Fatigue Level Analysis for Post-Harvest Activities of the Corn Farmers in Tanjung Bintang, South Lampung

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Abstract. Corn has its own charm in the agricultural industries, especially in Tanjung Bintang. This crop can be consumed as staples in food and feed industry. In corn production chain, post-harvest requires some special attentions, as its price tends to decrease due to incorrect post-harvest handling. The increase of corn demand must be followed by higher productivity that can be identified from several work elements, which consist of cutting (Ct), transporting (Tr), and milling (Mi). In this moment, the post-harvest process is carried out by both men and women. The post-harvest process of corn was performed when it had been dried on the field. Hence, there is no drying process was needed. The purpose of this study was to determine the fatigue level of corn farmers in post-harvest activities both subjectively and objectively. The objective method used in this study was direct observation in the field by measuring the heart rate using a HRM. On the other hand, the applied subjective method was the SOFI questionnaire data. The results of the questionnaire showed that there were significant differences in the dimensions of physical fatigue, which consists of lack of energy (LE), physical exertion (PE), and physical discomfort (PD) with the general transportation showing the highest fatigue and the lowest was milling. The subjective fatigue dimensions, Lack ofmotivation (LM) and sleepiness (S) did not indicate any significant difference due to the majority of the activities were the physical work. In the objective measurements, the IRHR showed that the highest IRHR value in the transporting and grinding was more than 1.50. This value indicated the work element classified as heavy work. In conclusion, the subjective and objective measurements appointed the transportation (Tr) had the highest level of fatigue.

1. Introduction

In Indonesia, corn is the most popular commodity after rice. There are over 3.4 million ha of corn harvest area in Indonesia and it meets about 18.35% of the total agricultural area for rice field and palawija field. The largest percentage is found in East Nusa Tenggara and Lampung [1]. The corn productivity in Lampung was 51.20 quintal/ha from 0.28 million ha harvest area in 2015 [2]. Decreasing productivity, because the condition of corn harvest area is decrease from 2010 to 2015. In addition, the applied technology that unsuitable with physical ability of farmers can reduce corn productivity as well.

In Lampung, corn harvesting is manually done by humans (farmers) effort power and control. Unfortunately, human has limit effort that must be concern. In the other hand, the human has difference in physical, physiology, and physiological characters. So, the suitability between worker characteristic and the type of work has to be considered more and more. The incompatibility of the work system, the work environment and the tools or machines that used in working can cause the

negative impact continuously. The direct impact from used machines as well as the bad posture are able to reduce work efficiency and effectiveness. Moreover, the work accident can occur if the worker is not watching out over for human factors. These problems are often identified with ergonomics risk.

Ergonomics is a study of the suitability of work between humans as work actors and the type of work. The Ergonomics can be used to identify and evaluate the suitability between people and working conditions to minimize the occurrence of work hazards, increase work efficiency and efficiency, and maximize productivity [3]. Fil'aini (2017) has previously reviewed the ergonomic in agriculture to determine the farmer needs in rice production in Bogor [4]. In addition, Syuaib (2012) also studied ergonomics to improve the system and productivity of oil palm harvesting activities [5]. Ergonomics of anthropometry for equipment design in agriculture have also been investigated [6]. The ergonomic aspect of the approach to workloads can therefore be used to evaluate the work fatigue level of corn farmers.

Fatigue that exceeds the physical capacity of farmers will lead to a decrease in productivity and work efficiency. To avoid physical fatigue that has an impact on decreasing work productivity, a study of the corn farmers' work capacity needs to be done. The work accident is able to occur due to unconscious fatigue during work. Therefore, that in order to balance the productivity, the workers have to consider their condition, both physically as well as mentality. It needs to calculate the number of fatigue level by using subjective and objective accumulation. The purpose of this study is to determine the fatigue level of post-harvest activities by corn farmers based on subjective measurement using Swedish Occupational Fatigue Inventory (SOFI) questionnaire and objective approaches using Heart Rate Monitor (HRM).

2. Method

Research data were collected in Tanjung Bintang, South Lampung and data processing was carried out at the Ergonomics Laboratory, TMB, IPB. The material used is the Heart Rate Monitor (HRM) for collecting data on heart rate and the questionnaire used to analyse farmers' fatigue levels based on a subjective view of the farmers. Subjective measurement of fatigue using Swedish Occupational Fatigue Inventory (SOFI).

The data collection design consisted of male and female farmers. Furthermore, measurements of the physical characteristics and heart rate of the subject when working. The research diagram can be seen in Figure 1. The study was conducted in several phases; the first phase of a location survey was conducted to determine the work system at the location of the study. After that, the work element was determined in post-harvest of corn.

Next preliminary measurements were made to determine the subject under study. Subjects consisted of male and female farmers with physical characteristics which did not differ significantly. Physical characteristics measured included gender, age, weight, and height. Farmers at the study location had experience in post-harvest corn activities.

While working, The HRM is paired on the subjects in order to record the heart rate of them. The heart rate recording setting uses a five-second interval. The HRM is a device that is attached to a subject such as wearing a watch and a belt attached to the chest. After the tools, have been properly installed, the subjects do their job as usual with using the HRM. Before they work, the subject is allowed to rest first. It is done in order to gain the lowest heart rate of the subject. The recorded lowest heart rate is the heart rate when the subject does not receive any burden or heart rate at rest (HR_{REST}). After completing of the work, the subject was expected to rest immediately to restore the heart rate of the subject. In addition, the data on the subject questionnaire was collected by conducting interviews personally. Objective fatigue level data analysis is done by analysing the heart rate data recorded in HRM. By using the Heart Rate Interface and Polar ProTrainer, the heart rate data are transferred to computer, then it is treated into Ms. Excel. The data is separated differently based on type of work performed. The data grouping of the heart rate is divided by comparing the data of the heart rate as described in Table 1 with the time data that can be seen from the Time Study Sheet.

The calculation of the Increase Ratio of Heart Rate (IRHR) is calculated by comparing the data of the working heart rate with the resting heart rate shown in Equation 1. After obtaining IRHR data, the

fatigue level of the subject can be determined using Table 1. The IRHR value is the relative heart rate rising that felt by every single subject and it is strongly influenced by the condition of each subject.

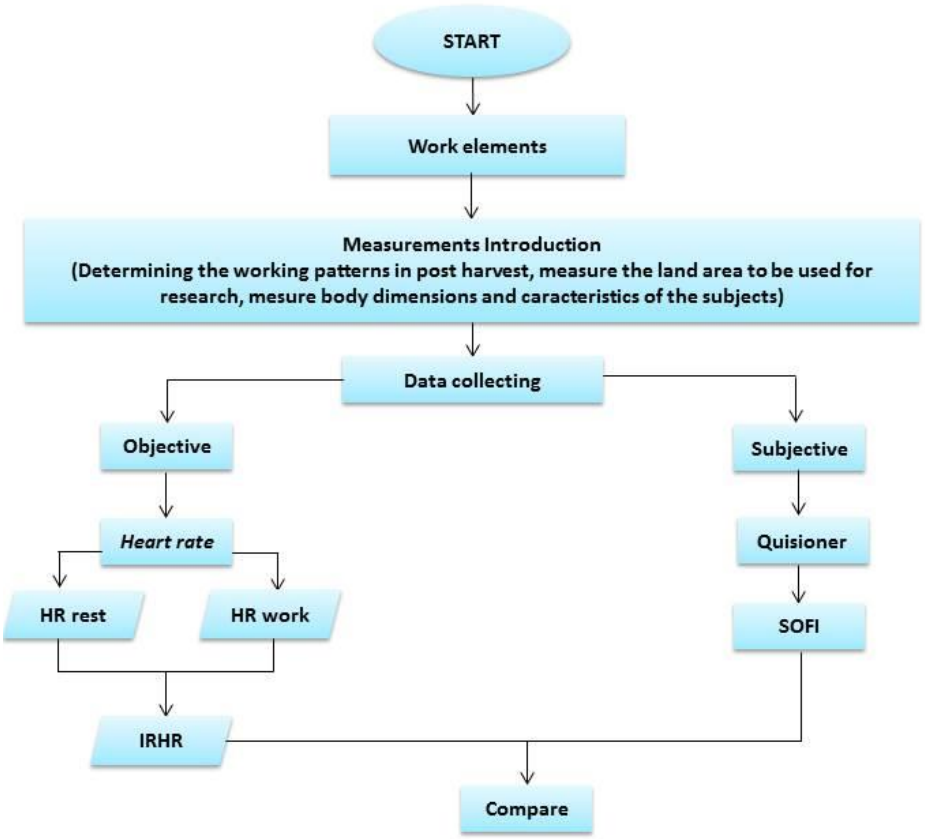

Figure 1. Diagram for research

$$IRHR = \frac{HR_{Work}}{HR_{Rest}} \quad (1)$$

Table 1. Level fatigue of IRHR [7]

Fatigue Level	Category		
Low	1.00	< IRHR ≤	1.25
Intermediate	1.25	< IRHR ≤	1.50
Advanced low	1.50	< IRHR ≤	1.75
Advanced middle	1.75	< IRHR ≤	2.00
Advanced high	2.00	< IRHR	

3. Results and Discussion

Corn sold must have a moisture content of about 14-16%. Therefore, post-harvest activities must be carried out quickly and correctly. The post-harvest process has several working elements, namely cutting (Ct), transporting (Tr) and milling (Mi). Harvesting activities by female subjects are carried out manually. Cutting is done when the corn has dried in the field so that the drying process is not necessary. After harvesting, the corn is placed before milling (Tr) in a storage area. Tr activities are carried out by male subjects, transporting several sacks of corn harvested. After the corn is collected,

the milling is done by using a machine, the milling activity is carried out by male subjects. Work elements of post-harvest corn can be seen in Figure 2.

In this research, there are ten research subjects consisting of five females on cutting activities (F1-F5), three males on transporting activities (M1-M3) and two males on milling activities (M4-M5). As the results (Table 2), it was found that post-harvest corn activities were classified as intermediate to advanced middle of work categories. The category of fatigue is based on an increase in the heart rate of the subject at work. The level of fatigue of the object can be seen subjectively from the IRHR value. The IRHR value describes the ratio between the heart rate at work and the heart rate at rest. The heart rate of the subject at rest implements the heart rate of the subject without loading. The value of the IRHR for each subject is different. Because the characteristics of each individual were strongly influenced, the workload analysed on IRHR values indicates the relative workload felt by each subject.

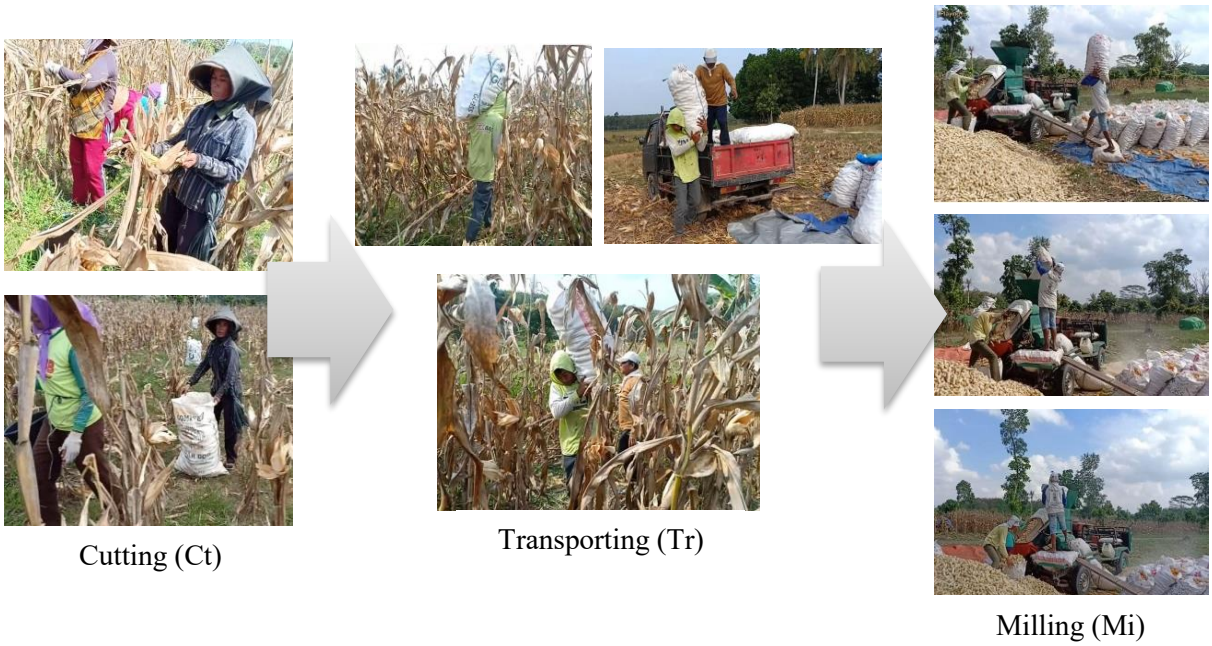

Figure 2. Work elements of corn post-harvest

Table 2. Fatigue level of each subject

Work elements	Symbol	Subject	Heart Rate		IRHR	Fatigue Level
			Rest	Work		
Cutting	Ct	F1	92.57	120.89	1.31	Intermediate
		F2	87.67	124.56	1.42	Intermediate
		F3	75.43	100.76	1.34	Intermediate
		F4	68.33	93.56	1.37	Intermediate
		F5	110.80	139.20	1.26	Intermediate
Transporting	Tr	M1	94.71	137.80	1.45	Intermediate
		M2	78.43	119.46	1.52	Advanced low
		M3	72.00	129.65	1.80	Advanced middle
Milling	Mi	M4	73.40	129.43	1.76	Advanced middle
		M5	85.00	115.52	1.36	Intermediate

- F = Female Subject
- M = Male Subject

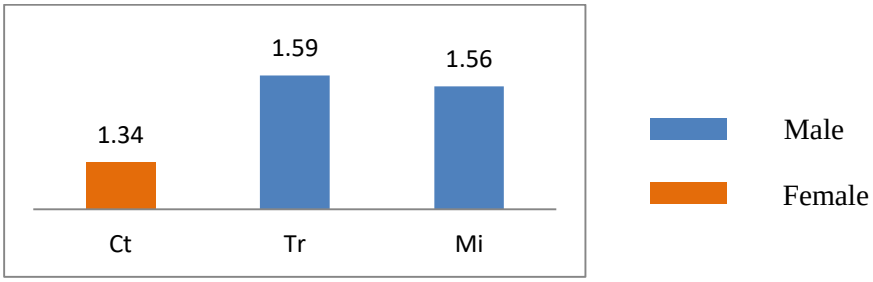

Figure 3. IRHR rate for work element

Subjects were determined according to the work system at the study site. The transporting and milling are usually done by male subject, while cutting is female subject. Based on the table, the highest level of fatigue was found in the activities of transporting (Tr) and milling (Mi), which is at advanced middle. The activity of Tr and Mi generate the fatigue impact to the workers significantly higher compared to the activity of Hr. Harvesting activity has a relatively mild fatigue effect rather than both Tr and Mi. Cutting (Ct) activities are activities that require accuracy compared to power in their work, so that the IRHR value of the subject was not too high.

The objective approach of the workload in the context of ergonomics was to design work systems in such a way as to achieve productivity and good quality work. The workload can be reviewed by measuring the heart rate of the subject while performing activities. Figure 3 shows that the lowest IRHR value is the Ct activity and the highest Tr. Transporting (Tr) was an activity with the highest IRHR value, followed by Mi, and the lowest is Ct, because Tr is a work element that requires high power compared to other work elements. However, if it is seen from Figure 3 Tr and Mi, the activities are not significantly different, because it stays in the same category of fatigue level.

Swedish Occupational Fatigue Inventory (SOFI) is a measuring tool used to measure the level of fatigue using a subjective approach. This measuring instrument considers fatigue into several dimensions. SOFI initially consisted of 25 criteria, which it represented into five factors, namely lack of energy (LE), physical exertion (PE), physical discomfort (PD), lack of motivation (LM), and sleepiness (S). Physical factors are seen in the dimensions of physical exertion (PE) and physical discomfort (PD). While the lack of motivation (LM) and sleepiness (S) take into account mental factors. While the lack of energy (LE) is more general in defining the dimensions of fatigue, including both physical and mental factors. The five factors are interconnected to one another.

Measurement of fatigue with SOFI questionnaire is distinguished in the cutting (Ct), transporting (Tr) and milling (Mi). Questionnaires are measured after participants have completed the activity. The measurement results are displayed in the following Figure 4.

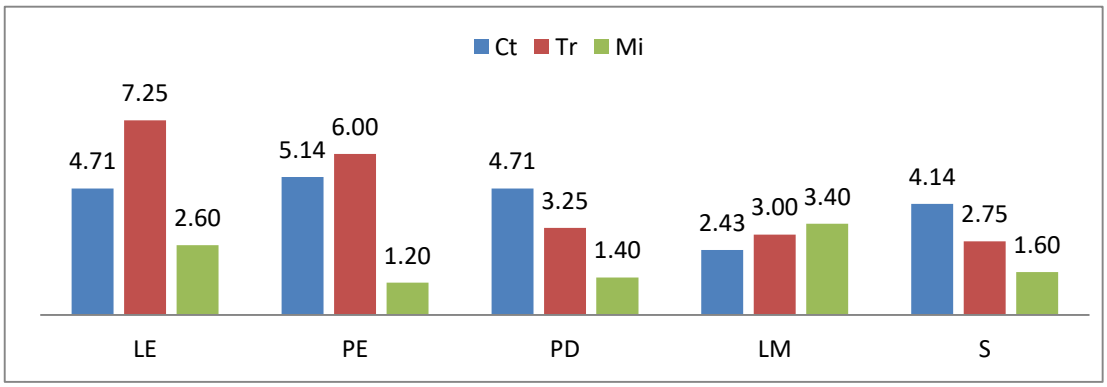

Figure 4. Graph of fatigue level SOFI

Table 3. Significant for each dimension

Dimension	p-value
LE	0.007*
PE	0.014*
PD	0.035*
LM	0.721
S	0.073

*significant at level α = 0.05

Table 4. IRHR; LE; PE; PD; LM; S Correlations

	IRHR	LE	PE	PD	LM
LE	0.660				
	0.016*				
PE	0.370	0.826			
	0.413	0.022*			
PD	-0.611	-0.462	-0.035		
	0.145	0.297	0.941		
LM	-0.281	0.252	0.298	0.536	
	0.541	0.586	0.517	0.214	
S	-0.490	-0.570	-0.424	0.270	-0.210
	0.264	0.181	0.343	0.558	0.652

Cell Contents
Pearson correlation
Signification level with α=0.05

The value obtained from the questionnaire was tested to see the significance of the difference in the level of fatigue in each work element obtained the following results (Table 3). The results of the questionnaire showed that the significant differences in the dimensions of physical fatigue consists of Lack of Energy (LE), Physical Exertion (PE), Physical Discomfort (PD) with the general transportation (Tr) showing the highest fatigue and the lowest work element was milling. The subjective fatigue dimension, Lack of Motivation (LM) and Sleepiness (S), does not show a significant difference, this is allegedly because the activities carried out dominantly require physical work, not mentally work.

The level of fatigue that results from the objective and subjective methods is performed to correlation test in order to determine the interrelationship between the measuring instruments. Following are the results of the correlation test. Based on table 4, the strong relationship and positive corelation is taken by both LE in SOFI and IRHR. The data shows that the strongest corelation is done by lack of energy.

4. Conclusions

As a result, the fatigue used to effect on work accident can calculate with objective approach and subjective approach. The objective approach uses qualitative workload calculation and fatigue level. While SOFI is the tool that used to subjective approach. Based on the both approaching objectively and subjectively, the transportation (Tr) resulted the highest point. By the case, the activity that have to concern progressively is the transportation (Tr) because it effects on Lack of Energy (LE), Physical Exertion (PE) and Physical Discomfort (PD).

Acknowledgments

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References

[1] Djulin AM., N. Syafaat, and Kasryno. 2005. Perkembangan Sistem Usahatani Jagung. Jakarta (ID): Badan Litbang Pertanian. 73-99.
[2] BPS (Badan Pusat Statistik). 2015. Available: bps.go.id [Accessed on 10 October 2018].
[3] Syuaib MF and Shimizu H. 2002. Ergonomic study on the process of mastering tractor operations rotary tillage operation using walking type tractor. Journal of JSAM 64 (4) : 61-67.
[4] Fil'aini R. 2017. Studi ergonomika untuk pemodelan sistem tata kerja pada produksi beras yang berkelanjutan (Studi komparasi pada sawah organik dan konvensional). [tesis]. Bogor (ID): Institut Pertanian Bogor.
[5] Syuaib MF et all. 2012. Laporan hasil kajian ergonomika untuk penyempurnaan sistem dan produktivitas kerja panen-muat sawit di kebun PT Astra Agro Lestari. Bogor (ID): Institut Pertanian Bogor.
[6] Syuaib MF. 2015. Anthropometric study of farm workers on Java Island, Indonesia, and its implications for the design of farm tools and equipment. Applied Ergonomics (51): 222-235.
[7] Syuaib MF. 2003. Ergonomic study on the process of mastering tractor operation. [dissertation]. Tokyo (JP): Tokyo University of Agricultural and Technology.