HYBRID POWER HERBICIDE SPRAYING VEHICLE

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830

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The invention is a lightweight three-wheeled utility farm vehicle equipped with a hybrid power electric sprayer system. The hybridisation lies on the two sources of energy connected in parallel either to charge a battery or to power the sprayer. The machine could carry up to 200 litres of water-chemical mixing at a time and able to undertake palm circle, strip or path spraying. Only one operator is required to handle the operation.

Several farm utility vehicles with herbicide spraying system have been adopted by the Malaysian oil palm plantation industry. However, most available technologies use secondary internal combustion engines for spraying and require more than two workers to conduct the activity (Pebrian and Yahya 2012). *Table 1* depicts the characteristic of an existing sprayer system on a utility vehicle. In average, about I litre of petrol is used for every ha of farm area sprayed and high-volume type nozzle is employed. Improvement in this specific agriculture activity could reduce chemical and fuel consumption.

TABLE 1. CHARACTERISTIC OF THE MECHANISED SPRAYER WITH PLUNGER PUMP AND ROBIN PETROL ENGINE FOR SPRAYING MECHANISM

Max. water capacity	**280 litre**
Spraying rate	3.5 litre min^{-1} to 4.5 litre min^{-1}
Average ratio of petrol fuel to water capacity	0.5: 200 or 1 litre of petrol for 400 litre of water

Farm vehicle with hybrid power system is one way of adopting electric power sprayer in a large plantation area and provides more effective spraying as compared to a mechanical control system. *Figure 1* shows the consistent trend of power and spraying rate of an electric power sprayer with low volume nozzle employed in the mechanised herbicide spraying activity. Thus, the system saves energy and chemical usage.

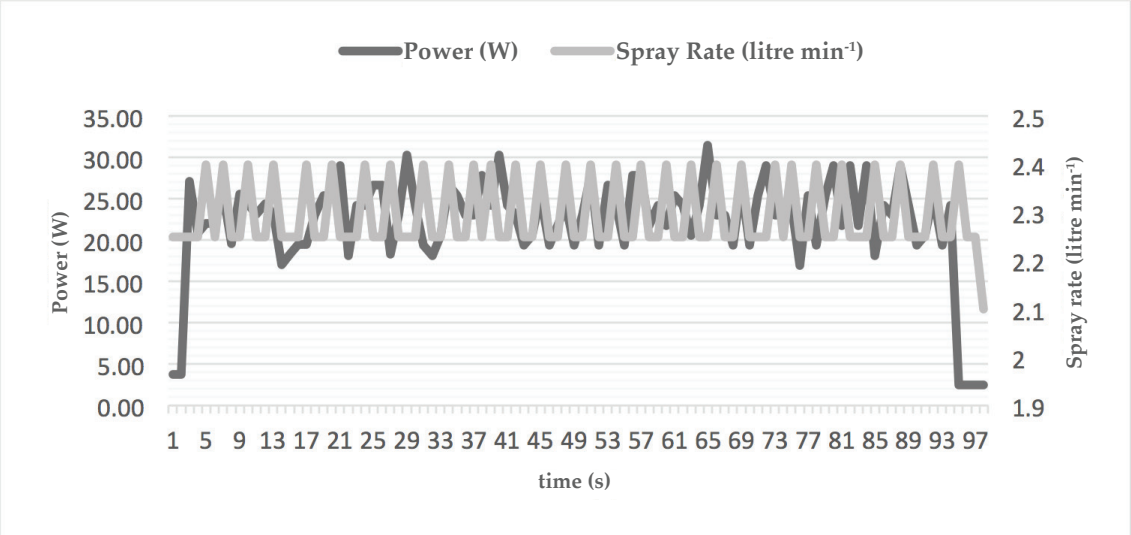

Figure 1. Power consumption of the electric DC pump at 3 bar pressure with 2.4 litres min^{-1} application rate.

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PROBLEM STATEMENT

The current practice of mechanised herbicide spraying in oil palm plantation operation requires additional fossil fuel power and more than two workers to undertake the activity. Furthermore, current utility vehicle concept unable to incorporate electric spraying system or could not cater electric load demand for the operation.

THE TECHNOLOGY

The Objective of the Technology

This project aims to develop a small footprint and lightweight utility type farm vehicle that is equipped with cleaner energy, which can reduce the fossil fuel utilisation, improve worker's productivity, reduce chemical used, and subsequently reduce the operational cost.

The Novelty of the Products/Technology

The novelty of this hybrid power spraying machine lies on its chassis design and its system to capture adequate energy for the intended purpose; as an herbicide spraying machine. The configuration was designed to reduce farm input energy during application, thereby saving more costs.

METHODOLOGY

Development of the Prototype

A three-wheeled utility farm vehicle was fabricated to assemble the proposed system. Specifications of the prototype are as depicted in *Table 2*.

A seven-horsepower air-cooled diesel engine with an electric starter and a rectifier generator was selected since the power is adequate to cater the proposed gross load of 400 kg based on the free force analysis (Azwan *et al*., 2017). *Figure 2* depicts the computational aided drawing (CAD) of the vehicle. The diaphragm pump is activated by a handle switch together with electric solenoids for left or right or both arm selection.

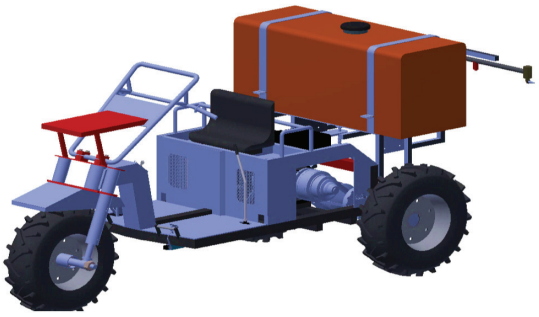

Figure 2. The Three-wheel type machine with a solar charging and electric spraying system.

In-field Test and Validation

From the beginning of May to the end of June 2018, a study on the prototype performance in the actual oil palm field was carried out for a duration of two months, covering almost 150 ha of the planted area. The trial indicated an excellent performance of the prototype and its productivity as depicted in *Figure 3*.

The result shows a significant improvement in productivity as compared to the manual labour of only 1-2 ha day^{-1} per operator and its productivity is almost similar with the existing mechanised spraying technology currently employed in the field, where the pressure water is pumped through a secondary fossil fuel engine.

TABLE 2. TECHNICAL SPECIFICATION OF THE PROTOTYPE

Technical Specification	Value
Dimension	240 cm (L) x 120 cm (W) x 125 cm (H)
Diesel engine	Brand Shohoku, Single cylinder air-cooled with rectifier generator and starter. 6.7 HP at 3600 RPM maximum
Weight without load	190 kg
Tyre	Off-road traction tyre size 6
Solar photovoltaic	12 V polycrystalline Venus Solar 10W – I_{max} 1.01 amp
Battery	Deep discharge 12V 100Ah.
Electric pump	Diaphragm pump -12V and 7 bar max.
Water tank capacity	180 litre
Transmission	CVT with a forward / rear transaxle
Turning radius	2.1 m

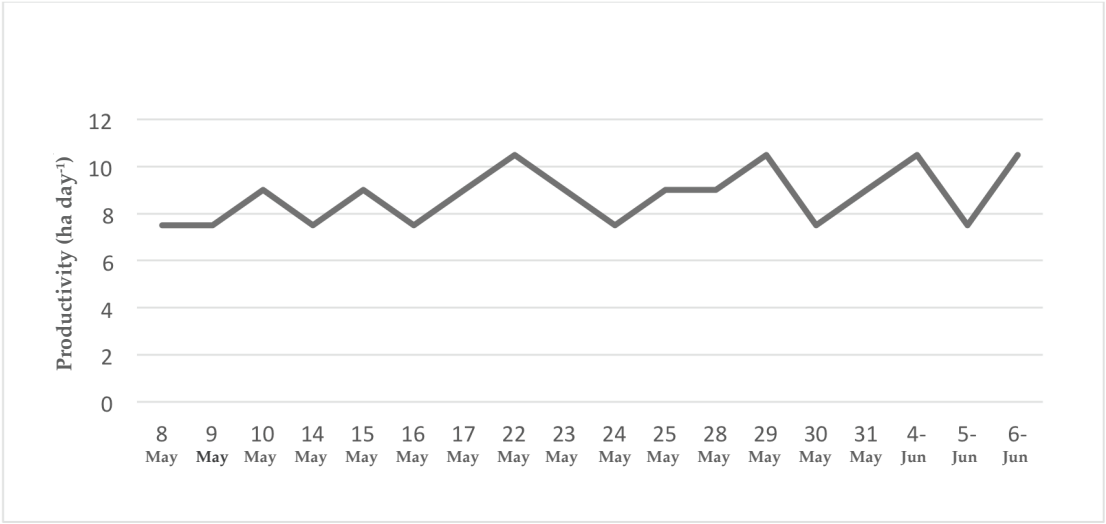

Figure 3. Productivity of the herbicide spraying (Average productivity: 8.5 ha day^{-1}).

BENEFITS AND ADVANTAGES

- Increase worker's productivity for the herbicide spraying or other farm maintenance activities;
- Improve corporate positioning of the oil palm plantation industry by utilising renewable energy source in the farm operations;
- Eliminate burden or risks posed to the workers associated with carrying the heavy and dangerous load for long working hours;
- Ergonomically design that improves working condition and safer application of chemical in the field;
- Lower operational cost as compared to other available technologies;
- Low cost of ownership since the continuous variable transmission is replacing the conventional and expensive gearbox;
- Lightweight and small footprint that enables the vehicle to move into the terrace and undulating area;
- Reduce energy consumption in carrying out the herbicide spraying activity and subsequently reduce operational cost; and
- The vehicle could be modified to carry out a load-hauling activity or other tasks.

ECONOMIC ANALYSIS AND COMMERCIAL BENEFITS/COMMERCIALISATION POTENTIAL

An economic feasibility study was conducted based on the ASABE standard (Azwan *et al*., 2017). A total material cost of RM20 000 was an indicative price based on the experience in developing the prototype and a 30% margin is assumed for the selling price. Data and assumption used for the analysis are based on the input gathered through the test and literature (Azwan *et al*., 2019). *Tables 3* and *4* showed the economic analysis, which is about RM7.35 hr^{-1} or RM7.82 ha^{-1}.

TABLE 3. AVERAGE OPERATIONAL COST PER HOUR

Item	Value
Salvage value (RM hr^{-1})	0.46
Tax, shelter and insurance (RM hr^{-1})	0.09
Interest on investment (RM hr^{-1})	0.09
Fuel cost (RM hr^{-1})	1.88
Repair and maintenance cost (RM hr^{-1})	0.28
Lubricant cost (RM hr^{-1})	0.05
Operator cost (RM hr^{-1}) @ 8 hr day^{-1}	4.5
Total (RM hr^{-1})	**7.35**

TABLE 4. AVERAGE OPERATIONAL COST PER HECTARE

Item	Value
Average daily productivity (ha day^{-1})	7.5
Effective field capacity (ha hr^{-1})	0.94
Total cost (RM ha^{-1})	**7.82**

IMPACT

It is envisaged that the developed technology could provide numerous advantages towards sustainable oil palm plantation operation in term of environment, low operational cost, ergonomic design, safer working condition, and reduction of the worker's requirement for the herbicide spraying. The utility vehicle can also be utilised for other farm duty applications.

IP STATUS

The IP application has been submitted, and the status is as follows:

- New Malaysia Patent Application No. PI2020000390.
- Filing Date: 23 January 2020.
- Applicant: Malaysian Palm Oil Board.
- Entitled: Utility vehicle.

CONCLUSION

In general, the hybrid power utility vehicle is technically and economically feasible for the mechanised spraying operation in oil palm plantation. The test and analysis carried out had justified the performance of the prototype. The benefit obtained is not only on the economic gain but also environmental advantages. No additional power such as secondary internal combustion engines or power take-off is required. About 8 ha day^{-1} of the productivity could be realised from the prototype with the low operational cost of RM7.35 hr^{-1} or RM7.82 ha^{-1}. Thus, in conclusion, the oil palm plantation operation could be efficiently managed by adopting mechanisation technology with cleaner energy consumption.

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