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Development of an Adjustable Cacao Pod-Sleeving Device

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ABSTRACT

The most common problem in farming is the infestation of their crops, making the production yield lower. Instead of using chemicals to prevent infestation, some farmers, particularly in the cacao industry, use another way to protect the cacao pods. One way of safeguarding the cacao pods is to sleeve using biodegradable plastic. Based on studies, pests cannot affect about 85%-95% of the sleeved cacao pods; however, among the unsleeved ones, 96% were damaged. The importance of having the cacao pod sleeved plays a vital role in the overall production rate. Cacao pods are distanced from one another, with some found on the treetop. The significance of having a device to assist in the process brought this study to reality. The study focused on designing and fabricating an adjustable cacao pod-sleeving device capable of extending the length to reach. The final output can be retracted and extended through the controls managed by a microcontroller. The device significantly decreased the time spent by manually sleeving the pods, given the varying cacao plant height and cacao pod location.

Keywords: *cacao, pod-sleeving device, applied research*

INTRODUCTION

Cacao, popularly termed cocoa, is a tropical evergreen tree planted for its edible seeds. After four years, the mature cacao tree produces fruit in the shape of elongated pods; it may yield up to 70 such fruits annually. Farmers sometimes keep cacao trees at least 1.8 m tall and must maintain them at about four meters to manage and harvest easier (Joseph et al., 2017). Because of its high demand in the worldwide market, cacao is farmed in most parts of the world. To produce high-quality cacao seed, chemical treatment and one-by-one sleeving of the cacao pod to prevent pest infestation and illnesses are required (ISROI, WIBOWO, SAVITRI, ERIS, & PURWANTARA, 2018). Many countries, particularly Southeast Asia and West Africa, rely heavily on cacao as an export crop. Black pod, witches' broom, bark cancer, cocoa pod borer, frosty pod rot, Cocoa swelling shoot virus, Fusarium roseum, mealy pod rot, and other diseases and pests kill up to 80% of the world's cacao supply (Chaidamsari, 2005). Cacao Pod Borers (CPBs) seriously affect cacao production (Vanhove et al., 2020). CPBs are

one of the most common and severe challenges to the cocoa industry's harvest quality, as the pest increases the cost of production and reduces yields for cocoa growers (Saripah et al., 2006).

Pod sleeving is one of the farmers' most prevalent procedures to keep their crops from becoming infested. Pod sleeving is a mechanical procedure that entails wrapping a cocoa pod of suitable age or size to prevent the pests from laying eggs and causing a new infestation of these pests (Saripah et al., 2006). The method of manual bagging is said to be effective, but it is also time-consuming, labor-intensive, and dangerous. Smallholder cacao producers in Indonesia have created a physical method for reducing the cocoa pod borer. They wrap the pods in plastic bags to keep the moth from laying eggs on the pods. The use of plastic sleeving can help prevent CPB infestations. However, there was a substantial difference in damage between fruits sleeved with plastic bags and those without sleeving in a commercial cacao plantation, where between 85% and 95% of the pods sleeved with degradable and non-degradable plastic were not affected by CPB, but 96% the unsleeved cacao were damaged by CPD (Sembel et al., 2011). The most effective control strategy is to bag cacao with plastic sleeves, which is the most helpful. Still, it is labor-intensive for farmers, and most say it is time-consuming and tough to do (Joseph et al., 2017). Moreover, there are tall cacao trees that the farmers need to climb to bag the cacao pod, and it may cause damage to the leaves and the branches. When cacao trees are tall, climbing them is considered very straining; and when it comes to manual bagging procedures, it is more laborious (Saripah et al., 2006). Each cacao pod takes most of the time and can slow down production.

This study improves previous research to make it more convenient, make the sleeving faster, and continuously save more time. In this project, the researchers could easily track the number of cacao pods that are already sleeved because of a counting mechanism. The previous research designed a magazine that needs to manually set the plastic bag and rubber band in every cacao pod to be sleeved. The length of the device is adjustable. The study's main objective is to design and build a cacao pod-sleeving device. Specifically, a mechanical design wraps the cacao pod with a counting mechanism. The goal is to provide a time-saving device to help farmers and cacao growers sleeve, especially in ordinarily out-of-reach cacao pods. They will be able to sleeve without the risk of damaging both the branches and cacao. This device will let the person or farmers bag their cacao pod effortlessly and faster. Every cycle has only ten plastic bags, which can display the number of cacao pods already bagged. The main body can be adjusted up to 0.5 meters, where the original height of the device is 1.5m, making the total length of the device 2m.

METHOD

Research Design

The study made use of the applied research approach. Before conducting the actual fabrication, a trade-off analysis between the two designs was made. The investigation was

made to establish the best design based on the study's objectives. Considerations made in the design include manufacturability, economic, social, and sustainability.

Materials and Resources

An Arduino Pro Mini with a microcontroller of Atmel Atmega328P-AU to control and process the program's instruction was used. A linear actuator is a primary mechanism for the body where the control and sleeve systems are placed. Push buttons and buttons utilize manual operation, while the NRF24L01 sends the signal to the Arduino whenever the sensor and the controls are pressed. MG 995 Servomotor is attached to the linear actuator, which serves as the motor for adjusting the length of the body. A Stepper motor and customized timing belt paired with a pulley (placed at the PVC's tip) allow the cellophane to hold and release. A plastic sheet (both ends are open and 6-inch x 12-inch in size) is used to wrap the cacao pod. A rubber band 1.5-inch in diameter is to hold the plastic sheet. An LCD displays the number of used and available sleeves.

Methods and Procedures

The device is agriculture-centered, avoids the usage of any harmful chemicals, and is approximately 2-3 kg. in weight for easy carrying. The sleeving process of the device considers the maturity of cacao pods (3-4 inches long) which is the starting age for sleeving. It uses a biodegradable plastic sheet and a reusable rubber band to enclose the top part (lightly tightened but not entirely closed to ensure that the cacao pods will not decay). The four buttons present in the device represent different functions. The rocker switch at the control system and the toggle switch at the sleeving system must be on to start the device. In controlling the length of the device, the toggle switch below the rocker switch is used to adjust the device's height depending on the cacao pod's height and location. Cacao pods are then fit-in in the PVC pipe's opening to ensure that it can be covered with a plastic sheet and enclosed by the rubber band when released. If the push button is pressed, the NRF24L01 sends the signal to the Arduino to run the stepper motor to release the plastic sheet, every press to the push button releases only one plastic sheet. With every release of plastic sheets, the LCD shows the number of remaining pieces of cellophane and the number of sleeved cacaos.

Cacao Pod Sleeving Device Functionality Test

The device's functionality is tested in 10 consecutive releases of cacao sleeves. For every release, the LCD displays the correct number of sleeves available and the number of sleeved cacao. The linear actuator is tested by going up and down to reach those cacaos that are in a higher or lower spot and to ensure the device has met the Pest Management and Protection criteria in PNS/BAFPS 104:2011, which provides guidelines for quality production of cacao. Before wrapping, the size and age of the cacao pods are to be distinguished. The starting age

is 3-4 inches long, which is the exact size to sleeve since most of the cacaos that CPB often infests past-long date. The ten released cacao pod sleeves are pulled lightly to ensure that the hold of the reusable rubber band and the cellophane can withstand any external factors that result in removed or loosened cellophane that may attract CPB (Cacao Pod Borer).

RESULTS AND DISCUSSION

Design of the Device

Shown in Figure 1 is the actual design of the pod-sleeving device. A linear actuator was used to extend the stick up to 0.5 m which makes the total length of the device 2 meters. When the push button on the linear actuator is pressed, it sends a signal to the upper half of the device, which causes the two-stepper motor to move upward. It is made of PVC in the upper section, and two belts are connected to the stepper motor where the cellophane and rubber band are placed.

Figure 1
Actual Device

Data Gathering

The researchers sleeved five cacao pods at an average height of 1.8 meters during the first cycle and another five cacao pods on a higher spot of around four meters from the ground. The first trial was on the manual process, while another set was done using the automated device. The said test was made to determine consumed time and accuracy.

Upon testing the automated device, the time that the device consumes every release is four seconds on an average height. While taking eight seconds on the higher cacao pods in the second cycle, it takes another four seconds on the first release by extending the stick to reach the cacao pods.

On the other hand, the cacao pods within the researchers' reach take seven seconds to sleeve, considering the errors of placing and tying the cellophane on the stem. Whereas the out-of-reach cacao pods are not likely to be sleeved easily because the researchers need to climb just enough to reach and sleeve the cacao pods. During the function testing, the device can sleeve, display the number of sleeved cacao pods, show the number of cellophane available, and adjust the length of the device up to 0.5 meters, as presented in Figures 2a and 2b.

Figure 2a
Wrapping of the Cacao Pod

Figure 2b
Controller Found in the Device

Analysis Between the Mean Manual and Automated Sleeving Time

The researchers used two methods in comparing the efficiency of wrapping the cacao pods: the manual method and the automated device. Trials 1 to 5 were assigned for the tree with a 1.8-meter average height, and trials 6 to 10 for the four-meter height. Based on the gathered data, the manual method struggles when cacao pods are in a higher spot and takes more time. Table 1 presents the time it took for the pods to be wrapped.

Table 1
Gathered Data on Time between Manual Sleeving and Automated Sleeving

Cacao Tree Height	Trial No.	Manual sleeving time	Automated Sleeving time
The Average Height of a Cacao Tree is 1.8 meters	1	7 seconds	4 seconds
	2	7 seconds	4 seconds
	3	7 seconds	4 seconds
	4	7 seconds	4 seconds
	5	7 seconds	4 seconds
Maximum Height of a Cacao Tree 4 meters	6	15 seconds	8 seconds
	7	13 seconds	4 seconds
	8	10 seconds	4 seconds
	9	17 seconds	4 seconds
	10	15 seconds	4 seconds

As per calculations, the t-tabular is 2.093; and the t-computed is 4.507. The mean of manual sleeving takes 10.5 seconds, whereas automated sleeving takes 4.4 seconds, meaning manual sleeving takes longer than the device. The two are incomparable since manual sleeving depends on the person's speed and cacao's height.

CONCLUSIONS AND FUTURE WORKS

The cacao pod-sleeving device was able to perform well for both trees with 1.8 and 4 meters average height. Also, the output was able to display the number of cacao pods that are already sleeved and the number of remaining sleeves. For the tall cacao trees, the extension boom extends to a height that can be able to sleeve the cacao. For future works, the researchers may modify the number of cacao pod sleeves attached to the device and add a harvesting blade that can be used to harvest ripe cacao in a higher spot.

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