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COMPARISON OF FIELD PERFORMANCE BETWEEN HALF-TRACK TRACTOR AND RUBBER WHEEL TRACTOR IN RICE PRODUCTION

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ABSTRACT

Better selection and management of the machinery in rice production is one of the key factors that can contribute to the management efficiency and increase in rice yield production. The purpose of this study was to determine field performances of rubber-wheeled tractor (RWT) and half-track tractor (HTT). The experiment was conducted in Jitra, Kedah under similar field conditions. The field performances of the tractors were measured during tillage operation in both wet and dry seasons. The effective field capacity (EFC) for both HTT and RWT in tillage operation were 0.6680 ha/hr and 0.6685 ha/hr, respectively. In terms of field efficiency, HTT was better in conducting the tillage operation, accounted for 10% increment, relative to the RWT. Meanwhile, field index for HTT and RWT were 0.882 and 0.885, respectively. For fuel consumption, HTT consumed less fuel compared to RWT which were 10.89 L/ha for HTT and 13.82 L/ha for RWT. The results suggested that, HTT was more efficient in conducting the tillage operation in a paddy field and relatively consumed less fuel than RWT.

KEYWORDS

Field performance, half-track tractor, rubber wheel tractor, field capacity, rice production

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INTRODUCTION

Rice cultivation is a very important industry in Malaysia because it falls under the food security program of the nation. Rice cultivation was categorized as one of the entry point projects (EPP) that was identified under the *National Key Economic Area (*NKEA). Under the EPP, the government aims to establish a long-term paddy production for food security and increase the income among the farmers through adoption of multi-machinery and technology application. The aim of the project was to raise the mean production from 5 MT to 8 MT per ha by 2020 (PEMANDU, 2010).

Land preparation is one of the important activities in rice cultivation in the view of energy consumption, cost of production and its impact on soil physical properties and crop yield (Meena et al., 2015). To reduce the operation timeline and cost of production, selecting appropriate machinery for tillage operation is a very important. Due to the nature of soil physical and mechanical conditions in paddy fields, it can cause many problems to utilize heavy tractors (Alizadeh et al., 2013). Calilung et al. (1989) examined three methods for paddy land preparation namely a mouldboard plough with comb harrow, mouldboard plough attached to tiller with comb harrow and rotovator. Results showed that rotovator was the most appropriate implement in the view of field performance and saving in fuel consumption. Total efficiency of farming operations was not merely investigated by power of 2 and 4 wheeled tractors, but there are other factors such as availability, size and shape of plots and location of a field that could affect tractor selection (Krouse, 1980).

Since field machinery comes in different sizes, types and functions, a proper performance testing prior to actual field application is important to make sure the field performance and operational cost of the selected machinery are at optimum level. Normally, field tests were conducted to evaluate the performance of different ranges of tractors under identical operating conditions (Muazu, 2014). The typical parameters evaluated during field testing of a tractor are travel reduction (wheel slippage), speed of operation, fuel consumption, effective field capacity, theoretical field capacity, field efficiency, and average width and depth of cut during ploughing operations.

Currently, there is no scientific study has been conducted to measure the performance of tractors in paddy field in Malaysia in order to guide farmers in selecting suitable tractor for land preparation. Thus, the objective of this study was to evaluate the field performances of half-track tractor (HTT) and rubber wheel tractor (RWT). This was done by comparing the field efficiency (FE), fuel consumption, and field machine index (FMI) of the tractors.

MATERIALS AND METHODS

Study area

This research was conducted at three different paddy fields located at Tunjang, Kedah. Each site location was divided into two equal plots namely plot 1 and plot 2. One plot was for a HTT and another plot was for RWT. After identifying the location of the site, the coordinate of each location was taken using GPS Trimble Juno 3b. Table 1 shows the information of study areas.

Table 1: Information of study area location

Location	Plot	Type of Tractor	Area (ha)
Pida 1	1	HTT	0.5190
	2	RWT	0.6370
Pida 2	1	HTT	0.3918
	2	RWT	0.3918
Pida 3	1	HTT	0.7441
	2	RWT	0.7441

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Tractor selection

Massey Ferguson Model 185 was used for all tillage operations on this study (Table 2). The implement of the tractor was a rotary tillage. For tillage operation, there were two types of tractor that had been operated at the field which were HTT (Figure 1) and RWT (Figure 2). Each tractor was operated by different operators.

Figure 1: Half-track tractor used for tillage operation at paddy field

Figure 2: Rubber wheel tractor used for tillage operation at paddy field

Field Test

GPS Garmin 64s equipment was deployed to record the tractor's path and average forward speed. In addition, timing for tillage operation was manually recorded during the operation. The times that was recorded were the starting, ending, and cornering time. Duration for the tractor for straight driving without any cornering was also recorded. This data was important in order to calculate the time losses during tillage operation. The fuel tank of the tractor was fully refilled before tillage operation was started. Fuel consumption of the tractors was recorded after each of the operation before the fuel was fully added for the next test (Abdallah, B. A., 2008). In addition to that, a few data were recorded such as implement cutting width, gear combination, and fuel consumption.

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Table 2: Tractors specification

Specification/Tractor type	RWT		HTT	
Part	Rear	Front	Rear	Front
Brand	Massey Ferguson			
Model	Massey Ferguson 185			
Maximum engine power (HP / kW)	75 HP (55.9 kW)			
Engine RPM	1701		1143	
Implement width, m	2.2			
PTO rpm	540 rpm			
Gear Selection	Low, 4		High, 1	
Total weight	2510		4130	
Total contact area pressure (kPa)	272		111	
Footprint area (m2)	0.21	0.04	1.11	0.09
Weight distribution (%)	80	19	83	14
Pressure (kpa)	114	158	35	76
Tyre diameter (m)	1.46	0.68	-	1.05
Track width (m)	-	-	0.69	-
Track length (m)	-	-	1.62	-

MEASUREMENT AND CALCULATION

Field Efficiency

Field efficiency was defined as the percentage of time the machine operated at its full rated speed and width while in the field (Nasri, N., 2015). Field efficiency described how effective the time was spent to do the work. Because of the headland turns, machine trouble, ground surface and overlapping, the field efficiency was always less than 100%. Field efficiency was determined as follows:

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

Where:

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

The ability of tractor and implement to perform each operation under an actual field condition can be defined as an effective field capacity (EFC). EFC was calculated using formula:

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

Where:

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

Field Machine Index (FMI)

Field Machine Index was the index that indicates the turning effectiveness of the tractors. As the value of FMI was higher, it was indicated that the turning time of the tractors was low.

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

Where:

EOT = effective operation time in second

RESULT AND DISCUSSION

Field Efficiency

In term of global data, HTT was more efficient in conducting tillage operation than RWT. Field efficiency was higher on the second tillage (T2) compared to the first tillage (T1). From contrast statistical analysis, there were significant difference between RWT at first tillage versus HTT at first tillage and both tractors for the first tillage versus both tractor for second tillage with F value ($\alpha = 0.05$) of 0.0306 and 0.0304 respectively.

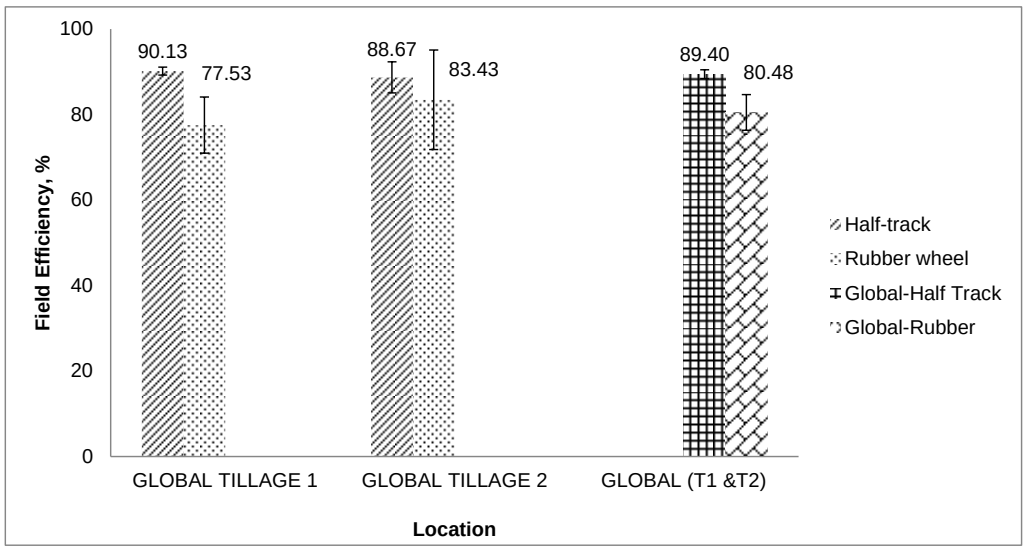

Figure 1: Field efficiency for Global Tillage 1, Global Tillage 2 and Global (T1&T2)

Fuel Consumption

RWT consumed more fuel compared to HTT according to the global data. In term of tillage, tillage 1 consumed more fuel compared to tillage 2. From contrast statistical analysis, there were a significant different between both tractors for the first tillage vs both tractors for the second tillage with F value ($\alpha = 0.05$) was 0.018.

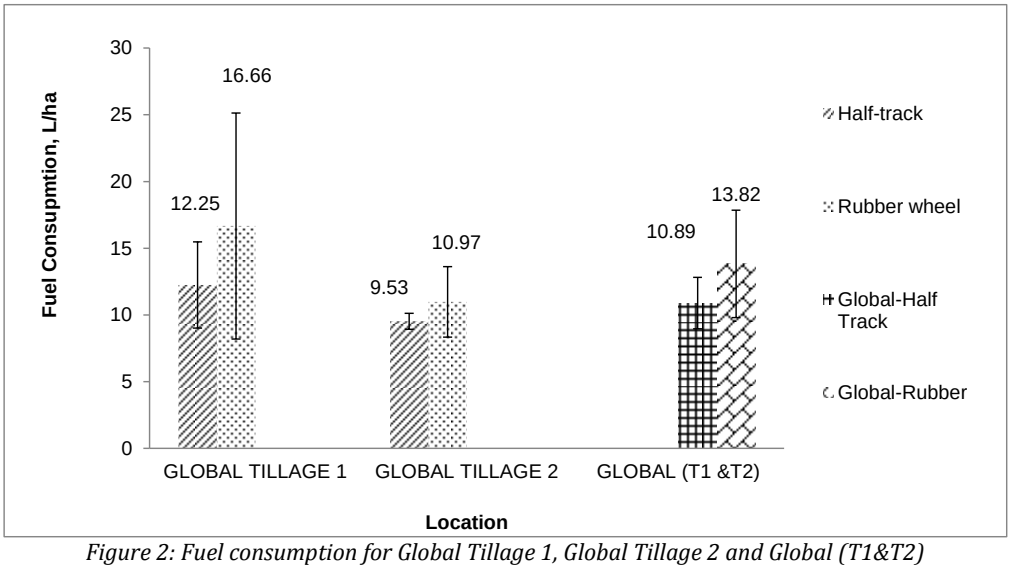

Figure 2: Fuel consumption for Global Tillage 1, Global Tillage 2 and Global (T1&T2)

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Field Machine Index

For global data, FMI for HTT and RWT was the same. Meanwhile, FMI was higher on tillage 2. From contrast statistical analysis, there were no significant different in all comparison.

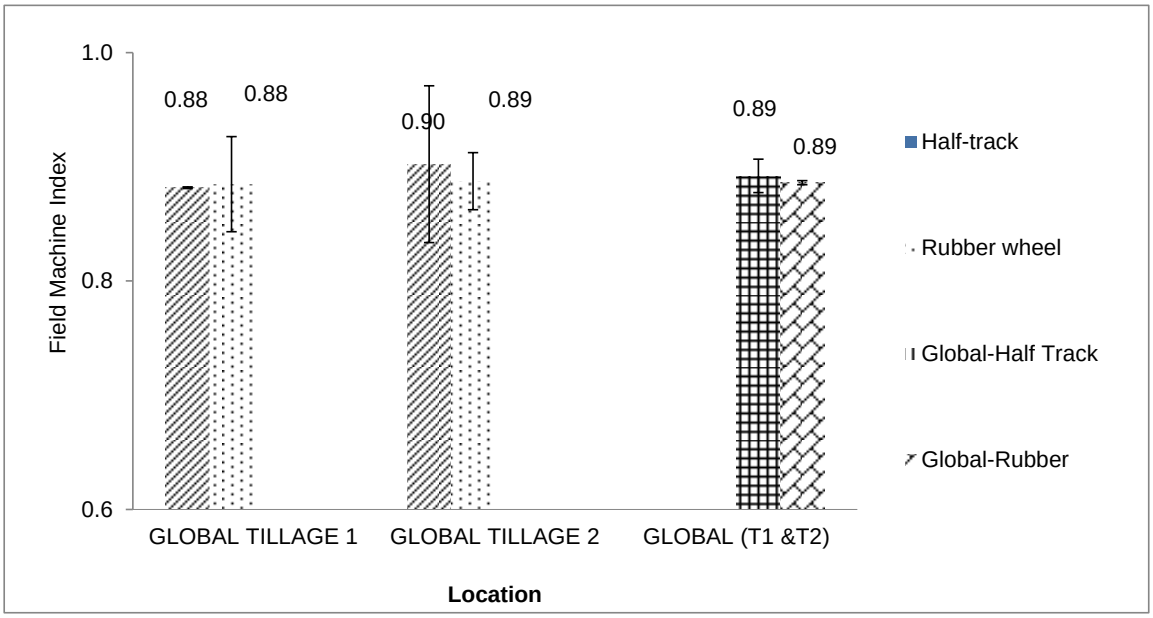

Figure 3: Field machine index for Global Tillage 1, Global Tillage 2 and Global (T1&T2)

CONCLUSIONS

From this study, it was found that the effective field capacity (EFC) for both HTT and RWT in the tillage operations were 0.6680 ha/hr and 0.6685 ha/hr, respectively. In terms of field efficiency, HTT was better in conducting the tillage operation, accounted for 10% increment, relative to the RWT. Meanwhile, field index for HTT and RWT were 0.882 and 0.885, respectively. For fuel consumption, HTT consumed less 2.93 L/ha fuel then RWT. The results suggested that, HTT was more efficient in conducting the tillage operation in a paddy field and relatively consumed less fuel than RWT.

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REFERENCES

1. Abdallah, B. A. 2008. Effect of Ploughing Depth and Speed of Three, 12(2): 17-22.
2. Ali, M., Amin, M., and Abdeshahi, A. 2012. Impact of mechanization on technical efficiency: A case study of rice farmers in Iran, 1(12): 176–185.
3. Alizadeh, M. R., and Allameh, A. 2013. Field performance of two and four wheeled tractors in paddy field preparation. Department of Agricultural Engineering, 2004: 298–305.
4. Calilung EG, Stickney RE. 1989. Comparison of tillage equipment for small rice farms. AMA 20(1): 9-16
5. Howard, C. N., Kocher, M. F., Hoy, R. M., & Blankenship, E. E. 2013. Testing the Fuel Efficiency of Tractors with Continuously Variable and Standard Geared Transmissions. Transactions of the ASABE, 56(3): 869–879

6. Krouse R. 1980. Tillage and energy demand: Irrigated crop production in semi-arid and arid regions. AMA 12(2): 17-22
7. Meena, J. R., Behera, U. K., Chakraborty, D., and Sharma, A. R. 2015. Tillage and residue management effect on soil properties, crop performance and energy relations in greengram (Vigna radiata L) under maize-based cropping systems. International Soil and Water Conservation Research, 3(4): 261–272
8. Muazu. A. 2014. Machinery Utilization and Production Cost of Wetland, Direct Seeding Paddy Cultivation in Malaysia. Agriculture and Agricultural Science Procedia, Volume 2: 361–369.
9. 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: 1–6.
10. Performance Management and Delivery Unit (PEMANDU). 2010. Agriculture. ETP Handbook: 513–550

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