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Field performance comparison of the combine harvesters utilized for rice harvesting in Malaysia

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Abstract

A large combine harvester has long been used for harvesting rice in Malaysia. Recently, a mini combine harvester has been introduced into this industry to be a low-cost alternative for a large combine harvester. Thus, this study was carried out to compare the field efficiency (FE), effective field capacity (EFC), fuel consumption (FC), and field machine index (FMI) between a mini combine harvester (MCH) and large combine harvester (LCH) under similar field conditions. The field performances of the combine harvesters were measured during harvest operation in two consecutive seasons. The EFC for both MCH and LCH in harvest operation were found to be 0.91 and 1.30 ha/hr, respectively. In terms of the FE, MCH had 0.78% higher efficiency than LCH. For the FMI, LCH and MCH had 0.86 and 0.87, respectively. For the FC, LCH consumed more fuel (14.51 L/ha) as compared to MCH (14.25 L/ha). T-test statistical analysis showed that there was no significant difference between LCH and MCH for FE, EFC, FMI and FC. The results suggested that MCH was more efficient and economical in conducting the harvest operation in a rice field.

1. Introduction

Rice is one of the most important crops in Malaysia because it is a staple food for the people in the country (Ramli *et al.,* 2012). Malaysian farmers supply 1.69 million metric ton of rice which were harvested from 675,000 hectares of rice granaries throughout the country, with an average yield of 2.50 metric ton per hectare in 2011 (Wailes and Chaves, 2012). However, due to the total domestic consumption of rice is estimated to be around 2.3 million ton yearly, the current rice self-sufficiency level (SSL) in Malaysia is only fulfilling 73% of the target (Raziah *et al.,* 2010). Due to that, this country still needs to import rice from other countries, such as Thailand, Vietnam and India.

Harvesting is one of the most important operations in rice production. Traditionally, this operation was regarded as a labor-intensive operation in the process of rice cultivation (Bautista, 2005). However, rice production in Malaysia faces the labor shortages problem due to the difficulty of getting people who are willing to work in this sector (Adam and Pebrian, 2017). Therefore, a combine harvester has long been introduced to mechanize rice harvesting system in an effort to tackle the labor shortage in Malaysian rice production. A well-designed combine harvester can play an important role in harvesting rice in time, efficiently and at low cost.

Typically, rice harvesting contractors use a large combine harvester to harvest rice in Malaysia. However, the use of a large and heavy combine harvester in a rice field could damage the soil and break the hardpan. Recently, several rice harvesting contractors have initiated the use of a mini combine harvester which is smaller and lighter than the large combine harvester. However, there is no scientific study was undertaken to compare the performance of these combine harvesters in Malaysia. Bawatharani *et al.* (2015) claimed that the performance of any combine harvester varied with respect to the field and the machine operational conditions. Thus, several investigations with different types of paddy varieties at various field conditions were needed to study the performance of different types of

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combine harvesters to optimize the operational factors (Chegini, 2013; Hossain *et al*., 2015).

Therefore, the purpose of this study was to compare the field performances between a mini and large combine harvesters under similar field conditions in Malaysia. The specific objective of this study was to measure the field efficiency (FE), effective field capacity (EFC), fuel consumption, and field machine index (FMI) of both types of the combine harvesters.

2. Materials and methods

2.1 Study area

This research was conducted at two different rice fields (Field A and Field B), located at Jitra, Kedah, Malaysia. Each field was divided into two equal plots namely plot 1 and plot 2. One plot was allocated for a mini combine harvester (MCH) and another plot for a large combine harvester (LCH). After identifying the location of the site, the coordinate of each location was taken using GPS Trimble Juno 3b. The experiments were conducted in two consecutive harvest seasons.

2.2 Combine harvester

There were two types of combine harvesters used in this study namely LCH and MCH. There were two combine models were chosen for the LCH namely New Holland 1545 (Figure 1) and New Holland 8070 (Figure 2). For the MCH, it was represented by Kubota DC-95M (Figure 3). The selection of these three different models was made since these models were predominantly used by contractors in this state. Table 1 shows the information of study areas with their respective combine harvesters. The specifications of combine harvesters are shown in Table 2.

2.3 Methods

2.3.1 Measurement of the operation times

Time consumption during harvest operation was manually measured using a stopwatch. The times that were recorded including the starting and stopping time. Duration for the combine harvester to perform straight driving and cornering were also recorded. This data was important to calculate the time losses during harvest operation (Sattar, 2015).

Figure 1. Typical large New Holland combine harvester model 1545

Figure 2. Typical large New Holland combine harvester model 8070

Figure 3. Typical mini Kubota combine harvester model DC-95M

Table 1. Machinery information for the study area

Location	Plot	Model of Combine	Area (ha)
Field A	1	New Holland 1545	0.39
	2	Kubota DC-95M	0.39
Field B	1	New Holland 8070	0.74
	2	Kubota DC-95M	0.74

Table 2. Specification of the combine harvesters

Specification	Type of Combine Harvester		
	New Holland 1545	New Holland 8070	Kubota DC-95M
Maximum engine power, kW	96	103	75
Implement width, m	3.58	4.57	2.48
Total body mass, kg	6450	8240	3550
Footprint area, m^2	1.52	1.07	1.95
Total contact pressure, kg/m^2	4243.42	7700.93	1820.51
Total contact area pressure, kPa	41.61	75.52	17.85

2.3.2 Determination of fuel consumption

The fuel of the combine harvesters was fully refilled before harvesting operation was started. The amount of fuel consumption of the combine harvesters was determined by measuring the difference of the fuel inside the fuel tank before and after the operation (Abdallah, 2008). In order to have comparable data on fuel consumption, a gear combination of each combine harvester was also recorded.

2.3.3 Determination of field efficiency

Field efficiency (FE) was defined as the percentage of time when the machine is operated at its full rated speed and width in the field (Nasri, 2015). FE described how effective the time was spent to do the work (Grisso, 2014). Because of the headland turns, machine trouble, ground surface and overlapping, the FE for an actual field operation was always less than 100% (Zandonadi, 2012). FE was determined as follows:

$$FE = \frac{EFC}{TFC} x\ 100 \qquad (1)$$

Where FE = field efficiency (%); EFC = effective field capacity (ha/hr); TFC = theoretical filed capacity (ha/hr)

The ability of a combine harvester to harvest rice under an actual field condition can be defined as an effective field capacity (EFC) (Zhou, 2012). EFC was calculated using the formula:

$$EFC = \frac{A}{Tp+T} \qquad (2)$$

Where A = area covered (ha); Tp = productive time (hr); and T = non-productive time (hr) such as breakdown in a field

2.3.4 Determination of field machine index

Field machine index (FMI) was the index that indicates the turning effectiveness of a combine harvester. As the value of FMI was higher, it was indicated that the turning time of the combine harvester was low (Shamshiri *et al.,* 2013)

$$FMI = \frac{EOT}{(EOT+Turning\ point)} \qquad (3)$$

Where EOT = effective operation time in second.

3. Results and discussion

3.1 Field efficiency

The averages of FE from two measurements in two seasons were shown in Figure 4. It was found that the FE for the MCH and LCH were 86.53% and 85.75%, respectively. The FE for the MCH was 0.78% higher than the LCH, indicating that the MCH more efficient in terms of time consumption in conducting harvesting operation. This finding is supported by the fact that the FE increases as the width of the implement decrease (Hanna, 2016). In this study, the widths of the cutter bar for the MCH and LCH were about 2.48 m and 4.57 m, respectively. According to t-test results shown in Table 3, the value of t stat and t critical two-tail were -0.21 and 3.18, respectively. There was no significant difference between LCH and MCH in terms of FE since the value of t stat was lower that the value of t critical two tail.

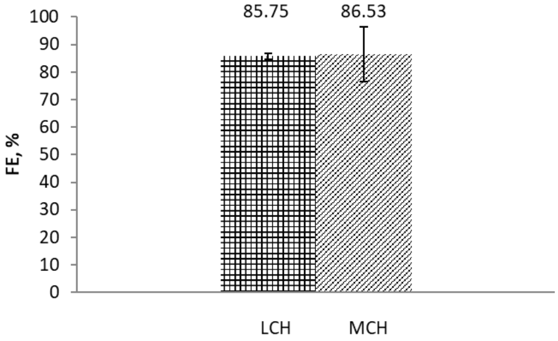

Figure 4. Field efficiency for harvesting operation

Table 3. T-test results for field efficiency

Field Efficiency (FE)		
Type of combine	LCH	MCH
Mean	85.75	86.53
Variance	4.92	66.45
T-Stat	-0.21	
P(T<=t) two-tail	0.85	
T Critical two-tail	3.18	

3.2 Effective field capacity

The averages of EFC from field measurements in two seasons were shown in Figure 5. Figure 5 shows that the EFC of the LCH was 1.30 ha/hr, 0.39 ha/hr (30%) higher than the EFC for the MCH of 0.91 ha/hr. This is acceptable because the MCH has a shorter cutter bar as compared to the LCH. Hossain *et al.,* (2015) reported that the EFC of a combine harvester would decrease when the width of the implement decreased. According to t-test results shown in Table 4, the value of t stat and t critical two-tail were 2.84 and 3.18, respectively with 0.05 alpha value. This indicates that there was no significant difference between LCH and MCH in terms of EFC since the value of t stat was lower than the value of t critical two tail.

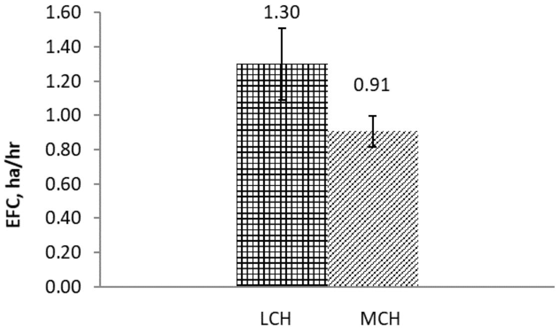

Figure 5. Effective field capacity for harvesting operation

Table 4. T-test results for effective field capacity

Effective Field Capacity (EFC)		
Type of combine	LCH	MCH
Mean	1.30	0.91
Variance	0.04	0.01
T Stat	2.84	
P(T<=t) two-tail	0.07	
T Critical two-tail	3.18	

3.3 Fuel consumption

Figure 6 shows that LCH consumed 14.51 l/ha of fuel while MCH only consumed 14.25 l/ha of fuel. This data indicated that the LCH consumed 0.26 L/ha fuel more than MCH under typical field conditions. This is true because a bigger engine will typically consume more fuel. In this study, based on Table 2, is it proven that the engine power of the LCH was higher than the MCH thus it consumed more fuel. According to t-test results shown in Table 5, the value of t stat and t critical two-tail were 0.13 and 3.18, respectively with the alpha value of 0.05. There was no significant difference between LCH and MCH for fuel consumption since the value of t stat was lower that the value of t critical two tail.

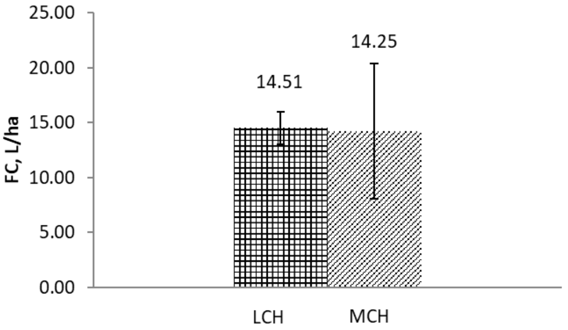

Figure 6. Fuel consumption for harvesting operation

Table 5. T-test results for fuel consumption

Fuel Consumption (FC)		
Type of combine	LCH	MCH
Mean	14.51	14.25
Variance	4.30	25.75
T Stat	0.13	
P(T<=t) two-tail	0.90	
T Critical two-tail	3.18	

3.4 Field machine index

According to the data shown in Figure 7, field machine index (FMI) for the MCH was 0.87 while for the LCH was 0.86. The MCH was found to have relatively higher FMI value as compared to the LCH. This is because the MCH needed to do more cornering as compared to the LCH due to its shorter cutter bar. However, it was observed that the MCH could have higher field speed as compared to LCH. According to t-test results shown in Table 6, the value of t stat and t critical two-tail were -0.21 and 3.18, respectively with alpha value of 0.05. There was no significant difference between LCH and MCH for FMI since the value of t stat was lower the value of t critical two tail.

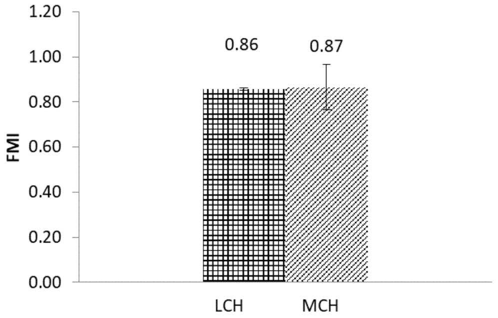

Figure 7. Field machine index for harvesting operation

Table 6. T-test results for field machine index

Field Machine Index (FMI)		
Type of combine	LCH	MCH
Mean	0.86	0.87
Variance	0.00	0.01
T Stat	-0.21	
P(T<=t) two-tail	0.85	
T Critical two-tail	3.18	

4. Conclusion

The EFC for the both LCH and MCH in harvest operation were 1.30 ha/hr and 0.91 ha/hr, respectively. In terms of FE, the MCH had 0.78% higher efficiency as compared to the LCH. Meanwhile, the FMI for the LCH and MCH were 0.86 and 0.87, respectively. For the FC, the LCH consumed 0.26 L/ha more fuel than the MCH. The results suggested that the MCH was more efficient in conducting the harvest operation in a rice field. Besides that, the MCH consumed less fuel than the LCH. The time loss of the MCH in conducting the harvesting was less as compared with the LCH since FMI values for the MCH was the highest. However, statistically, there were no significant differences between the LCH and MCH in terms of FE, EFC, FC and FMI.

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References

Abdallah, B.A. (2008). Effect of Ploughing Depth and Speed of Three difference tractors. Khartoum, Sudan: University of Khartoum, BSc. Thesis.

Adam, N.S. and Pebrian, D.E. (2017). Factors affecting farmers' satisfactions with mechanized rice harvesting in Malaysian paddy fields: A case study of hiring custom operators. *Agricultural Engineering International*, 19(2), 120–128.

Bautista, E.U. and Javier, E.F. (2005). The Evolution of Rice Production Practices the Evolution of Rice Production Practices. Discussion Paper Series No. 2005-14. Phillipines: Philippine Institute for Development Studies

Bawatharani, R., Dharmasena, D.N.J.D.A.N. and Bandara, M.H.M.A. (2015). Field Performance of a Conventional Combine Harvester in Harvesting Bg-300 Paddy Variety in Batticaloa, Sri Lanka. *International Journal of Engineering Research*, 5013 (4), 33–35. https://doi.org/10.17950/ijer/v4s1/108

Chegini, G.R. (2013). Determine of Optimum Operating Conditions of Combine Harvester with Stripper-Header. *World Applied Sciences Journal,* 23(10), 1399–1407.

Grisso, R.D., Kocher, M.F., Adamchuk, V.I., Jasa, P.J. and Schroeder, M.A. (2004). Field Efficiency Determination Using Traffic Pattern Indices. *Applied Engineering in Agriculture*, 20(5), 563–572. https://doi.org/10.13031/2013.17456

Hanna, M. (2016). Estimating the Field Capacity of Farm Machines. Retrieved from Iowa State University website: https://www.extension.iastate.edu/agdm/crops/html/a3-24.html

Hossain, M.A., Hoque, M.A., Wohab, M.A., Miah, M.A.M., and Hassan, M.S. (2015). Technical and economic performance of combined harvester in farmers' field. *Bangladesh Journal of Agricultural Research*, 40(6), 291–304. https://doi.org/10.3329/bjar.v40i2.24569

Nasri, N.N., Nawi, N.M., Abdullah, N., Saripa, S. and Mat, R. (2015). Measurement of Field Efficiency for Different Field Operations in Sweet Corn Production. *Proceedings of the Technology and Innovation National Conference*, 1–6.

Ramli, N.N., Shamsudin, M.N., Mohamed, Z. and Radam, A. (2012). The Impact of Fertilizer Subsidy on Malaysia Paddy / Rice Industry Using a System Dynamics Approach. *International Journal of Social Science and Humanity*, 2(3), 213–219.

Sattar, M., Ali, M., Ali, L., Waqar, M.Q., Ali, M.A. and Khalid, L. (2015). Grain Losses of Wheat as Affected by Different Harvesting and Threshing Techniques. *International Journal of Research in Agriculture and Forestry*, 2(6), 20–26.

Shamshiri, R., Ehsani, R., Maja, J.M. and Roka, F.M. (2013). Determining machine efficiency parameters for a citrus canopy shaker using yield monitor data. *Applied Engineering in Agriculture*, 29(1), 33–41. https://doi.org/10.13031/2013.42526

Wailes, E.J., and Chavez, E.C. (2012). ASEAN and Global Rice Situation and Outlook. *ADB Sustainable Development Working Paper Series*, 22, 1–42.

Zandonadi, R.S. (2012). Computational Tools for Improving Route Planning in Agricultural Field Operations. Lexington, Kentucky: University of Kentucky, PhD Thesis.

Zhou, K., Leck Jensen, A., Bothtis, D.D. and Sørensen, C.G. (2012). Simulation modelling for in-field planning of sequential machinery operations in cropping systems. Denmark: Aarhus University, PhD Thesis.