PERFORMANCE EVALUATION OF IMPROVED MINI ROUND BALER IN COLLECTION OF RICE STRAW

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ABSTRACT

Rice straw is produced during the harvesting process of rice and abundantly available at the field. Nowadays, rice harvesting is conducted using a combine harvester and the rice straw will be left behind on the stubble. In 2021, around 3.0 million tonnes of rice straw were generated by 647,859 hectares of rice planted area. Open burning of the rice straw is widely practised by the farmers because it is easy and cheaper. In order to benefit the natural resource that is freely available, collection of the rice straw to fulfil demand for various applications is necessary. Nevertheless, the current commercial baler that is used for rice straw collection is unable to function properly in every season of rice harvesting. The trailer-type baler can only be used during dry soil condition and it has experienced moving difficulties during wet soil condition. An improved baler that attached to three-point link of a tractor can be used to collect the rice straw at both soil conditions. Evaluation of the baler was conducted to determine its performance and capability at the speed of 1.6 km/hour. Collection of the rice straw was conducted without slashing the stubble and it was collected on the stubble through manual adjustment of feeding tine position. The amount of rice straw generated by a hectare of rice is 1,588.7 kg. Density of bale that produced by this baler is 91.6 kg/m3 with the size of diameter and length is 50cm and 70cm respectively. The baler is capable to collect 0.66 tonnes/hour of rice straw. Utilization of the improved baler to collect the rice straw on every season able to increase its productivity towards sustainability of the rice industry.

Keywords: *Rice Straw, Mini Baler, Machine Performance, Field Mechanization, Rice Industry*

INTRODUCTION

Rice straw is generated during harvesting process of rice. Nowadays, combine harvester is commonly used to harvest the rice and rice straw will be left behind on the stubble. In 2021, total number of rice planted area in Malaysia is 647,859 ha and able to produce 2,428,889 MT of rice (Booklet Statistik Tanaman, 2022). Yield of total rice straw generated is varies depending to variety and cutting height of the straw during crop harvesting. A study conducted by Martin G. et.al. (2020) had disclosed the straw to grain ratio was 0.5:1 for the cutting height of remained stubble at 40 cm. However, in Malaysia, the ratio of grain to straw as reported by MADA (2010) was 0.45:0.55. In this ratio, the amount of straw is an accumulation of straw and stubble. The stubble is slashed prior to straw collection. Based on this ratio, quantity of rice straw that available in 2021 is approximated to 3.0 million MT.

Currently, there are several approaches being implemented by farmers to manage the rice straw such as open burning, incorporation in the field and off-field usage (Aditya S. et. al., 2022). Nevertheless, the most famous method by farmers is open burning to clear it from the field prior to starting of next planting season. This method is easy & cheaper, traditionally practiced, able to eliminate disease & pest and contribute to soil fertilization (Rosmiza M.Z. et al., 2012). Burning of rice straw may contributes to bad effect on environment such as air pollution that led to deterioration of the local community health and safety.

Besides, the rice straw also collected during dry soil condition only by using a trailer-type commercial baler that attached to a tractor. The baler was commonly produced round bale straw with the size of 1 m diameter and 1.2m length and weight around 150.0 kg. The baled straw was ejected from the machine on the field and can be collected using a grabber. This practice has been conducted in several locations such as MADA and Sekinchan area. Rice straw is a renewable resource and potentially can be used for various application such as lifestock feed, compost, craft paper making, mushroom growth medium, energy production, nursery mat and other products development (Rosmiza M.Z. et. al., 2015 and Lakhvir S. and Balraj S.B., 2021).

However, collection of rice straw during wet soil condition cannot be performed by using the trailer-type commercial baler. The soft soil has restricted the baler to function because of its movement and bale handling issues. Quality of the baled straw also affected after discharged from the machine and get contact with the wet soil and water. Utilization of an improved baler for operation in all soil conditions must be used in order to overcome the highlighted issues and increase productivity of rice straw bale. Collection of rice straw in both dry and wet soil conditions may increase the production of bale and enhance the socioeconomic of local community towards sustainability of rice industry.

MATERIAL AND METHOD

Experimental Site

Performance evaluation of the improved rice straw baler was conducted at research rice plot in MARDI Parit, Perak. The plot was grown with MARDI SIRAJ 297 rice variety by using transplanter machine. Total area of the rice plot used in the evaluation is 1 ha. The rice was harvested using a combine harvester and the yield obtained for the plot was recorded.

Sampling of Rice Straw

Prior to conduct machine performance evaluation, sampling of rice straw to calculate its availability was conducted at each row of harvesting path. There are 10 lanes of harvesting path and 3 locations for each lane were selected to collect the rice straw on the rice stubble. The sampling size for rice straw collection is 1m x 4.42m (width of combine harvester header). The rice straw on the stubble was collected to measure its mass and moisture content by using digital balance and moisture balance respectively. The average mass of rice straw for each harvesting lane was calculated and total mass of the rice straw for one hectare was determined.

Machine Performance Evaluation

A mini round baler with improved at bale discharge mechanism was used in the machine performance evaluation. A new structure at bale discharge area was attached to the machine to keep and prevent the bale from touching the ground. The baler was attached to 3-points link of a tractor and adjustment of the top link was conducted to enable the machine working properly. Level of feeder tine at the baler can be adjusted mechanically by tractor's operator based on the rice straw condition on the stubble. The baler was setup at medium density of bale, 3 layers of bale wrapping and the operation was implemented at constant speed of tractor which is 1.6 km/hour. Size of the bale produced was 50 cm diameter and 70 cm width. The quantity and weight of bales produced were measured and recorded for each 10 rows of harvesting lane. Average density of bale was calculated using formula in Equation 2.

$$Density\ of\ Bale\ (kg/m^3) = \frac{Weight\ of\ Bale\ (kg)}{Volume\ of\ Bale\ (m^3)} \qquad \text{Equation 1}$$

Duration to complete the baling operation also was recorded accordingly and used to calculate field performances. The collection capacity of the baler was calculated according to Equation 2.

$$Collection\ Capacity\ (kg/hr) = \frac{Total\ weight\ of\ bale\ (kg)}{Total\ duration\ of\ operation\ (hr)} \qquad \text{Equation 2}$$

Data Analysis

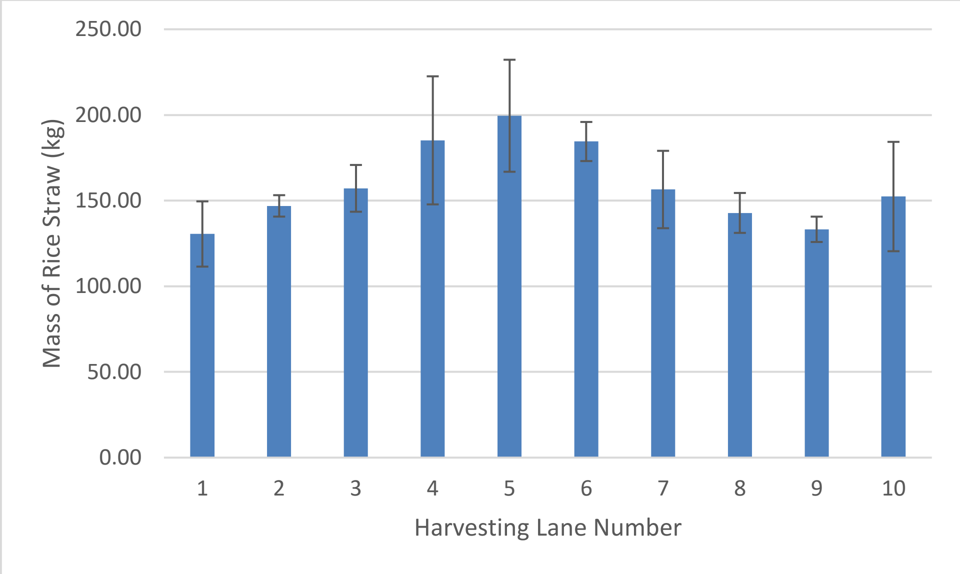
Data obtained from rice straw sampling and machine performance evaluation were analysed using Minitab 16 software at confidence interval (CI) 95%. Data normality test was conducted on the result of rice straw mass and collection capacity. Result of P-value from the normality test was referred to justify the data either following normal distribution or not. Correlation study was also conducted for these results to verify its relationship behaviour.

RESULT AND DISCUSSION

Sampling of Rice Straw

Results of the rice straw sampling can be observed in Figure 1. Based on this result, total rice straw available and can be collected is 1,588.7 kg at moisture content of 12.56%. The result is in line with findings as reported by Martin G. et. al. (2020) after considering damage straw due to the machine's track about 20% of the total plot area.

Figure 1: Result of rice straw sampling at each harvesting lane



In this study, the minimum and maximum amount of rice straw are represented by lane number 1 and 5 respectively with the range value of 69.0 kg. Result of the Anderson-Darling Normality test has disclosed that the data of rice straw mass not following normal distribution. Mean and standard deviation for this result is 158.8 and 29.0 respectively. Generally, amount of the rice straw at middle area of the plot is higher than other area. Factor of plant density at this area has contributed to the results after considering the cutting height during yield harvesting is consistence at 40 cm from the ground. The standard deviation for harvesting lane number 4, 5, 7 and 10 are slightly higher because the mass of rice straw at three locations for the lanes exhibited bigger range of data. Result of rice straw sampling is necessary to determine the collecting performance of the rice straw using baler.

Machine performance evaluation

Results of collection capacity for the improved baler is 0.66 tonnes/hour. The baler is capable to collect more than 90% of rice straw on the stubble. Result of the collection capacity is slightly higher than finding as reported by Carlito B. et. al. (2020) which is 0.54 tonnes/hour by using the small round baler (STAR MRB0850B). In average, 12 bales of rice straw can be collected from each harvesting lane within 15 minutes. The average bale density obtained for the performance evaluation is 91.6 kg/m^3. Result of the collection capacity for each harvesting lane and the results of its normality test as indicated in the Table 3 and Table 4 respectively. P-value of the test has concluded that the collection capacity data was normally distributed.

Table 3: Result of collection capacity for modified rice straw baler

	Harvesting Lane Number									
	1	2	3	4	5	6	7	8	9	10
Collection Capacity (tonnes/hour)	0.64	0.66	0.65	0.66	0.67	0.67	0.65	0.63	0.65	0.68

Table 4: Result of Anderson normality test for machine capacity

Mean	Standard Deviation	P-Value
0.66	0.01	0.96

The collection capacity for the harvesting lane number 4, 5, 6 and 10 have displayed higher result as compared to others. The result of correlation study has indicated that the average value of rice straw mass and collection capacity having positive linear relationship. The Pearson correlation coefficient for this result is 0.628. The collection capacity can be improved if the rice straw evenly distributed on the stubble. Based on these results, application of improved mini round baler to collect rice straw on the stubble can be used in dry and wet soil condition. The bale produced can be managed manually because the average is 12.5kg only.

CONCLUSION

Utilization of an improved mini round baler to collect rice straw on the stubble can be implemented. This machine can be used for both season either dry or wet season to increase number of the baled straw for various application. Attachment of the bale collection structure at the baler may keep the bale on the machine. Collection of the rice straw that uniformly distributed on the stubble may ease the baler's operation to obtain an optimum performance at 0.66 tonnes/hour. The baler is able to produce around 120 units of bale or 1,500 kg of rice straw in 1 ha of rice planted area. This approach may generate additional income to farmers by selling off the baled straw. Socioeconomic of local people also expanding throughout supply chain of the straw. Utilization of agro waste like rice straw is a green approach in its management towards sustainability of agriculture industry.

REFERENCES

Aditya Shukla, Mukesh Kumar, Himanshu Tiwari, and Akanksha Shukla (2022). Alternative Uses of Rice Straw in North-Western Regions of India: A Review. International Journal of Environment and Climate Change. Vol.12, N0.11, p206-216. ISSN: 2581-8627. https://doi.org/10.9734/IJECC/2022/v12i1130962

Booklet Statistik Tanaman (Sub-sektor Tanaman Makanan) 2022.Unit Perangkaan Pertanian, Bahagian Perancangan Strategik, Jabatan Pertanian Semenanjung Malaysia.

Carlito Balingbing, Nguyen Van Hung, Ampy Paulo Roxas, Daniel Aquino, Mary Grace Barbacias and Martin Gummert (2020). An Assessment on the Technical and Economic Feasibility of Mechanized Rice Straw Collection in the Philippines. Journal of Sustainability. Vol.12,7150; doi:10.3390/su12177150.

Lembaga Kemajuan Pertanian Muda (MADA) (2010) Laporan Tahunan. Alor Setar, Kedah.

Lakhvir Singh and Balraj Singh Brar (2021). A Review on Rice Straw Management Strategies. Nature Environment and Pollution Technology. Vol.20, No.4, p1485-1493. e-ISSN: 2395-3454 https://doi.org/10.46488/NEPT.2021.v20i04.010

Martin Gummert, Nguyen Van Hung, Pauline Chivenge and Boru Douthwaite. (2020) Sustainable Rice Straw Management. ISBN 978-3-030-32373-8. https://doi.org/10.1007/978-3-030-32373-8.

Rosmiza M.Z., Amriah B., and Rosniza Aznie C.R. (2012). Impact of Rice Straw Development towards Agricultural Environment and Farmers' Socio-Economy in MADA Region, Kedah. DOI: 10.7763/IPEDR. 2012. V54. 50

Rosmiza M.Z., Davies W.P., Rosniza Aznie C.R., Jabil M.J., Mazdi M., Wan Toren W.Y., and Che Rosmawati C.M. (2015). Stagnation of Rice Straw Agribusiness Development in Malaysia: The Entrepreneurs' Perspectives. Mediterranean Journal of Social Sciences, MCSER Publishing, Rome-Italy, Vol 6 No 4, ISSN 2039-2117.