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Time and Motion Studies of Manual Harvesting Methods for Oil Palm Fruit Bunches: A Malaysian Case Study

Nizaroyani Saibani*, Ariff Azly Muhamed, Mohd Faizal Maliami, Rasyidah Ahmad

Department of Mechanical and Materials Engineering, Faculty of Engineering and Built Environment, Universiti Kebangsaan Malaysia, 43600 Bangi, Selangor, Malaysia

*Corresponding author: nizaroyani@gmail.com

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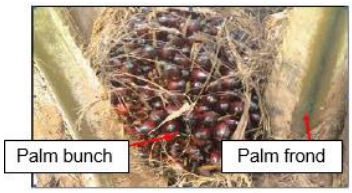
Graphical abstract



Abstract

In optimizing the yield of oil palm fruit bunches collection, the mechanization of the collection process is very important. However, before the analysis of the cost benefits of any mechanization development can be utilized, this study has to be carried out. Time and Motion Studies (TMS) is used to identify and measure the efficiency of the oil palm fruit bunches' manual harvesting technique. The Direct Time Study Technique has been selected to determine and record the time taken by the harvester to harvest the oil palm fruit bunches, where the tool used in this technique is a stopwatch, alongside the Time Study Observation Sheet. Meanwhile, to examine the motions used by the harvester in the harvesting process, the Therblig's Motion Principle is applied to identify effective and non- effective motions. A field work study has been conducted by monitoring two harvesters and all the real time data is recorded in the time study observation sheet and analyzed to get a value of Normal Time (NT) and also Standard Time (ST) for each work element involved in the manual harvesting process of palm oil. There are seven work elements that have been identified to have been used by the harvester to complete the process, the first element is searching for the mature palm oil tree (NT= 40.73 seconds), the second element is adjusting the Aluminium Pole and Knife (APK) cutter (NT= 23.36 seconds), the third element is cutting the oil palm's frond (NT= 51.30 seconds), the fourth element is cutting the mature oil palm's bunches (NT= 60.26 seconds), the fifth element is collecting the oil palm's frond that has been cut (NT= 21.69 seconds), the sixth element is putting the oil palm's bunches that have been cut into the wheel barrow (NT= 34.25 seconds) and the seventh element is collecting the loose oil palm fruits or called fruitlets (NT= 77.49 seconds). The study also categorized a few non-effective work elements carried out during the manual harvesting process. The elements are: searching for the oil palm trees that have mature oil palm bunches, adjusting the APK cutter and also collecting the loose oil palm fruitlets off the ground.

Keywords: Time and motion study; oil palm bunch; Therblig's motion principle

Abstrak

Dalam mengoptimumkan hasil kutipan tandan buah kelapa sawit, mekanisasi merupakan proses yang sangat penting. Walau bagaimanapun, sebelum analisis ke atas manfaat kos ke atas pembangunan mekanisasi boleh dijalankan, kajian ini perlu dijalankan. Kajian gerakan dan masa (TMS) digunakan dalam mengenal pasti dan mengukur kecekapan teknik penuaian tandan buah kelapa sawit secara manual. Teknik Kajian Masa langsung telah dipilih untuk menentukan dan merekodkan masa yang diambil oleh penuai untuk menuai tandan buah kelapa sawit, di mana alat yang digunakan dalam teknik ini adalah jam randik, bersama dengan Lembaran Pemerhatian Masa Kajian. Sementara itu, untuk mengkaji usul yang digunakan oleh penuai yang dalam proses penuaian, Usul Prinsip Therblig digunakan untuk mengenal pasti pergerakan yang berkesan dan tidak berkesan. Satu kajian kerja lapangan telah dijalankan dengan memantau dua penuai dan data masa sebenar direkodkan dan dianalisis untuk mendapatkan nilai Masa Normal (NT) dan juga Masa Standard (ST) bagi setiap elemen kerja yang terlibat dalam proses penuaian tandan kelapa sawit secara manual. Terdapat tujuh elemen kerja yang telah dikenal pasti telah digunakan oleh penuai untuk menyelesaikan proses tersebut, elemen pertama adalah mencari pokok kelapa sawit matang (NT = 40.73 saat), elemen kedua menyesuaikan Pemotong dan Batang Aluminium (APK), (NT = 23.36 saat), elemen yang ketiga adalah memotong pelepah kelapa sawit (NT = 51.30 saat), elemen keempat adalah memotong tandan kelapa sawit yang matang (NT = 60.26 saat), unsur kelima mengumpul minyak pelepah sawit yang telah dipotong (NT = 21.69 saat), elemen yang keenam meletakkan tandan kelapa sawit yang telah dipotong ke dalam kereta sorong (NT = 34.25 saat) dan elemen yang ketujuh mengumpul buah kelapa sawit terlerai (NT = 77.49 saat). Kajian ini juga mengkategorikan beberapa elemen kerja tidak berkesan dijalankan semasa proses penuaian manual. Elemen-elemen ini adalah: mencari pokok-pokok kelapa sawit yang mempunyai tandan kelapa sawit matang, menyesuaikan dalam melaraskan pemotong APK dan juga mengumpul buah kelapa sawit terlerai di atas tanah.

Kata kunci: Masa dan kajian gerakan; tandan kelapa sawit; prinsip gerakan Therblig ini

1.0 INTRODUCTION

Industrial plantation of palm (Elaeis guineesis) has become a major industrial sectors throughout the world and Malaysia is one of the largest palm oil producers in the world. The products of the processing of palm fruits are widely used in the manufacturing sector, food and pharmaceutical sectors. Malaysia is the second highest country supplying palm oil with 12.8% of the world's demand for organic oil [1]. The palm oil industry in Malaysia must seek adequate skills and appropriate techniques for improving productivity to accommodate increasing operations. Oil palm harvesting utilises 60% from the total labor cost and this constitutes 50% more than the total cost of palm oil production [2]. Many studies have been done to improve the quality of palm oil and to improve the output of the harvested palm fruits. In 2000, Malaysia has established an organization for the care and advancement of the Malaysian palm industry namely the Malaysian Palm Oil Corporation [3]. Figure 1 shows a palm oil tree with a matured palm oil bunch.

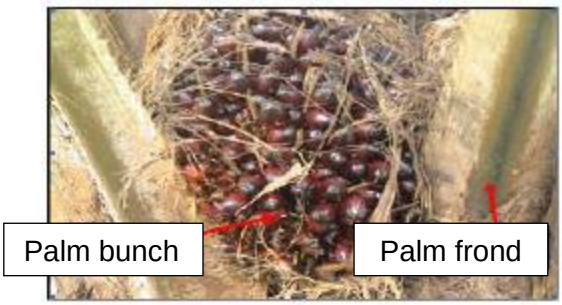


Figure 1 Palm oil tree[4]

According to a report from the Department of Statistics, 2011 for the end of year of 2012, a total of 296 395 permanent employees and 1771 part-time employees were working in the palm oil industry, while for small estates, there were about 1257 permanent workers and 98 temporary staffs. Based on the statistics provided, the industry requires a strong workforce which will lead to the increase in the production costs.

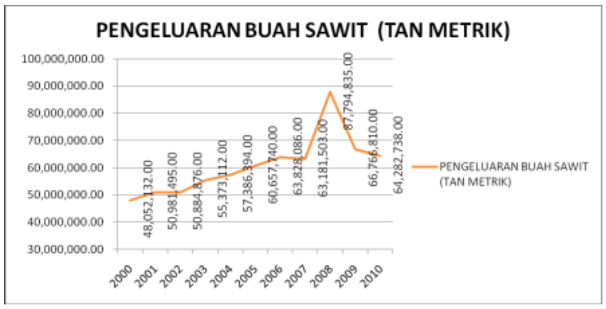


Figure 2 Statistic of expenditure palm product in Malaysia year 2000-2010[5]

Based on Figure 2, the information from the Department of Statistics shows that the palm fruit production in Malaysia had increased from year 2000 to 2010, and this proves that the method of harvesting palm fruit is very essential to increase the production to meet the demands of the world. This study will focus on the study of time and the farm labor movement in the process of harvesting the ripe bunches of palm fruit.

2.0 TRADITIONAL METHODS IN HARVESTING OIL PALM FRUIT BUNCHES

Traditional harvesting techniques are still practiced in many oil palm plantations due to the lack of technology transfer. Even though a number of mechanically harvesting process was introduced in the industry, the machines are still not widely utilized at industrial scale. Harvesting is traditionally done with the use of bamboo-sickle (Pole-and-Knife), thus, the traditional harvesting techniques are less efficient and they tend to become too dependent on the employees' skills. There are three types of traditional techniques in harvesting palm bunch, and they are Single Rope-and-Cutlass (SRC), Bamboo Pole and Knife (BPK) and Aluminum Pole and Knife (APK). The last two traditional techniques are limited in use because these techniques are best used on palm trees with a height of less than 3 meters. The following sections will explain each of the techniques briefly.

2.1 Single Rope-and-Cutlass (SRC) Technique

Studies done by [6] state that there are two traditional methods used in the process of harvesting-for trees of over 9 meters high, the method used is the single rope sword method (Single Rope-and-Cutlass (SRC)) shown in Figure 3, and twin strap and short sword (Double Rope-and-Cutlass (DRC)), while for the palm trees that have a height that can be reached by hand, a sword or a scythe will be used to cut the clusters or bunches. [6] also noted that the SRC is more widely used because it is faster despite the fact that the technique is dangerous. The SRC technique generally uses only three elements of the work (Figure 4).

Figure 3 The SRC technique[6]

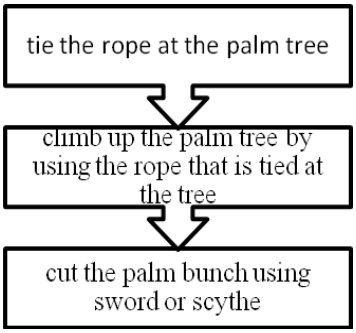


Figure 4 Work element of SRC[6]

2.2 Bamboo Pole and Knife (BPK) Technique

SRC techniques have evolved across time when [7] state that the method of Bamboo Pole and Knife (CPC) has been applied in the process of harvesting palm fruit. Studies done by Adetan *et al*. (2007) state that for the medium tall palm tree reaching a height of 9 meters the bamboo poles and knives method (Bamboo Pole and Knife (CPC)) will tend to be adopted. The CPC technique will use the bamboo poles and sickle for the harvesting process where workers who perform the harvesting will stand on the ground while the CPC tool will be raised to harvest bunches that are still on the trees. However the CPC techniques are ineffective and harmful to the worker-harvesters because, as stated in the study by [7], when using the CPC to harvest bunches at a height of more than 5.5meter, bamboo poles used will begin to bend and they will give certain pressure on the labor of harvesting, so through time, the bamboo poles used tend to be replaced with aluminum poles with a diameter of 40 mm.

2.3 Aluminum Pole and Knife (APK)Technique

The CPC technique has been developed by using an aluminum pole to replace the bamboo poles; known as the aluminum poles and knives (Aluminum Pole and Knife (APK)), this will reduce the energy used by the employee. Figure 5 shows five element types of the work done by workers harvesting using APK techniques. This traditional harvesting techniques use a relatively high amount of energy, therefore, [8] had studied the use of the energy used by workers who performed the harvesting. For most matured frond, the energy used could require the exertion of a force as much as 18,048 N for harvesting oil palm even for cutting a single frond alone, using the sickle cutter (a type of Malaysian knives). This finding was further strengthened by [9] in their study carried out on palms aged 9 to 25 years in Malaysia, which establishes that almost 43.5 to 45.4 % of the annual number of days worked were intended for the oil palm bunch harvesting process.

Figure 5 (a) worker adjusts the APK tool to adjust the height of the palm trees for harvesting (b) worker adjusts the pole's knife (c) the employee performs the harvesting of the oil palm bunches using the APK on much higher trees (d) APK tool adjusted to harvest another oil palm tree[10]

2.4 Work Elements in Oil Palm Harvesting

[11] concluded that there are five elements in the process of traditional harvesting of oil palm bunches as illustrated in Figure 6.

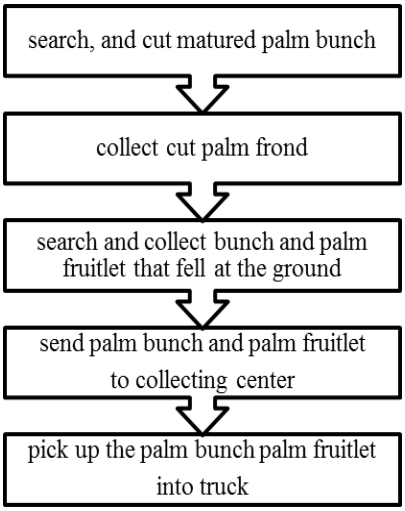


Figure 6 Work elements of palm harvesting process[11]

Figure 6 shows the lengthy process of harvesting palm fruit where earlier on, workers had to pick up the palm fronds that did not contribute to the yield of the harvest and the workers also had to collect loose fruits after the harvesting was done. There is a need for the mechanical system to accelerate the process of harvesting palm fruit and increase the productivity.

■3.0 TIME AND MOTION STUDY (TMS)

Initially, the time study introduced by Taylor and motion study developed by Gilbreth were regarded as two different things. Initially time study was widely used to determine the standard time, while the motion study was used to improve work methods. Time study was preliminarily adopted more widely, especially in incentive pay system compared with the use of motion study. In 1930s, people began to realize that time study and motion study are two things that are interrelated and supporting each other, until the two terms are then combined into a "time and motion studies". Using time study, work methods can result for better alternatives. However, to find the best design work methods, study time should also be done. The term time and motion study later became an inseparable unity. Another term often used for time and motion study is methods engineering [12].

Time and motion study is a systematic review of worksystems. The purposes of time and motion study are [13]:

i. To develop systems and methods better-usually with cheaper funding.
ii. To standardize systems and methods.
iii. To determine the standard time.
iv. To help train workers to implement better methods.

The term "time and motion study" also known as engineering methods (Methods Engineering) and then rendered as a method of working procedures [14]. Further multiple research works were performed with the aim to implement or develop the methods of time and motion study. In 1940, in England, work sampling was first used by LHC Tippett in textile factories. Due to the use and

its practical way, this method has been widely used in various other countries. The results obtained from the sampling work can be used to determine the rate of utilization of machines and staff work, the flexibility given in a particular job and determine production standards [15]. Based on the results of the study conducted by the basic movement of Gilbreth, some experts then develop a system of time measurement with data movement known Predetermined System Standard Time (PTSS). Several measurement systems were developed such as Work Factor by JH Quick, W.J. Shea and R.E. Koehler in 1938, the time measurement system using Methods Time Measurement (MTM) by Maynard, Stegemerten and Schwab in 1948, and the measurement system using MOST by Zandin in 1967.

Work-Factor is one of the measurement system of Predetermined Time Standard System (PTSS) which was first used widely. According to the Work-Factor system, there are four variables that affect the length of time to perform a work movement:

i. use of limbs,
ii. the distance moved,
iii. human control purposes, and
iv. the weight or load involved in the work.

Time measurement system with Methods Time Measurement (MTM) is developed based on the study of labor movements at work in industrial operations. Time measurement system indirectly with MTM is regarded as the most detailed system, precise and widely accepted [16]. For some types of work that have a high repetition and short operating cycle, phase accuracy and details on MTM are very effective system to allow recognition of work method that can be improved [16]. Measurement system with a succession Maynard Operation Sequence Technique (MOST) developed by Zandin in 1967 which is based on concepts included in the measurement system with MTM. With MOST method, time measurement system with indirect method can be done five times faster than with MTM [15].

Time and motion study's aim is to get rid of unnecessary work and they form the most efficient rules and procedures with an addition to provide measurements for determining the performance index for an individual or group of workers, an office or the entire organization. Time and motion study comprises two parts [13]:

i. motion study or work methods design-to find the most preferred method of carrying out the work.
ii. time study or work measurement-to get standard time to perform a certain task.

The most common methods in time and motion study are [17];

i. Stopwatch Method
This method is a conventional method for recording and evaluating the work elements for a particular job carried out in a certain circumstances. The data is further analyzed to determine the standard time for a particular job.
ii. Work sampling
Observations are made in a period of time on one or a group of machines, processes or employees. This technique is designed to measure the percentage of time during the work done.
iii. Pre-determined Motion Time System (PMTS)
A work measurement technique developed using a predetermined time before the foundation of the movement of people in time measurement unit (TMU).
iv. Maynard Operation Sequencing Technique (MOST)
A complete study of an operation or sub-operation where normally appropriate parameter time values are set, producing a normal time for the operation or sub-operation.

[14] defines the method of work procedures as the best techniques and principles for worksystem design. Worksystem is defined as a unit consisting of elements of human, material, equipment and tools, work methods and work environment for a specific purpose [14]. Performance of a worksystem can be measured using several criteria; among which are the time, energy, psychology and sociology [14]. Therefore, a worksystem is deemed as good if the system enables a short working time solution, the energy required to complete is at a minimum level with minimum psychological and sociological effects.

3.1 Time and Motion Study Techniques in Agricultural Study

Time and motion study has been widely adopted in various sectors such as manufacturing, services, forestry, agriculture and others. A large number of the use of time and motion studies are aimed at improving efficiency in the processing operations or work in certain sectors. Methods or techniques of time and motion study used are varied to suit the particular industry or sector respectively. For the agricultural sector, there are several methods that have been used in previous studies. Table 1 shows some of the methods used in the study related to agriculture, which involves the use of time and motion study.

Table 1 TMS method in agricultural related studies

Title of Study	Authors	TMS Method	Year
Time-Motion Analysis of Feedlot manure Collection Systems	J. M. Sweeten D. L. Reddell	Direct time study - Continuous stopwatch	1979
Cut-To-Length of Short Rotation Eucalyptus at Simpson Tehama Fiber Farm (Proceeding)	B. R. Hartsough D. J. Cooper	Direct time study	1998
Some Measurements of Mechanical Sugarcane Harvester Performance	E. Meyer	Direct time study - Cumulative Time Method	1999
Time-Motion Analysis of Corn Silage Harvest Systems	T. M. Harrigan	Direct time study	2003
Assessment of Manual and Shear Harvesting in High Elevation Tea Plantations in Sri Lanka	R.R Shankar Jayathilaka Wanigasundera	Direct time study with video recording	2003
Industrial Harvesting of Olive Tree Pruning Residue for Energy Biomass	R. Spinelli G. Picchi	Direct time study - Field laptop Husky Hunter® with SiWork 3 software	2010
Productivity and Cost Analysis of Manual Felling and Skidding in Oriental Spruce	E. Caliskan	Direct time study	2012

Based on the Table 1, it is found that nearly all studies related to the agricultural sector used the direct time study method. However, the equipment used to record the time is varied, based on work cycle or measured work elements. In addition, it was found that most of the agriculture-related research using time and motion study as research methods, using the concept of field work where each measurement is done directly in the field (field or plantation). Although no time and motion study specifically on the palm oil sector is found, but based on methods conducted by previous studies, we can summarize that direct time study is appropriate to be used to in this study.

■4.0 RESULTS ON TIME AND MOTION STUDY OF HARVESTING OIL PALM BUNCH BY THE TRADITIONAL METHOD

4.1 Motion Element

Field work was carried out at the National University of Malaysia's oil palm plantations and all the elements of motion

and time involved in the process of harvesting palm fruits were recorded. Based on the field work done, there are seven elements carried out by plantation workers in completing the harvesting process traditionally, and it was done by two farm workers, which was in contrast to the findings of a study done by [11] who conclude that there are only five elements of the work done during the process of harvesting the traditional way. The process of harvesting palm fruit using the traditional technique, that is Aluminum Pole knife (APK) has been recorded and the working elements in the process of harvesting have been identified as shown in Figure 7.

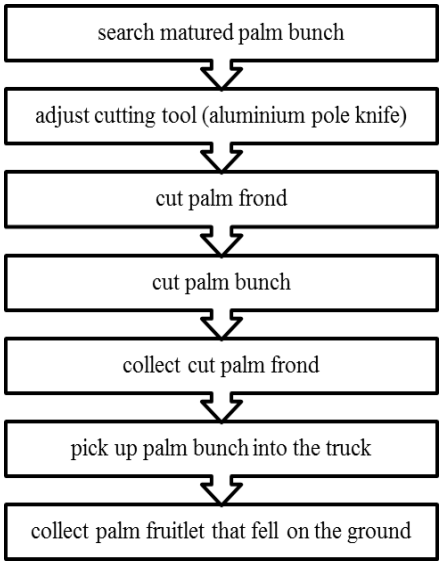


Figure 7 Elements of work process harvesting palm plantation

Figure 8 shows the elements of the work done by plantation workers in performing the cutting process the traditional way. Two oil palm plantation workers were needed to complete the elements of the traditional cutting oil palm fruit. Elements of the work done by farm workers were demonstrated by two employees labelled as workers A and B. Elements of the work done by worker A is as shown in Figure 8 and those of worker B shown in Figure 9.

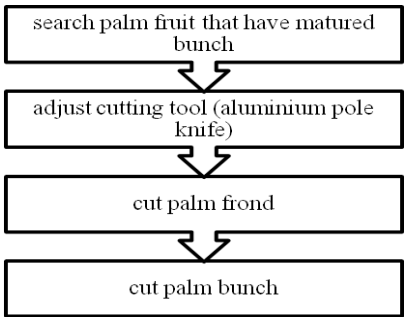


Figure 8 Elements of cutting oil palm plantation worker A

Figure 8 shows the elements of the work done by the employees of a farm, where there are four elements of the work that would have to be completed to finish the traditional cutting process. Figure 9 shows the elements of the work done by farm worker B.

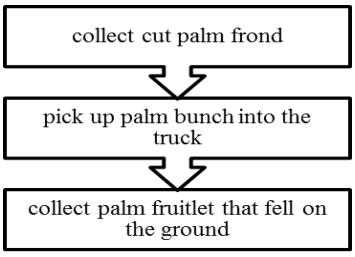
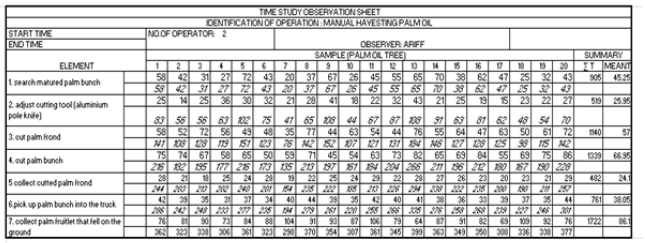


Figure 9 Elements of work (cutting oil palm) by plantation worker B

Figure 9 shows worker B cutting oil palm bunches in a few elements. There is a distinction in terms of the number of working elements between workers A and B. Each farm worker's working elements will be assessed in terms of the average time taken, normal time and standard time.

4.2 Time Study

To accomplish the study, the work elements were done by two workers. One worker was assigned to search for matured bunches, adjust the cutting tool, cut the palm frond and bunch. Meanwhile, another worker was asked to collect the palm fronds, pick up the bunches into the truck and collect the palm fruitlets. All the data obtained were recorded in the Time Study Observation Sheet as shown in Figure10.



TIME STUDY OBSERVATION SHEET

IDENTIFICATION OF OPERATION : MANUAL HAVESTING PALM OIL

START TIME — NO.OF OPERATOR: 2

END TIME — OBSERVER: ARIFF

ELEMENT	SAMPLE (PALM OIL TREE)																				SUMMARY	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Σ T	MEANT
1. search matured palm bunch	58	42	31	27	72	43	20	37	67	26	45	55	65	70	38	62	47	25	32	43	905	45.25
	58	42	31	27	72	43	20	37	67	26	45	55	65	70	38	62	47	25	32	43		
2. adjust cutting tool (aluminium pole knife)	25	14	25	36	30	32	21	28	41	18	22	32	43	21	25	15	15	23	22	27	519	25.95
	83	56	56	63	102	75	41	65	108	44	67	87	108	91	63	81	62	48	54	70		
3. cut palm frond	58	52	72	56	43	48	35	77	44	63	54	44	76	55	64	47	63	50	61	72	1140	57
	141	108	128	119	157	123	76	142	152	107	121	131	184	146	127	128	125	98	115	142		
4. cut palm bunch	75	74	67	58	65	50	58	71	45	54	63	73	82	65	69	84	55	69	75	86	1339	66.95
	216	182	195	177	222	173	135	213	197	161	184	204	266	211	196	212	180	167	190	228		
5 collect cutted palm frond	28	21	18	25	24	28	19	22	25	24	29	22	28	27	26	23	20	23	21	29	482	24.1
	244	203	213	202	246	201	154	235	222	185	213	226	294	238	222	235	200	190	211	257		
6.pick up palm bunch into the truck	42	28	35	31	37	34	40	44	39	35	42	40	41	38	36	33	39	37	35	44	761	38.05
	286	231	248	233	283	235	194	279	261	220	255	266	335	276	258	268	239	227	246	301		
7. collect palm fruitlet that fell on the ground	76	91	90	73	84	88	104	91	93	87	106	79	64	87	91	82	69	109	90	76	1722	86.1
	362	323	338	306	367	323	298	370	354	307	361	345	399	363	349	350	308	336	336	377		

Figure 10 Time observation sheet: work element of harvesting the palm fruit using traditional way

Figure 10 indicates the record which was made during the process of harvesting the palm fruit by workers using a sample of 20 trees. Based on our observation, the samples recorded to have the longest time was at the 20th principal that is over 377 while all the working elements needed to complete the harvesting were prepared.

4.3 Allowances

Worker allowance for the plantation workers must be considered becuse the allowance levels will determine the standard time required by plantation workers to complete the work of each element. In overall, plantation workers have to do their work for ten hours a day (600 minutes). The overall value of their allowances will be added to the following percentage:

i) Personal Allowance

Personal allowance involves workers' allowable activities during the harvesting palm fruit such as giving reasons for absence and also talking with other workers. It is assumed that 20 minutes were sufficient for the workers when it comes to personal allowance. Personal allowance is expressed as follows:

Personal Allowance = (15 minutes / 600 minutes) x 100% = 2.5%

The result for the workers' personal allowance in the study is 2.5%.

ii) Fatigue Allowance
Fatigue allowance is the workers' relaxation time allowed by employers after the work is done in order to release any body exhaution. In this study, the workers were allowed to rest for one hour (60 minutes) in the afternoon as a way for them to be re-energised after all the hard work. The calculation of the fatigue allowance for farm workers is as follows:

Fatigue Allowance = (60minutes / 600minutes) x 100% = 10%
based on the calculation, the fatigue allowance for each plantation worker is 10%. Fatigue allowance raised will be used to determine the elements of standard time to work on the traditional harvesting process.

iii) Delay Allowance
The delay allowance for plantation workers while performing work applies to cases such as workers having to tend to the sickle blade to clean off the dirt, causing the work to be disrupted. It has been recorded that the delay allowance is estimated to last 15 minutes per session. This allowance is expressed as follows:

Delay Allowance = (15 minutes / 600minutes) x 100%
After the calculation was done, the delay allowance derived from the farm studies was 2.5%. This delay allowance cannot be avoided during the cutting process because it involves the entire working environment.

iv) Total Allowance
The total allowance derived from observations on the farm work done is obtained after summing up all earned allowances as computed below:
Total allowance = personal allowance + delay allowance + fatigue allowance

= 2.5% + 2.5% + 10% = 15%

The total allowance for the workers is 15%. The allowance value obtained is important in determining the standard time to be analyzed for each work element.

■5.0 DISCUSSION ON NORMAL TIME AND STANDARD TIME

Each element of the work will be evaluated in terms of the average time, normal time and standard time taken. The calculations of both the normal time and standard time are as follows. The time recorded for plantation workers is as exhibited in Figure 11.

	search matured palm bunch																			total
tree	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	time
time (secs)	58	42	31	27	72	43	20	37	67	26	45	55	65	70	38	62	47	25	32	43	905

Figure 11 Time to find mature oil palm bunch

Figure 11 shows the time recorded for the plantation worker to find a mature bunch of palm trees before the bunch is cut down. The mature palm bunches can be found still on the trees, while the over-ripe ones will become loose and the fruitlets will naturally fall off. According to the manager of the plantation, the quantity of loose palm fruits that have fallen to the ground must be more than five pieces, and this will give the indication that the bunch right on top of the loose fruitlets is already matured and ready to be harvested. According to Figure 11, the amount of time needed to find the 20 palm trees that had matured fruit bunches (that would then be sent away to be pressed) was 905 seconds (905sec / 60 = 15.08 mins). The average time spent for the process of finding palm trees with mature fruit bunch is given as below:

The normal time (NT) for the process of looking is shown below by assuming that the worker's performance rating is 90%:

Normal time (NT) = average time x performance rating
Normal time (NT) = 45.24 x 0.9 = 40.73 seconds

Normal time is recorded as 40.73 seconds, where this means that for every lookup, farm workers need 40.73 seconds. Meanwhile, for the standard time (ST) of the searching process workers' allowance is assigned at 15%:

Standard Time (ST) = NT (1 + allowance)
Standard Time (ST) = 40.73 when (1 + 0.15) = 46.84

ST for the workers to search for a matured oil palm bunch was recorded as 46.84 seconds (0.78 min). Based on the analysis, it took about 45.25 seconds of average time to search for palm trees that had mature fruit bunch/es. Following the principle of the therbligs movement, if it involves the process of searching type of work elements, therbligs movement would be rendered as ineffective. Ineffective work elements should be analysed further, whether it can be eliminated in order to reduce the whole work content.

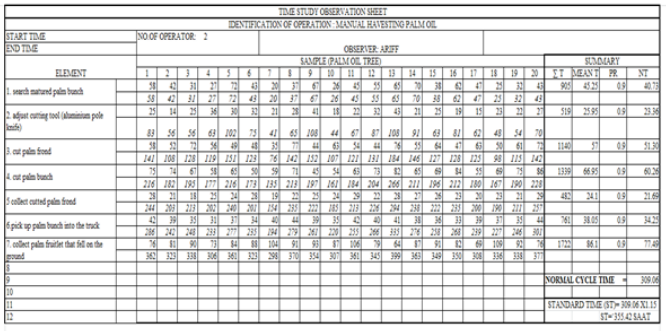

TIME STUDY OBSERVATION SHEET
IDENTIFICATION OF OPERATION : MANUAL HAVESTING PALM OIL
START TIME
END TIME
NO OF OPERATOR: 2
OBSERVER: ARIFF
SAMPLE (PALM OIL TREE)
SUMMARY
ELEMENT
1. search matured palm bunch
2. adjust cutting tool (aluminium pole knife)
3. cut palm frond
4. cut palm bunch
5 collect cutted palm frond
6 pick up palm bunch into the truck
7. collect palm fruitlet that fell on the ground
NORMAL CYCLE TIME = 309.06
STANDARD TIME (ST)= 309.06 XL 15
ST= 355.42 SAAT

Figure 12 Time observation sheet: work element of traditionally harvesting palm fruit

Figure 12 shows the time records that had been made during the process of harvesting by plantation workers with a sample size of 20 trees. The overall process required two people working at the farms to complete the whole cycle of work content. Based on the record, the work element of collecting loose palm fruit shows to be an element of work that requires the longest time to be prepared, which took 1722 seconds, while the work element of collecting palm fronds is completed the quickest, as compared to other work elements.

■6.0 CONCLUSIONS

The motion and time study was performed at the National University of Malaysia. The Traditional Palm-Harvesting Process in the Palm Oil Plantation is a study that gives a clear picture of the working elements found in the traditional harvesting process. Motion and time study techniques used in the process of harvesting are traditional techniques for Direct Time and Motion Studies. This technique is seen as the most effective technique in

studying the oil palm harvesting and the entire process has been separated into elements of work done and the time spent by employees in performing each work element as recorded in the Time Study Observation Sheet. Through these techniques, researchers can see in more detail the elements of work done and the time element involved when employees do the work, thus facilitating the analysis of the data.

Standard time optimal result obtained was 355.42 seconds for the whole process of harvesting using the traditional methods. Time standards derived from farm studies must be reduced by reviewing the most appropriate method, either by using a mechanical system or by removing elements of the work where no (non-value added activity) has been identified such as cutting palm fronds, picking fruit palm during the cutting, and carrying and loading bunches of palms into the carts. These work elements should be analysed futher in order to help reducing the whole work content.

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References

[1] USDA. 2011. Monthly Summary-July 2011a/. *Conservative Reserve Programme.*

[2] Malek, N., Selamat, M. B., & Jamak, J. 2003. *Technologies for Oil Palm Harvesting, Evacuation and Loose Fruit Collection*, MPOB.

[3] Malaysian Palm Oil Board. 2006. *Manual Penggredan Buah Kelapa Sawit.* 3rd edition. MPOB. Selangor.

[4] Hudzari, M. R., Ssomad, A., Halim, M. A & Roslan, S. 2012. A Review on Crop Production and Ripeness Forecasting. *International Journal of Agriculture and Crop Sciences*. 4(2): 54–63.

[5] Department of Statistics Malaysia. 2011. *Selected Indicators for Agriculture, Cropsand Livestock (2006-2010).* ISSN 2232-0997. Malaysia.

[6] Ironbar, J. E. 1981. *Report on My One Year in Office as the Officer in Charge of Harvesting Unit, NIFOR*. An unpublished report, NIFOR, Benin City, Nigeria.

[7] Adetan, D.A., Adekoya, L.O., & Oladejo, K. A. 2007. An Improved Pole-And-Knife Method of Harvesting Oil Palm. *Agricultural Engineering International: the CIGR Ejournal Manuscript*.

[8] Jelani, A. R., Ahmad, D., Hitam, A., Yahya, A., & Jamak, J. 1999. Reaction Force and Energy Requirement for Cutting Oil Palm Fronds by Spring Powered Sickle Cutter. *Journal of Oil Palm Research*

[9] Bevan, J. W. L. And Gray, B. S. 1969. *The Organization and Control Farm Practice for Large Scale Oil Palm Planting in Malaysia*. Incorporated Society of Planeters Malaysia, Kuala Lumpur.

[10] Ng, Y. G., Bahri, M. T. S., Syah, M. Y. I., Mori, I., & Hashim, Z. 2013. Ergonomics Observation: Harvesting Tasks at Oil Palm Plantation. *Journal of Occupational Health*. 55: 405–414.

[11] Adetan, D. A., Adekoya, L .O. 1995. *Comparison of Two Methods of Manual Harvesting of Oil Palm*. Tropical Agriculture

[12] Wignjosoebroto, S. 1995. *Ergonomi, Studi Gerak dan Waktu*. Edisi Pertama. Surabaya: Prima Printing.

[13] Barnes, R. M. 1980. *Motion and Time Study: Design and Measurement of Work*. 7th Ed.. New York: John Wiley & Sons. Inc.

[14] Sutalaksana, I. Z., Anggawisata, R. & Tjakraatmadja, J. H. 1979. *Teknik Tata Cara Kerja*. Bandung: Institut Teknologi Bandung.

[15] Niebel, B.&. Freivalds, A. 2002. *Methods, Standards and Work Design*. 11th edition. New York: McGraw-Hill.

[16] Zandin, K. B. 2003. *MOST Work Measurement Systems*. 3rd Edition. New York: CRC Press.

[17] Puvanasvaran, A.P., Mei, C.Z. & Alagendran, V. A. 2013. Overall Equipment Efficiency Improvement Using Time Study in an Aerospace Industry. International Tribology Conference Malaysia 2013. *Procedia Engineering*. 68: 271–277.