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Development of integrated loose fruit collector machine for oil palm plantations

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Article Info

ABSTRACT

Oil palm loose fruit have always been part of oil palm harvesting operation. The current manual loose fruit collection by hand picking or raking is contributing to the minimum productivity and large amounts of debris. Effort in future shall be explored for the potential machine or system to collect the loose fruit in the field with the result of clean loose fruit. A new machine for loose fruit collection is being developed and examined which knows as integrated oil palm loose fruit collection machine for collecting loose fruit from the palm base. Consist of three main integrated stages; the suction stage is used to collect the loose fruit, followed by segregating stage, which used to segregate the loose fruit from debris through double layer rotating drum and unloading stage of loose fruit to the 3-4 metric tons bin by using hydraulic tipping cylinder. Result indicates that at least more than 50% productivity of loose fruit collection were increased. In addition, the clean loose fruit collection resulted with the debris less than 10%. Hence, with this development, better quality loose fruits are collected with minimum debris for further processing in the palm oil mill, which will contribute to better oil extraction rate.

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1. INTRODUCTION

Malaysia is a major global palm oil producer in the world with a planted area of 5.64 million hectares in 2015. The national average yields for the plam oil performance in 2015 are 18.48 tonnes per hectare fresh fruit bunch (FFB), 3.78 tonnes per hectares crude palm oil (CPO), 0.93 tonnes per hectare palm kernel and 20.46% oil extraction rate (OER). Meanwhile, for the Malaysia gross domestic product (GDP) performance, the oil palm industry contributed approximately RM60-RM70 billion in 2015 and this is expected to increase to RM178 billion by 2020 [1-3]. This performance greatly influenced by the oil palm industry practices.

The oil palm industry practices rely on the harvesting process whereby the loose fruit (LF) collection is main part of harvesting process. The LF collection contributed to the highest amount of oil provided it should not be contaminated by debris and proper managed collected [4-6]. Moreover, as stated by [7, 8], the LF contribute the highest of OER with 40% per weight ratio as compared to FFB with 20% to 25% of the OER per weight ratio. In other words, as far as the LF collection is concerned, the more the LF collected, not be contaminated and proper managed, the higher OER can be generated, which result the higher lost income can be save.

Currently, LF collection are collected manually in the oil palm industries. Throughout the collection process, the worker needs to bring rake, and bags. The workers need to go from palm to palm andsquat down to collect all the scattered LF on the ground by using the rake before put it into the bag. Once the LF bags full, it will be placed at the roadside before being loaded into a tractor. These processes are repeated at every harvested palm tree. The tractor will bring the bags to the sieve which is located at the estate ramp for the cleaning process before they send to the mill, in which consequently will be consumed the time. Studies have shown that [9-11] at least more than 25% and up to 70% of the harvester's times have to spend to collect the LFs. Also, it was estimated that the time taken to collect loose fruits was about 30% of the total fruit handling time and about 28% of the harvester's time is dedicated to collecting oil palm loose fruits. Its shows that the proportion of time taken to collect oil palm loose fruits in the cutter-carrier team harvesting system was about 43% for the raking method. In addition, the LF with the manual collection will be consisted with the amount of debris as they need to collect all the scattered LF on the ground by using the rake. As mentioned by [12, 13] the debris accumulated in a collected loose fruit can reach up to 60% of its total weight and this large amount of debris will affect the mill productivity due to debris will absorb the oil content of the fruit.

Hence, the development of the machinery system to collect and manage the LF may contributed to the appropriate way of LF collection [14-16]. There have been a few development of LF collecting machines whereby some of them gave promising productivity that may eventually be used in commercial oil palm plantations. Consists of two main categories of LF collector machine such mechanical loose fruit collector and roller-type oil palm loose fruit picker (RP), both of these categories present the different mechanism development [17-21]. The mechanical loose fruit collector consists of engine, vacuum and compartment whereby this machine is able to pick up all the LF by direct suction method through the vacuum and store the LF inside the compartment. The average output of this machine is up to 1500 kg/day LF collected. On the other hand, for the roller type oil palm loose fruit picker, this machine consists the plurality of wires, rods and an oval-shaped which is able to pick up all the LF on the ground by using roller method and LF will be stored inside the oval shape case.

The average output of this machine is less than 50% from the mechanical loose fruit collector. Both of these categories machines gave the promising productivity, however, there are still limitation to take into consideration which is contaminated the LF collected. Note that, the contaminated LF collected refer to the debris that contain inside LF collected whereby it shall be carefully separated from the LF before milling. Hence, the development of integrated oil palm loose fruit collector (ILFC) machinery is proposed to overcome the previous machine and manual LF collected whereby there are three mechanism of machine which is suction, segregating the debris and tipping the clean LF collected. Integrated of these mechanism may able to collect, decontaminated debris and manage the LF collected. It is an anticipated that this machine is able to collect the LF, segregate the debris and tipping the clean LF into the bin. For future, there are another mechanism that maybe attached to the ILFC machine as a value added [22-25] such as detection the colour of LF to be collected, monitoring the movement of the ILFC in the field with the intergration of Internet of Things (IoT) and palm oil loader system. This article is focused on the development of ILFC machine whereby the paper is organized as follows; research methods deal with more detailed on the development of ILFC machine and the flow of work in collecting the LF. Then, results and discussion section covered on the performance of ILFC and manual collection method and conclusion section conclude the findings.

2. RESEARCH METHOD

A comprehensive explanation regarding the research method being applied is presented. It consists of the flow of research work and the expanding of explanation on the each of research work flow; site visit on the plantation estate, design and development of ILFC and the data collection method. These research work flow is shown in Figure 1. One of the Sime Darby plantation estate was selected as a site visit for a trial-testing machine. It is due to the accessibility, nearest to the Sime Darby Research Centre and the factors of estate environment. Once selected, estate environments were identified which includes the terrain type, land structure and coverage hectares. This estate covers the inland terrain with 436.50 total hectare mature area at average from 141 palms to 178 palms per hectare.

Later, the ILFC machine was designed with the three main mechanism as shown in Figure 2. First mechanism involves with the suction process. The process utilizing the vacuum technique, whereby LF are sucked into air-tight compartment. The air tight compartment will open by itself once the engine throttle is put into idle. From here the LF with debris will flow into the double layer rotating drum by gravity for segregating process. Second mechanism deals with double layers rotating drum to segregate between debris and LF. The LF with debris will be segregated during rotation of double layer drum. Bigger size and longer

fiber debris such as stone, soil, frond butt and male flower will rotate inside the inner drum and withdrawal towards the end of inner drum into the debris discharge chute. While LF with small size and short fiber debris will drop into the outer layer drum. From there LF and the debris inside the outer layer drum will rotate forward inside the outer layer drum (guided by spiral conveyor). Cleaning process is done during the rotation, whereby small and short fiber debris will drop onto the ground and clean LF will drop into the LF bin (on the prime mover). Movement of loose fruit with debris from inlet to outlet point is guided by a spiral conveyor to increase the efficiency of the machine.
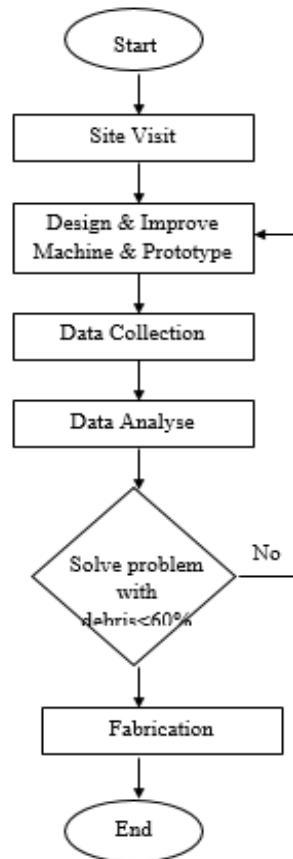

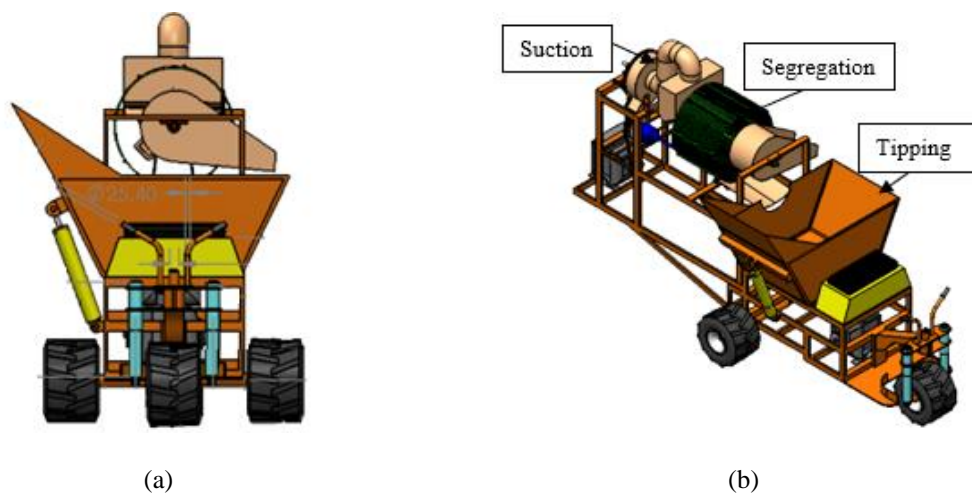Figure 1. Flow chart of work

| (a) | (b) |

Figure 2. ILFC configuration view, (a) front, (b) isometric

Last mechanism covers the three-wheeler attachment whereby the prime mover is equipped with hydraulic tipping bin. When the bin is full, the LF inside the bin is transferred into the 3 tons bin located strategically in the field. The process continue until the 3 tons bin is full. The full 3 tons bin will then hook and lift by tractor and transferred into a haulage tractor or lorry. In short, the machine makes use of direct suction method to collect the LF from the palm base and a double layer rotating drum technique to separate the LF from the debris. Both suction and double layer rotating drum components are attached to 3-Wheeler prime mover. Also, the machine also equipped with hydraulic tipping system to unload collected LF to the 3-4 tons bin. Detailed specifications of ILFC machine are tabulated in Table 1.

Table 1. ILFC machine specification

ILFC machine	Specifications
Length (m)	3
Height (m)	2.5
Width (m)	1.5
Rotating drum speed (rpm)	20-30
Fan speed range (rpm)	4500-5400
Prime mover engine (hp)	10
Suction fan and rotating drum engine (hp)	7

Then, the harvesting data collection was carried out by implementing the ILFC machine over a six month period at Sime Darby plantation estate. Noted that, the ILFC machine was operated by one-man operation machine, whereby the operator machine will drive the ILFC along the harvester path as presented in figure 3. He starts collected all the LF by hold the suction nozzle handle and point the suction nozzle end directly to LF on the ground and start the suction operation. The collected LF will be stored inside the tipping container with the clean LF and then will drive the machine to the 3 tons bin location, once LF is fully loaded and transfer it. The same process repeated for the trial field
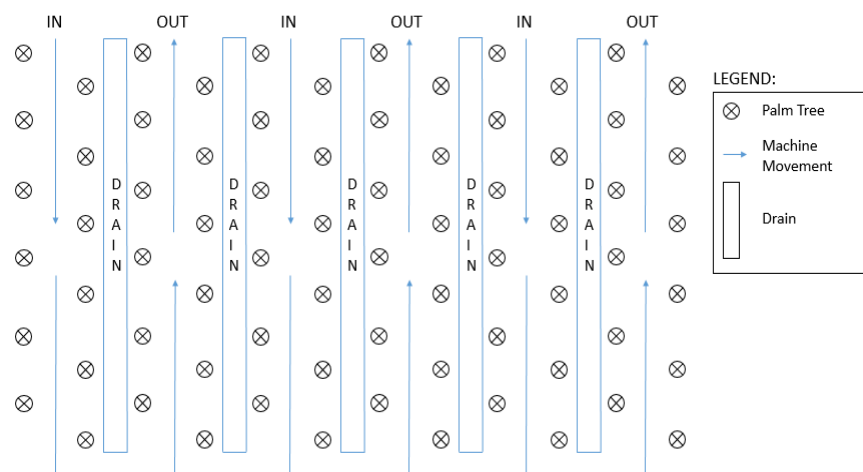

Figure 3. Movement of ILFC machine along harvester path

3. RESULTS AND DISCUSSION

In Table 2 shows the comparison results between manual and ILFC machine. Both collection methods are being implemented at Sime Darby plantation estate field trial by following movement trial in Figure 3. The productivity of LF collection for working hour of 8-9 hours per days for both collection methods were measured. Results indicated that at least more than 50% productivity of ILFC was collected compared to manual collection. Also, this result represents the ability of the machinery to operate for about 8 to 9 hours per day which fits with the harvesting system and compact machine whereby it able to operate with the different soil and topology characteristics in the estate. Hence, the overall of the results shows that the ILFC machine is able to suck the LF, segregate the debris and tipping the clean LF into the bin. Loose fruit collection method shown in Figure 4 (a) and Figure 4 (b).

Table 2. Comparison of ILFC and manual collection method

Description	Productivity (kg/day) *	Debris (% by weight)
ILFC	650-1000	5-10
Manual	150-450	20-30
Percentage Difference* (%)	Up to 70%	Up to 300%

*Productivity (kg/day)=clean loose fruit
*Percentage Difference=(ILFC data- Manual data / (ILFC data + Manual data/2) x 100%

(a)   (b)

Figure 4. Loose fruit collection method, (a) manual, (b) ILFC

Lastly, the economic analysis was carried out by assuming: One-man operation to operate the machine. Table 3 shows the economic analysis of ILFC machine whereby the initial cost for the machine is RM35, 000 with the 5-year life span in the field. Based on the estimation of ILFC output at 0.65 mt to 1 mt loose fruit per day, total cost per mt were calculated at RM 73.90 to RM 113 per day.

Table 3. The economic analysis of ILFC machine

Description	Value
Expected machine price	RM35,000.00
Economic life	5 years
Productivity	0.65-1 mt/day
Machine Depreciation	RM23.30/day
Fuel Cost	RM8.30/day
Labour cost	RM40.00/day
Repair and Maintenance cost	RM2.30/day
Total cost	RM73.90
Total cost per mt	RM73.90- RM113

4. CONCLUSION

The development of integrated loose fruit collector machine has been discussed. The concept of separation of loose fruit and debris by using the combination of vacuum, double layer rotating drum and tipping is recognized to be effective. The result shows that the machine have a decent performance to carry out the load and works well with the different surface areas. Also, more than 50% productivity were increase in which provide with the clean loose fruit. Hence, it is anticipated that, the development of integrated loose fruit collector machine possibly will give assistance to the oil palm industries in term of loose fruit collection areas and clean loose fruit before sending to the mill.

ACKNOWLEDGEMENTS

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Mohd Zulfahmi Mohd Yusoff was graduated from Universiti Malaysia Perlis (Unimap) with B.Eng degree in 2009. In 2015, he completed his studies in MSc of Engineering from University Putra Malaysia (UPM). In 2017, he perusing his Doctor of Engineering in Universiti Putra Malaysia under Yayasan Sime Darby (YSD) scholarship. Currently he is working in Sime Darby Plantation Research Sdn Bhd as Chief Engineer II.To date, he has filed several patents/IP related to in field Fresh Fruit Bunch (FFB) and Loose Fruit (FB) mechanization

Ahmad Zamri Md Yusof was graduated from Universiti Putra Malaysia (UPM) with Bachelor of Engineering (agriculture) degree in 1994. He is dedicated to his work to deliver results and has 11.7 years in current position as Head, Mechanisation Unit, R&D. Very strong technical and competency in field mechanisation with main focus on FFB and loose fruit collection and cleaning. That includes the development of motorised wheelbarrow, loose fruit segregator and collector, mechanical buffalo with scissor lift, mechanical buffalo grabber etc. To date, he has filed 10 patents/IP related to in field FFB and LF mechanization and published and presented 32 papers in various conferences.

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