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Effect of Field Speeds of Rice Combine Harvester on Grain Loss: A Preliminary Evaluation in Malaysian Paddy Fields

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Abstract
Combine harvester is one of the important farm machinery that universally used in rice harvesting to overcome the labor shortage problem in Malaysian paddy fields. The machine is generally used in the harvesting of rice in the rice granaries of the country. However, the excessive grain loss during rice harvesting in Malaysia is still problematic. Among the factors of causing the significant grain loss is the field speed of the combine harvester. A preliminary study was conducted to investigate the effect of combine field speeds on grain loss in Malaysia paddy fields. This study was able to determine the most suitable combine field speed in rice harvesting with minimum the grain losses. The field speeds have a linear relationship with grain loss. The best speed with was found to be 3.87 km/hr, which contributes only 0.67 % grain loss or equal to RM8.04/ha of profit losses. Conclusively, the results can encourage the improvement of mechanization quality in rice harvesting and help in reducing rice farmer's profits losses.

Keywords: combine harvester, grain loss, mechanization, paddy cultivation, harvesting

Introduction

Utilization of combine harvester is becoming a success solution to overcome shortage of labor for harvesting paddy in Malaysia. To date, the machines are commonly being operated to harvest almost all rice fields throughout rice granaries in the country. However, the persistent issue in mechanized paddy harvesting using combine harvester is that how to minimize the grain loss.

Consequently, in order to reduce grain loss, the factors that cause extreme grain loss should be identified. One of the factors that have been studied that give excessive of grain loss during harvesting is the field speed of combine harvester. For minimizing grain loss, Mansouri and Minaei (2003) suggested the field speed of combine harvester should be in-between 1.25 km/hr to 1.50 km/hr. They said field speed affects the grain loss. The grain loss increased with increasing field speed of combine harvester during harvesting. Hunt and Wilson (2016) admitted that the most significant factor to maximize the combine harvester performance is field speed. When the field speed of combine harvester is too fast, it increased the field efficiency, but decreased the material capacity as there is grain spill out on the ground. Therefore, proper combine field speed can minimize the grain loss.

Nowadays it is believed that many operators of combine harvesters in Malaysia do not yet give great attention on the effect of field speed of combine harvester on grain loss. Even it is not yet known the current field speed of combine harvester applied by the operators in the fields and how its effects on the grain loss because no the suitable standard field speed for combine harvester operation in Malaysia revealed in the research literatures. The available field speed of self-propelled combine harvester provided by the American Society of Agricultural and Biological Engineers (ASABE) suggests the typical field speed should be 5.0 km/hr, and within the ranges of 3.0 km/hr to 6.5 km/hr (ASABE Standards, 2011).

Thus, there is a need to investigate the effect of current field speed of combine harvester on grain loss in Malaysian paddy fields. This paper is a preliminary attempt to evaluate current field speed of combine harvester and its effect to the grain loss. Current field speeds practiced by the operators in paddy fields were measured and evaluated. This study would hopefully lead to the findings of the best field speed of combine harvester with lowest grain loss during the harvesting of paddy under Malaysian conditions.

Materials and methods

This preliminary study was conducted through direct field measurements on daily harvesting operations at Bagan Serai, Perak state of Malaysia from July to September 2017. The fields were planted with certified paddy variety MR 220 and were divided into three plots. A New Holland Clayson 1545 combine harvester was operated in the study area. Details of specifications of the combine harvester used in the study are in Table 1. The paddy age was 110 days old, and average ambient temperature was 32 ˚C. Grain moisture was in the ranges of 5 to 10%, while mean soil moisture content was 3.45%. The perpendicularly position of planted paddy to ground was averaged at 88˚ tilt angle. The field speed of

combine harvester was measured based on the time taken by the combine harvester at 30 m travel distance. The travel distance was measured with a measuring tape and the time spent was counted with a stop watch. Such operation was replicated in three times for each plot in order to obtain the average field speed of combine harvester for three days duration. The effective field speed was calculated by dividing the travel distance by time required to travel within that distance. As for the measured the grain loss, five quadrats with an area size of 1m x 1m were placed randomly inside each plot. The average loss per plot was measured and calculated. Spreadsheet software was used to analyze the collected data. Correlation analysis was made to explain the relationship between fields speed and grain loss.

Table 1. Specifications of the Combine Harvester

Brand	*New Holland*
Model	*Clayson 1545*
Engine type (model/version)	*2715E*
Engine capacity	*6220 cm3*
Power	*96 kW*
Engine fuel tank	*250 L*
Header width (working)	*457 cm*
Reel diameter	*107 cm*
Diameter of cylinder threshing mechanism	*60 cm*
Width of cylinder threshing mechanism	*127.5 cm*
Maximum speed	*21.4 km/hr*

Results and discussion

Table 2 shows the highest loss related to maximum field speed and vice versa. Generally, the grain loss in the study area ranged from 0.83% to 2.50%.The highest value of grain losses is 2.50 %, 2.20 %, and 1.80 % were recorded at field speeds of 6.11 km/hr and 5.81 km/hr. These losses caused profit losses amounting to RM30/ha, RM26.40/ha and RM21.60, respectively. The field speeds of 3.87 km/hr and 3.97 km/hr resulted in the lowest grain losses of 0.83 % and also the lowest profit losses, which accounted for RM8.04/ha. In spite of this, generally all the replications showed an increasing trend in the grain loss with respect to the increase in forward speed from 3.87 km/hr to 6.11 km/hr. It is obvious that more vibration occurred in the header unit of the combine harvester as the field speed increased. Moreover, the incompatibility between the reel speed and field speed of the combine harvester also increased the amount of grain scattered from the spikes.

As found by Stephen (1981), who informed that grain loss in the cutting, threshing, separation, and cleaning units would be increased by increasing field speed of combine harvester. The extreme field speed of combine harvester could lead to push out dry spikes forward, breaking grain, and also spill out some of grain to the ground which may increases the losses (Ramadan, 2010). The current findings agree with the pervious findings of many researchers, such as Ali et al., (1990) who studied about a self-propelled rice combine harvester. They reported that rising travel speed from 0.80 to 2.90 km/h may also increase grain loss. The same thing also has been reported by Qarnar-uz-Zaman (1992), who proved that losses increased as increasing field speed. Junsiri & Chinsuwan (2009) also indicated that head grain loss increased with increase in reel rotational speed. While Mansoori & Minaee (2003) said that there is the effect of field speed on header loss, and it indicated that header loss increased thru increasing field speed.

Figure 1 shows the relationship between field speed and grain loss. The regression data in the graph was almost certainly defined as a straight line. It means that the effect of field speed as dependent variable on grain loss was very strong positive, where the higher field speed of combine harvester, the higher grain loss. To predict the grain loss, a simple mathematical model was also successfully developed from the regression analysis as shown in Equation (1):

$$GL=0.6873FS-1.966 \qquad r^2 = 0.9402 \qquad (1)$$

Where:
GL = estimated grain loss (%)
FS = field speed of combine harvester (km/hr)

Having r^2= 0.9402, this model proves a strong relationship between variables and it can be considered as highly acceptable model.

Table 2. Field Speeds of Combine Harvester and Grain Loss

Day	Field speed (km/hr)	Grain loss (%)
	6.11	2.50
	6.11	2.20
1	5.81	1.80
	4.25	1.00
	4.25	1.20
Average	5.31	1.74
	4.51	1.20
	4.51	1.00
2	3.97	0.83
	5.22	1.50
	5.22	1.70
Average	4.67	1.25
	4.41	1.00
	4.41	1.00
3	3.87	0.67
	4.14	0.83
	4.14	0.83
Average	4.19	0.87

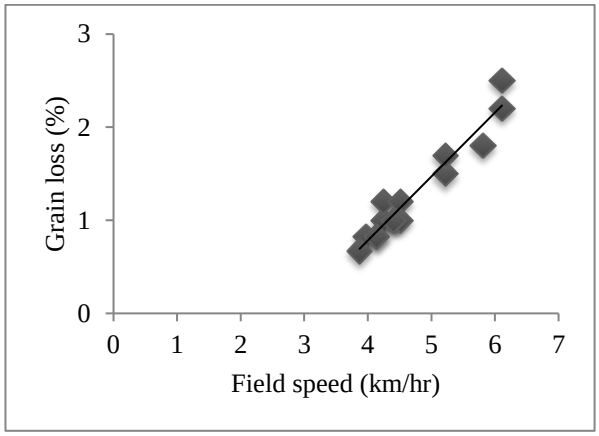

Figure 1. Relationship between field speeds of combine harvester with grain loss

Conclusions

A study to investigate the current effect of field speed of combine harvester on grain loss in rice harvesting in Malaysian paddy fields has been successfully conducted. This study proved that the field speeds of combine harvester affect the grain loss during harvesting. The best field speed was found to be 3.87 km/hr, which significantly gave the lowest grain loss around 0.67%, which also contribute to the profits losses of RM8.04/ha. The field speeds were suggested to be not more than 6.11 km/hr since it can give 2.50% of grain loss or equal to the highest profit losses of RM30.00/ha.

As the results revealed the grain losses increased with increasing of combine harvester's field speed. Therefore, important to educate the operators about the field speeds range in order to increase the farmers' profits. In order to minimize grain loss with mechanized harvesting, the relevant government agency was suggested to improve the extension services such as regular training to the combine harvesters' operators. It was also advocated to enhance the operators' awareness in regards to the importance of grain loss on the economic viability among farmers. The findings of this current study enriched knowledge in management of grain loss with mechanized rice harvesting. In fact, the results can also encourage the improvement of mechanization quality in rice harvesting and help in reducing rice farmer's profits losses.

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