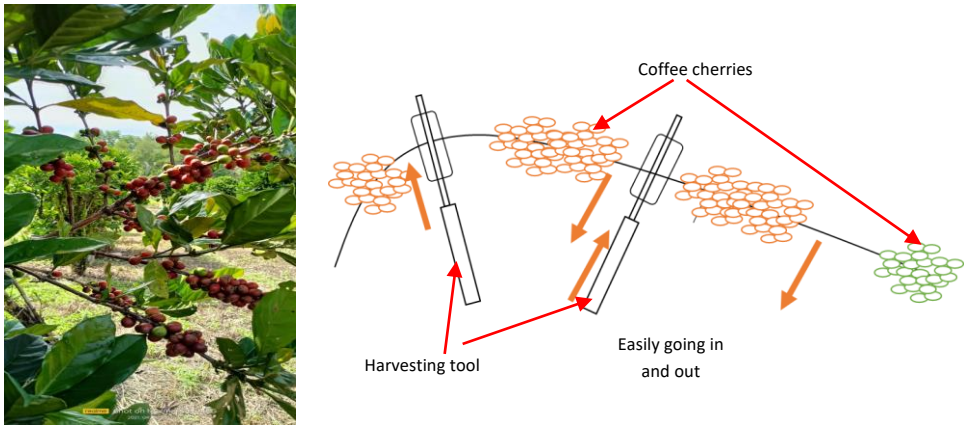

Figure 6. Schematic diagram the principal of harvesting coffee using mechanical tool

RESULT AND DISCUSSION

I. Coffee cherry physical parameters

In this experiment, physical parameters of two grades from the coffee cherry were measured and tabulated (Table 1). Statistical analysis showed that there were significant differences in diameter between each size ($p<0.01$) for the circumference of coffee cherry. This measurement is necessary to provide a clearance diameter for cherry on the branch so that the rotating arms can easily access between the tree branches. With this result, the machine on switch can be set to the appropriate clearance diameter.

Table 1. Physical parameters of all the coffee cherries

Sizes	Weight (g)	p-value Diameter
A	5.9±0.70	0.01
B	4.0±0.93	
	Diameter (cm)	**p-value Diameter**
A	21.1±1.0	0.02
B	17.7±1.6	

II. Coffee cherry stem

The ultimate hypothesis is that the stem strength of ripe cherry is lower than that of unripe cherry. Where the Arabica variety has a low stalk strength allowing the concept of shaking to be adapted. From this study, it was found that the Liberica variety has a difference in terms of coffee cherry stem strength. According to the results of an experiment, ripe coffee cherry (red) required higher force that are 17.60N than unripe coffee cherry (green) is 14.70N, while overripe coffee cherry has a very low force stem at 2.25N (Table 2 & Figure 7) .

Table 2. Coffee cherries stem

Index	Cherry stalk strength (N)	Weight (g)	Diameter (mm)
Ripe (Red)	17.600	6.400	19.100
Unripe (Green)	14.700	3.500	13.600
Overripe (Black)	2.250	0.470	9.300

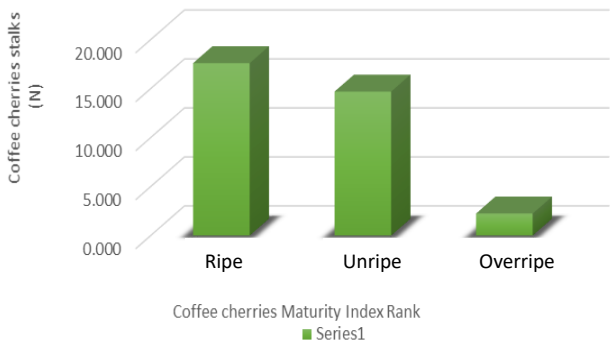

Figure 7. Index coffee cherry stem strength

III. The performance evaluation coffee harvesting tool

From the results obtained (Table 3), Using T-test it shows there is a significant difference with p-value >0.00 between harvesting manually (Figure 8) and tools (Figure 9). Using tools has been shown to be more effective and result in a higher harvest yield compared to manual harvesting, which produces 2.03 kg, while using harvest tool is 4.50 kg for 15 minutes. According to the chart below (Figure 10), the maximum amount harvested using mechanical harvesting tool is 5.53kg and the lowest amount harvested is 3.88kg. The results for a manual evaluation show a maximum is 2.71kg and a minimum of 1.24kg. There is a substantial difference between the two treatments. Covered TUP is also seen to be very useful because the tool does less damage to the tree when it goes through them compared to if it doesn't have a cover, due to the character of TUP being like rubber that is soft and chewy.



Figure 8. Conventional method (manually harvest)



Figure 9. Coffee mechanical harvesting tool

Table 3. Performance evaluation : Compare between using a mechanical harvesting tool and the conventional method (Manual) Performance evaluation

Treatment	Weight (Kg/average)	P-value	Max amount (Kg)	Minimum amount (Kg)	Number of samples	Time taken for each sample
Manual	2.03±0.4	0.00	2.71	1.24	12	15 Minute
Harvesting	4.50±0.5		5.53	3.88	12	15 Minute

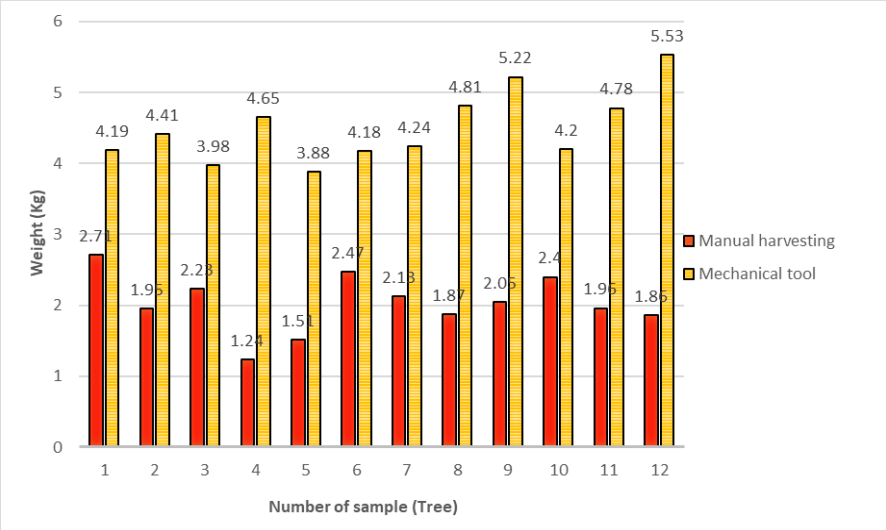

Figure 10 . Performance evaluation of manual and mechanical tool for 15 minutes per sample for both treatments

CONCLUSION

Liberica variety coffee can be harvested with a strong pull or push force of up to 17N on the mature coffee cherry stem, whereas Arabica variety coffee can be harvested with only 12N of shaking on the tree's trunk, which logically only requires less than 10N of shaking on a coffee tree branch. In conclusion, the mechanical harvesting tool is seen to have great potential to be used in coffee harvesting operations. Where it can strip-harvest in a single direction. The uniformity of the coffee cherry maturity index is also essential for harvesting only mature and high-quality coffee cherry. Agronomics continues to attempt to overcome these issues for the future. For the mechanization approach, improvements and additional research are required. Using the coffee harvesting tool will require regulations and standards to meet safety, performance, and quality standards. Policies must be implemented to ensure that the coffee harvesting tool are tested, certified, and approved for use in agriculture. Besides that, it may require farmers to invest in new method and technology. Policies must be implemented to ensure that small and medium-sized farmers have access to this technology and are not left behind. This policy should benefit the coffee harvesting tool while minimizing any potential negative impacts

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