DEVELOPMENT AND PERFORMANCE OF MOBILE YIELD MONITORING SYSTEM

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ABSTRACT

Crop yield monitoring has been an essential part to precision agriculture technology. Yield monitoring systems not only provides detailed information about the yields of a specific plot but also provides information in crop management for the upcoming season. The objective of this paper is to evaluate a mobile-based yield monitoring system. The system comprises of a set of optical yield sensors, a grain moisture sensor, GNSS (Global Navigation Satellite System) receiver, a Bluetooth module and an Android-based tablet. The crop yield monitoring system was installed on a conventional tangential flow combine harvester. Experiments were conducted in a large-scale paddy field at MARDI Parit. The crop yield monitoring system was found to produce real-time mapping and data for rice yields and harvested paddy moisture. The accuracy of the readings obtained from the crop yield monitoring system was 95%. This mobile-based yield monitoring system has the potential to be used for determining yield in the fields.

Keywords: yield monitoring, yield mapping, precision agriculture, paddy harvesting, combine harvester

INTRODUCTION

Crop yield monitoring has been an essential part to precision agriculture technology. Yield monitoring system is a system that provides information based on Global Navigation Satellite System (GNSS) coordinates. Yield maps generated by this system are one of the most valuable sources of spatial data for precision agriculture (Ahmad & Mahdi, 2018). Shaheb et al. (2022) stated that yield monitoring is the first step towards precision farming because farmers can obtain specific information about yield based on the management and performance of existing crops. Yield monitoring is a real-time sensing of yield performed by sensors. Yield mapping shows spatially changing yield within a plot (Chung et al., 2017). To date, this technology is still considered new as it is introduced to inform farmers through mapping, the yield produced based on existing crop management, and actions that can be taken in terms of the use and application of plant inputs in the upcoming season to improve yield.

There are various types of yield monitoring systems available in the international market. This system is still considered new in Malaysia because the acquisition cost of this system is high and is suitable for use by harvesting service providers or estates managed aesthetically.

Typically, yield monitoring systems consist of components that can track coordinates using GNSS, sensors that can track the position or height of the cutting table during harvesting, sensors that can track the moisture of paddy before entering the paddy storage tank, and result sensors that can estimate the yield entering the tank based on GNSS coordinates. All of these sensors will send data to the touch screen display, which also functions as a real-time data reception and collection system. There are also yield monitoring systems that have additional sensors with their own functions, with additional costs.

A local yield monitoring system was developed by Kin et al.(2011). The system consisted of cutting table position sensors, cutting width sensors, weight-based yield sensors, moisture sensors for paddy, and loss sensors connected to the GPS system.

(Putri et al.(2016) developed a wireless yield monitoring system consisting of displacement sensors, moisture sensors for paddy, and yield sensors supported by the GPS system.

MARDI has installed a yield monitoring system on a re-conditioned combine harvester (Mohd Taufik et al., 2017). Initial tests have shown fairly accurate data, with an accuracy of 90% (Mohd Taufik et al., 2018).

The objective of this paper is to evaluate a mobile-based yield monitoring system.

MATERIAL AND METHODS

Machine

A conventional combine harvester of the dual tangent flow type has been used (New Holland TC5.30, Belgium). This harvester is equipped with a front drive system using a D4-type half track system, while the rear wheels are used for steering control.

Yield Monitoring System

There are several components in the Yield Monitoring System (FarmTRX, Canada) with specific functions, namely:

i) Optical Yield Sensors
A set of sensors installed on the clean grain elevator of the combine harvester that measures the time taken for the sensor to be obstructed by grain on the elevator's paddles. These sensors are positioned opposite to each other on the upper side of the elevator.

ii) Grain Moisture Sensor
Grain moisture was measured using this sensor which was placed at the bottom of the clean grain elevator.

iii) GNSS Receiver
A GNSS (Global Navigation Satellite System) receiver was used to log location data for each yield point reading.

iv) Bluetooth data logger
This data logger connects all the sensors of the system and transmits the data via Bluetooth connection to a display.

v) Mobile app
The mobile app, which is compatible with most Android or iOS devices, receives data from the data logger via Bluetooth connectivity. This app was used to input data such as harvester size and calibration data and to show real-time information such as crop yield, grain moisture and harvesting speed.

v) Display
A touch-screen Android tablet (Samsung S8, Korea)was used to ease calibration and settings of the system and also display real-time information of yield harvested.

Calibration of the Yield Monitoring System

The calibration of the yield monitoring system was carried out following standard procedures (ASABE, 2016). Calibration was performed at MARDI Parit, using four cutting widths: full cutting table, 75% cutting table, 50% cutting table, and 25% cutting table. The harvester harvested at a constant travel speed throughout the calibration test, which was 3.6 km/h over a distance of 50m. This method was replicated three times for each cutting width. Two parameters were measured: the weight of the collected grain in the tank and the grain moisture content. These data were recorded and entered into the touch screen display to obtain the calibration curve.

Field Test

The combine harvester with the calibrated yield monitoring system, performed a field test in a prepared paddy field. The system's performance was monitored on the data display shown on the touch screen, including yield data by location, grain moisture data by location, and harvester speed data by location. This data was displayed in numbers, showing both the harvested rice and the moisture content of the harvested paddy. The data was then uploaded to a cloud server (FarmTRX Web App, Canada) where data in the form of maps were generated based on location.

Post-processing data

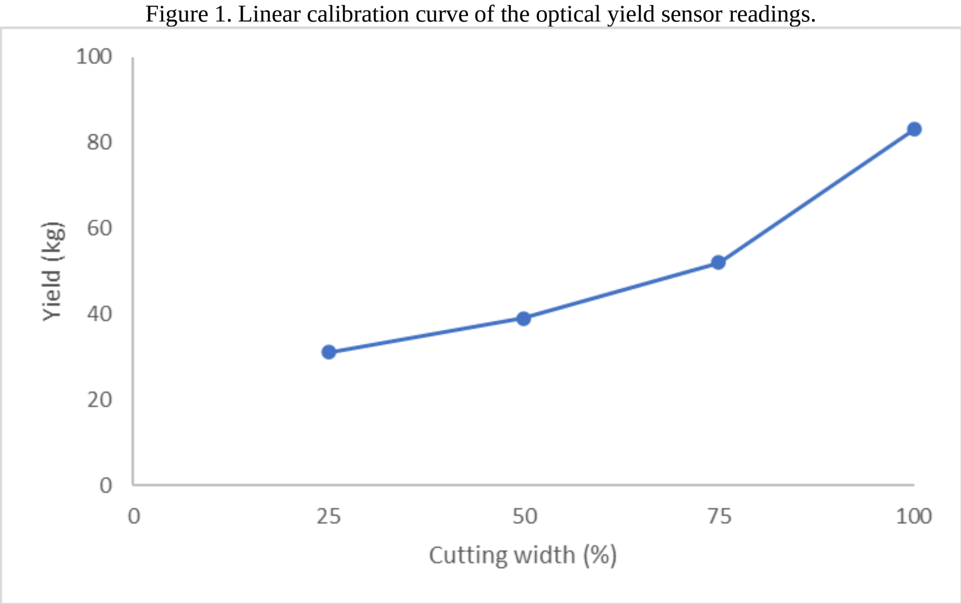
Spatial Management Software (SMS, AgLeader, USA) was used for post-processing data that was recorded and collected using the touch screen display. The software facilitates users in obtaining in-depth information of the yield, including attributes such as yield, moisture and harvesting speed.

RESULTS AND DISCUSSIONS

Physical parameters of pineapple fruit

Yield Monitoring System Calibration
The yield monitoring system was calibrated using four different cutting widths. The results showed that a consistently proportional calibration curve was obtained when plotting yield weight against cutting width (Figure 1). This result proves that the optical yield sensor is functioning well because it can estimate real-time yields harvested at specific locations.

Figure 1. Linear calibration curve of the optical yield sensor readings.



Yield Monitoring System Test

The yield monitoring system functioned effectively after calibration. Real-time harvesting data that includes yield, grain moisture content, harvesting speed and harvested area were shown on the mobile app. When these data were uploaded to the cloud server and web-based app was accessed, yield and grain moisture maps were generated according to the respective paddy plots (Figure 2 and Figure 3).

Figure 2. Yield map generated using FarmTRX Web App

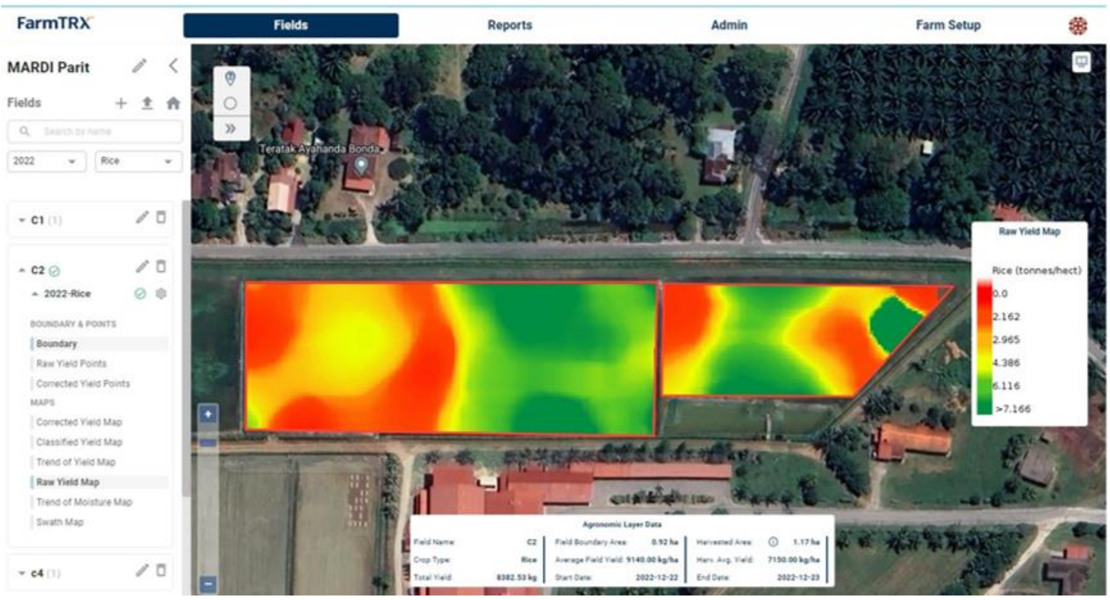
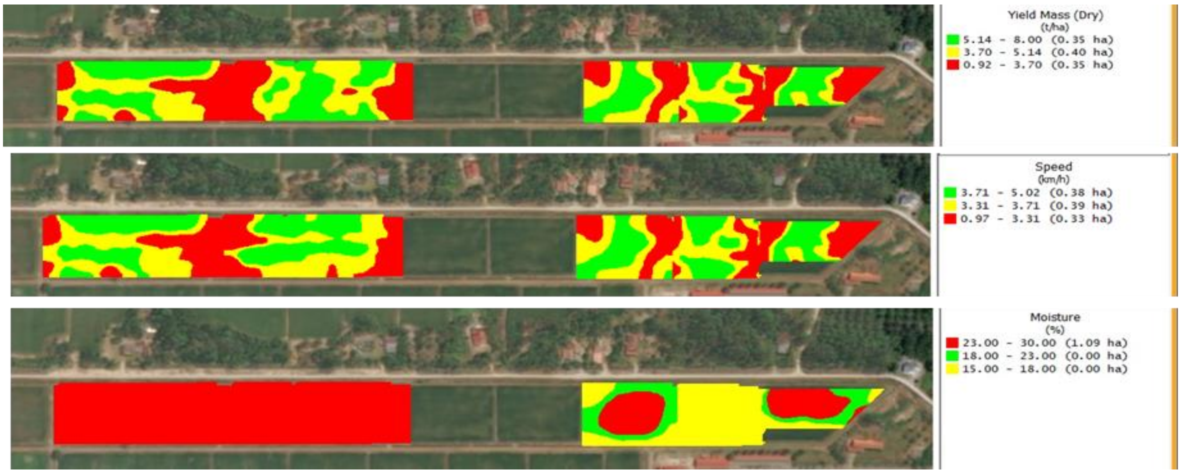


Figure 3. Grain moisture map generated using FarmTRX Web App

The yield map showed areas in the experimental plot with high, medium, and low yields. A comparison of yield readings between the yield harvesting system and the weighing station at the rice processing mill indicates that the system can provide accuracy up to 95%.

Post-processing software generated additional information and maps such as yield, moisture and harvesting speed maps. (Figure 4).

Figure 4. Yield map, harvesting speed map and moisture map generated using post-processing software, SMS



CONCLUSION

The yield monitoring system has been tested to evaluate its performance on a combine harvester of the dual tangent flow type. It was found that the yield monitoring system effectively generates real-time mapping and data for rice yield and grain moisture. This capability could help assists farmers in evaluating their crop performance. The yield monitoring system can provide accuracy up to 95%.

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