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Energy Utilization and Greenhouse Gas (GHG) Emissions of Tillage Operation in Wetland Rice Cultivation

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Abstract: In Malaysia, wetland rice is cultivated over two cropping seasons: the main season, from June to November, and the off-season, from January to June. The aim of this study was to investigate tillage operations in rice production in relation to actual field operations and under real field conditions for two rice cultivation seasons. The results showed that 80.7%, 17%, and 2.3% of the total time was spent on the actual operation, turning time, and reversing time, respectively. The results also showed that the mean effective field capacity, field efficiency, and fuel consumption were 1.2 ha/h, 80%, and 7.6 L/ha, respectively. The distribution of energy used in the first, second, and third tillage passes amounted to 37%, 33%, and 30% of the total energy, respectively. Fuel, machinery, and total GHG emissions were 62.4, 7.6, and 70 kg CO_2eq/ha, respectively. Fuel represented the highest contributor of energy expenditure and GHG emissions. The distributions of GHG emissions in the first, second, and third tillage passes were 37%, 32%, and 31% of the total GHG emissions. The results reveal that carrying out minimum-tillage operations led to a reduction in environmental impacts.

Keywords: field performance; energy use; greenhouse gas emissions; tillage operation; environmental impact

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1. Introduction

Rice is the most produced and consumed cereal in Malaysia [1]. The average amount of rice produced in Malaysia in 1968 was 1.4 million tons, which has increased by 57.2%, with 2.3 million tons produced in 2016. With proper infrastructural support and the development of new rice varieties by the government, the country's average yield increased from 2.9 tons/ha in 1980 to 3.8 tons/ha in 2014 [2]. Land preparation in rice cultivation is performed to provide suitable growing conditions for optimum plant establishment. The result of any good land preparation activity is the facilitation of effective weed control and the enhancement of water-use efficiency during the crop-growing season. Tillage is also a concern as it facilitates the movement of air and water through the breaking up and pulverization of soil [3]. Tillage operations in rice cultivation are used to enhance soil surface roughness and aerate soil by increasing porosity and stimulating the decomposition of crop residues. Hence, tillage is considered a key factor in optimizing growth. In rice cultivation, tillage usually takes place at least twice in one growing season. It consumes up to 59% of the total diesel required for all operations in crop production [4]. Performance data on tractors and implements constitute a crucial factor for the management of agricultural machinery; they facilitate and support the optimal selection of suitable tillage machines for a particular farm, which minimizes crop production energy input [5].

Although agriculture is considered a major producer and consumer of energy, agricultural production is positively related to energy input. Agricultural operations need