EFFECTIVENESS OF HARVESTING PATTERN FOR GRAIN CORN USING MINI COMBINE IN CORN PRODUCTION

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ABSTRACT

Malaysia's livestock food production exceeds demand. This is about 45-65% of the composition of most products. In Malaysia, imports of grain maize increased from about 2.5 million tons in 2000 to 4.0 million tons in 2017 for livestock feed. This experiment was carried out in MARDI SeberangPerai, Pulau Pinang from June 2018 to the end of February 2020 using a mini combine of Worldstar 7.0 PLUS (WS7.0PLUS). The basic operation of the mini combine harvester is the same like kubota mini combine which are widely used in paddy and grain corn now days. During the harvesting process, three rows of harvesting methods were used. In fact, the mini combine harvester is capable of harvesting four rows at once, but must be considered for crop losses afterwards. During harvesting, three different patterns of harvesting were used to study the effectiveness of each pattern of harvesting. This pattern of harvesting will also influence the rate of losses and the rate of work efficiency of the mini combine will depend on the soil surface of the test plot. Losses during harvesting can be determined by two situations. These are losses at the cutting header during harvesting and losses during threshing of the crop into grain. Losses at the cutting header have been measured by collecting the crop in each row after the combine has passed for harvesting patch. Losses during threshing shall be measured by collecting a sample of grain corn that drops on the back to be combined during harvesting using 2 m x 2 m quadrant PVC pipe. As a result, losses due to header cutting and losses on the threshing system in total during harvest due to the combine harvester were 1.9% to 3.64% which are below 4.00%. Each pattern of harvesting had its own result, which had an impact on the rate of losses.

Key words: Harvesting Pattern, effectiveness, mini combine, losses

INTRODUCTION

Grain corn is an important component of animal feed.Depending on the formula, the composition of grain corn may range from 45 to 65 per cent for most livestock food products.It is a very critical component of the livestock industry, particularly chicken.Malaysia is now importing almost all grain corn needs to the tune of 3.71 million tons of RM3.09 billion a year.The Corn Action Plan National Grains (MOA 2018), aimed at 2032, will produce 1.44 million tons of grain corn with an area of 80,000 hectares.Planting maize in Malaysia is nothing new and has been in operation again since 1960. In the field of research with optimum input levels and good management, cereal yields of corn maybe between 6 and 8 t/ha (Lee 1986; Tan and Wong 2007; Tengku Ahmad et al. 1990). Several pilot planting projects have also been carried outat various locations by government agencies and private companies.Harvesting is one of the most important operations in the production of maize.Traditionally, this operation was considered to be a labor-intensive operation (Bautista, 2005).However, corn production in Malaysia faces labor shortage problems due to the difficulty of getting people willing to work in this sector (Adam and Pebrian, 2017).Therefore, a mini combine harvester has been introduced to mechanize corn harvesting system in an effort to tackle the labor shortage in Malaysian corn production.A well-designed mini combine harvester can play an important role in harvesting corn in a timely, efficient and low cost manner.During the harvesting process, three rows of harvesting methods were used.In fact, the mini combine harvester is capable of harvesting four rows at once, but must be considered for crop losses afterwards.The crop spacing is 75mm X 19mm. For this study,WorldStar 7.0 PLUS(WS7.0PLUS) mini combine has been used, the combine had a same basic operation and both can be used for paddy production.Practically in Malaysian grain corn production, the used of mini combine are widely used compare to normal combine because the planted area of corn are limited. Therefore, the purpose of this study was to determine the effectiveness of using three different harvesting pattern that may affected the field performance, work rate and rate of losses.
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MATERIALS AND METHOD

Study area

This research was conducted at MARDI Seberang Perai, Pulau Pinang, Malaysia. The layout of the experiment was divided into sub-plot 3 namely A, B and C, referring to the pattern of harvesting, which will be replicated into three additional sub-plots of 20m X 20m sizes shown in Figure 1. The total size of Block B is 1.25 hectare were shown in Figure 2.

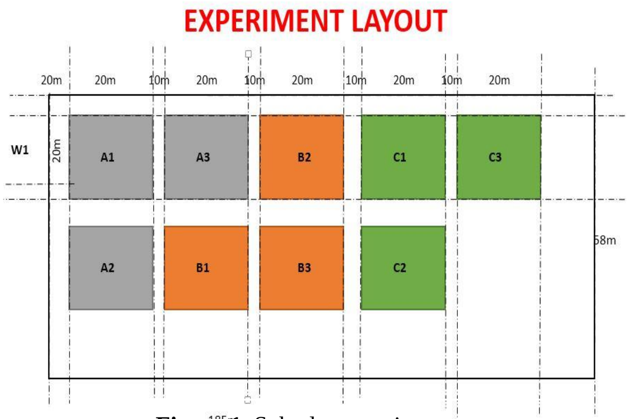


Figure 1. Sub plot experiment

Figure 2. Block experiment

Harvesting pattern

There are three types of harvest patterns identified as A, B and C.Patten A is harvesting direction following crop rotation means that the combine harvester of follows the same direction as the corn planter as shown in Figure 3.This pattern is normally used in corn harvesting and the turning point of the combine needed to be widely spaced so as to avoid hitting the crop before entering the crop row after turning. For pattern B, the harvest directions opposite to the crop line. This pattern is a harvest from the side of the corn crop where the distance between each row is 19cmx19cm allowing the blend to be harvest with 4 rows at a time, but the pattern is seen against the row of plants and the feed rate of the cutting blades takes little time to harvest and is often unable to carve the corn stumps as it lay 75 cm to the next corn crop shown in the figure 4. And lastly, Pattern C is harvesting around the crop. This pattern is widely used in the harvesting of paddy grain and this pattern appears to be faster in the harvesting of corn because the turning point of the blend is limited before it becomes the next row of the crop. For this pattern, combine harvest in line and also harvesting line opposite to the crop line shown in Figure 5. Before the experiment is run, the mini combine will cut the path around the sub-plot to make it easier to identify the pattern set to the sub-plot.

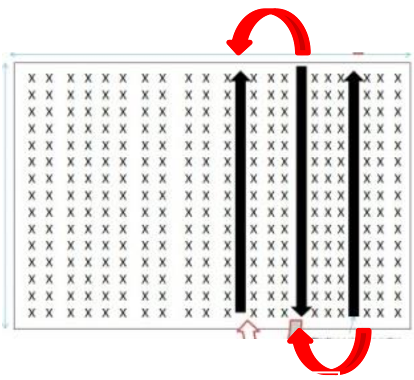


Figure 3. Pattern A

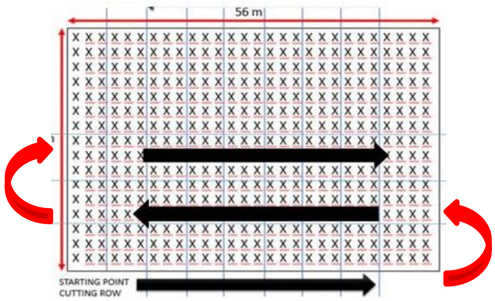


Figure 4. Pattern B

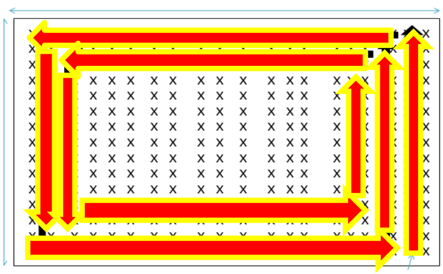


Figure 5. Pattern C

Mini combine harvester

The used of mini combine Worldstar 7.0 PLUS (WS7.0PLUS) is shown in Figure 6.The selection models was made since these models were mainly used by government agencies also contractors in that state. Table 1 shows the information of the study areas with their respective combined harvesters. The specifications for combine harvesters are shown in Table 2.For this study, it was decided using to use 2500 rpm harvesting gear.

Figure 6. Worldstar 7.0 PLUS

Table 1. Machinery Information for experiments

Location	Plot	Model of mini combine	Area (ha)
Block B	A	Worldstar 7.0 PLUS	20 X 20 (0.04ha)
	B		20 X 20 (0.04ha)
	C		20 X 20 (0.04ha)

Table 2. Specification of the mini combine harvesters

Specifications			Worldstar 7.0 PLUS
Body size (Overall Length, width and height)			5150mm x 2890mm x 2700mm
Total body mass			3400Kg
Machine	Cylinder capacity		3.958
	Type		Vertical, water-cooled-4stroke, injection-turbocharger
	Max Hp (Kw/Rpm)		88/2600
Fuel tank capacity			130Lit
Moving system (Crawler)	With & Ground Contac length		500 x1700
	Average ground load		
	Gearbox system		Static power steering system (HST) 3 speed (Low, Harvesting and walking)
Harvesting system	Paddle scratch	Diameter x Width	900x2028
		System hull	Hydraulic system
	Cutting jaw length (mm)		
	Length rod blade		
Threshing system	Type		Axial-Flow system
	Thresher	Diameter x horizontal	620 x 2010
		Threshing speed	560
		Net floor area (m2)	1.64

Harvesting consideration

In the harvesting operation, the basis for consideration should be emphasized so that the corn is less harmful, free or less of crop residues, and the rate of loss of the minimum grain.
Harvesting will generally take place after 10 a.m. depending on the weather to ensure that the trees and the corn stalks are dry (the ideal percentage of grain for grains is < 25) and not moist (Mohamad B.A.G 2019) Harvesting is done by cutting closer to the bottom of the corn cob to reduce the rest of the plants. These are the four main components of the command and function.

Field performance

They were tested in the MARDI Steerageway plot. Performance assessments include farm capacity, efficiency, harvesting losses, engine speed and others harvesting with two rows of corn plants per trip. Harvest time has been recorded. Speed is therefore determined by the length of the line of harvest divided by the time of harvest (Sattar, 2015).

Determined of Field Work Rate (FWR)

The Field Work Rate (FWR) was that indicates the harvesting efficiency of the combined harvester. Theoretically, the work rate is proportional to "the width of the cutter bar and the speed. “However, the rate of work varies depending on the shape and size of the fields, soil and crop conditions. The rate of operation of the test should be more than 0.4 m / sand the harvesting work should be smooth (The national test code of the combine harvester, 1976).

$$FWR = \frac{Area(ha)}{EOT}$$

Where EOT = effective operation time in second.

Determined of Field efficiency (%) (FE)

Field efficiency (FE) was defined as the percentage of time the machine operates at its full rated speed and field width (Nasri, 2015). FE described the effectiveness of the time spent doing the work (Grisso, 2014). The FE for actual field operation was always less than 100% due to headland turns, machine trouble, ground surface and overlapping.
(Zandonadi, 2012). FE was determined as follows:

$$FE = \frac{AOT}{TWT}$$

Where AOT= Actual Operating time in second
TWT=Total work time whole plot in second

Grain Losses

Losses during harvesting can be determined by two situations. These are losses at the cutting header during harvesting and losses during threshing the corn grains. Losses at the cutting header have been measured by collecting the crop in each row after the mini combine has passed for harvesting path. Losses during threshing shall be measured by collecting a sample of grain corn that drops to the back to be mini combine during harvesting. The loss of grain yield in the field is determined by sampling technique by collecting all grains of corn that fall to the ground. Sample area is 2 m x 2 m square with randomized complete block design (RCBD) Abu Hassan, D et al.Al (2012). In order to determine the loss of corn due to corn starch, the corn cobs fall along the harvest line as operations are collected. All corn cobs that fell and did not harvest during the harvesting process were weighed and considered to be grain loss in the grain field, assuming that 1 kg of corn cobs could produce 0.75 kg of grain. When the grain storage tank is full, the tractor with a trailer and a jumbo bag inside is ready to receive the grain harvested. The grain is lifted from the tank by the rim of the unloading auger and drained out to the side pipe (unloader mini combine) which flows into the jumbo bag in the trailer. This operation will continue until all the plots have been harvested. The data collected is used to calculate effective and efficient field capacity and theory.

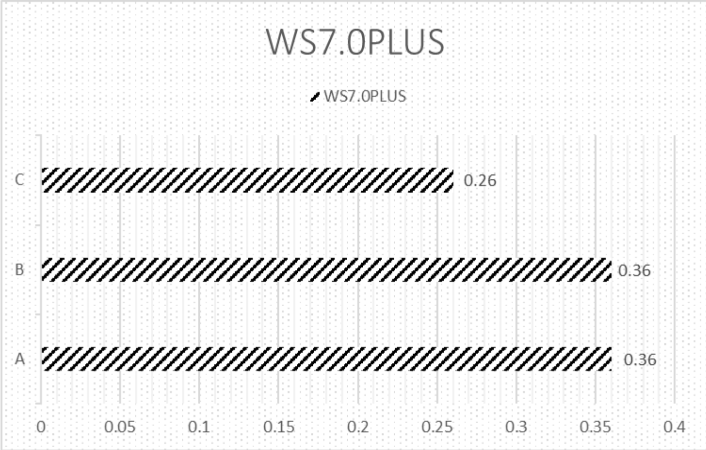
RESULT AND DISCUSSION

As for Table 3, WS7.0PLUS that pattern A produces low percentage losses below 1.90%. This shows that pattern A, which is a pattern of harvesting by row of plants, is also appropriate. The effect of this pattern results in a low rate of grain loss compared to other patterns. Show that pattern B and pattern C result in a fairly high rate of grain loss of 3.64% and 3.27%.

Table 3: WS7.0 PLUS Field work, Field efficiency and grains losses

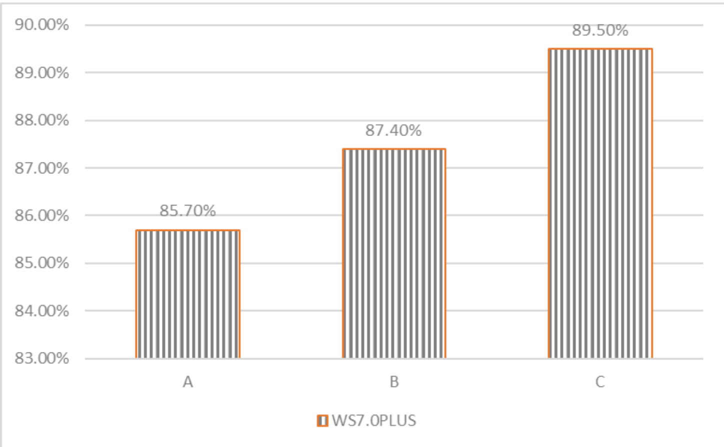
Block	Pattern harvesting	Test plot sizes (ha)	Field work (FWR)(ha/hr)	Field efficiency (FE) (%)	Header Losses (HL) (%)	Threshing losses (TL) (%)	Total losses (%)
B	A	0.04	0.36	85.7	1.53	0.41	1.9
B	B	0.04	0.36	87.4	3.27	0.39	3.64
B	C	0.04	0.26	89.5	2.94	0.35	3.27

Figure 7. Field work (FWR)



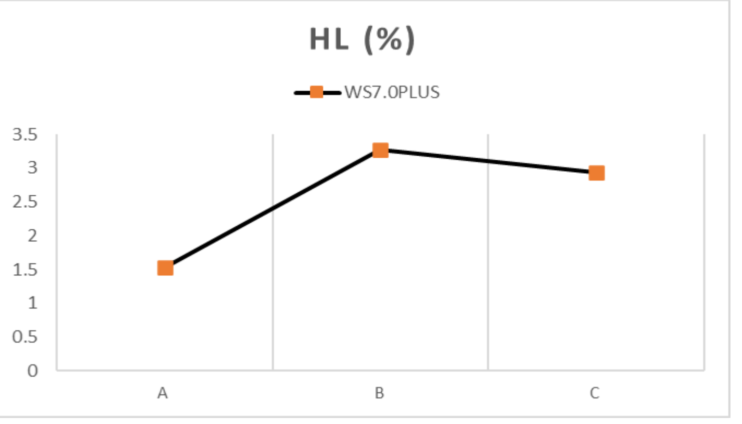
The FWR shows in Figure 7 that minis combine field work. The result shows that only the C pattern was slightly different from 0.26 WS7.0PLUS working rates compared to the A and B patterns. During this time, Block B for WS7.0PLUS is bit grassy between rainy crops every day. This may be difficult for the combine to harvest smoothly. This indicates that there was no significant difference between pattern A and pattern B in terms of FWR, since the value of t stat was lower than the value of t critical to tail. (Hossain et. al, 2015).

Figure 8. Field efficiency (FE)



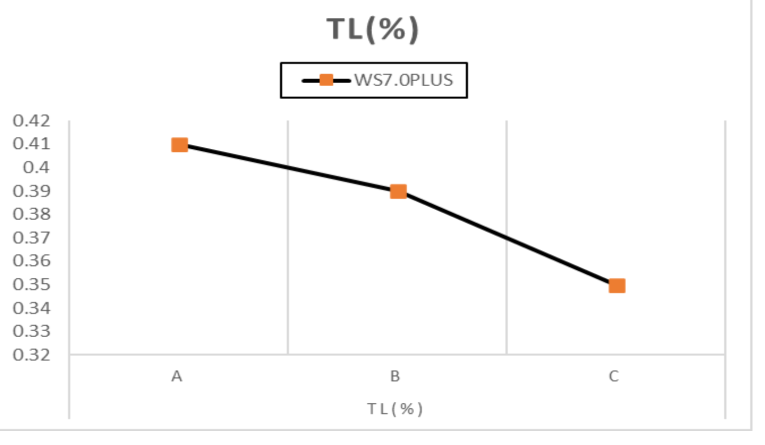
Field Efficiency (FE) for WS7.0PLUS is shown in Figure 8. Shows that all patterns of harvesting produce up to 60%. Show that WS7.0PLUS gather a result of pattern A is 85.70%, pattern B is 87.40% and C pattern is 89.50%. The result shows the pattern A is a little lower because during harvesting the block B sub-plot area was full of grass between the crop as a result of which the operator had to stop working for a while because the grass that was stuck at the cutting head of the combine had to be removed before continuing harvesting. There was no significant difference between pattern A and pattern B in terms of FE, since the value of t stat was lower than the value of t critical to tail (Hossain etal. 2015).

Figure 9. Header losses (HL)



From the result shown in Figure 9. The header loss for pattern A for pattern WS7.0PLUS is 1.53, pattern B is 3.27 % and pattern C is 2.69%. Pattern B which is the result of 3.27 percent higher for WS7.0PLUS compared to other patterns. The combine header bar always hit the crop, causing the crop to collapse while making a straight turn. The second highest is pattern C, because the direction of harvesting included all the direction of harvesting. Head losses are significantly affected by the ability of the operator to handle forward speed and turn for combine harvesters (Tanveer, D et.al.2017). However, for this study, the mini combine may be capable of harvesting 4 rows at once with the skill operator

Figure 10. Threshing losses (TL)



These data are taken from a pipe square of 2 m x 2 cm by collecting the grains that fell to the ground (Abu Hassan, D et al 2012). Figure 10 shows the result of each pattern. WS7.0PLUS pattern A is 0.41%, pattern B is 0.39%, and pattern C is 0.35%. As a result, the C pattern is higher than the others. For example, very accurate spacing between spike teeth, profile and concave threshing unit is required to prevent kernel breakage and is also significantly influenced by operator skill, forward speed, feed rate and threshing drum speed (Tanveer, D. et.al 2017). Otherwise, the rate of losses also affects the pattern of harvesting itself.

CONCLUSION

The main factor that causes post-harvest loss rate is due to the harvester header hit the crop between the rows and planting distance also need to be emphasized so that the harvester can harvest smoothly. From the results obtained it is seen that pattern B obtains a high loss rate for header loss because the pattern is harvest directions against crop line with a rate of 3.27% and threshing loss of 3.9% . For this pattern the combine header bar always hit the crop, causing the crop to collapse while making a straight turn. Followed by pattern C is 2.94% header loss and 0.35% threshing loss and pattern A obtained the lowest rate results of 1.53% header loss and 0.41threshing loss. Therefore, for grain corn with a planting distance of 75cm X 20cm between rows it is highly recommended to use a 3-row harvest method to avoid high loss rates and use pattern A which are the directions of harvesting follow the planting rows line. Operator’s skill also the critical factor to control the combine during harvesting of grain corn crop.

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REFERENCES

Mohamad B.A. Ghaffar, Dr. Chan.C. S (2019)
LAPORAN KHAS POTENSI PENANAMAN JAGUNG BIJIAN DI MALAYSIA: PENGALAMAN MARDI / ISBN 978-967-936-672-3 ms-33

Abu Hassan, D et. al (2012). Manual Teknologi operasi penilaian jentuai padi dan kehilangan lepas tuai. MARDI.

Abdul Aziz, A.M. (2008). Current status and prospects for grain corn production in Malaysia. Workshop on Animal Feedstuffs i Malaysia: Exploring Alternative Strategies. 15 – 16 April 2008, Putrajaya, Malaysia, M.S. 11 – 22

Tengku Ahmad, T.S., Engku Ismail, E.A. dan Noor Rawi, A.B. (1990). Pengeluaran jagung bijirin di Kelantan dan Terengganu, (Mansor, P. dan Wong, L.J, Eds.) Proc. National Maize Workshop 1987, 21 – 23 Julai 1987, Pulau Pinang, (Mansor, P. dan Wong, L.J., ed.), m.s 96 – 104. Serdang: MARDI

USDA (2016). Malaysia Grain and Feed Annual, GAIN Report Number: MY6001 Wong, I.F.T. (2009). Soil-crop suitability Classification for Peninsular Malaysia, JabatanPertanian Malaysia

Adam, N.S. and Pebrian, D.E. (2017). Factors affecting farmers' satisfactions with mechanized rice harvesting in Malaysian paddy fields: A case study of hiring custom operators. Agricultural Engineering International, 19(2), 120–128.

Bautista, E.U. and Javier, E.F. (2005). The Evolution of Rice Production Practices the Evolution of Rice Production Practices. Discussion Paper Series No. 2005-14. Phillipines: Philippine Institute for Development Studies

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. *Proceedings of the Technology and Innovation National Conference*, 1–6.

Tanveer Ahmad, Zulfiqar Ali and Hafiz Sultan MahmoodFactors Causing Low Head Rice Recovery in Combine-Harvested Paddy Agricultural and Biological Engineering Institute, National Agricultural Research Centre, Islamabad, Pakistan. Science, Technology and Development 36 (2): 84-90, 2017
SSN 0254-6418 / DOI: 10.3923/std.2017.84.90 © 2017 Pakistan Council for Science and Technology

Grisso, R.D., Kocher, M.F., Adamchuk, V.I., Jasa, P.J. and Schroeder, M.A. (2004). Field Efficiency Determination Using Traffic Pattern Indices. *Applied Engineering in Agriculture*, 20(5), 563–572. https:// doi.org/10.13031/2013.17456

Zandonadi, R.S. (2012). Computational Tools for Improving Route Planning in Agricultural Field Operations. Lexington, Kentucky: University of Kentucky, PhD Thesis.

Sattar, M., Ali, M., Ali, L., Waqar, M.Q., Ali, M.A. and Khalid, L. (2015). Grain Losses of Wheat as Affected by Different Harvesting and Threshing Techniques. International Journal of Research in Agriculture and Forestry, 2(6), 20–26.

The national test code of the combine harvester. Official Gazette issued on April 7 (1976) [In Japanese].

Hossain, M.A., Hoque, M.A., Wohab, M.A., Miah, M.A.M., and Hassan, M.S. (2015). Technical and economic performance of combined harvester in farmers' field. Bangladesh Journal of Agricultural Research, 40(6), 291–304. https://doi.org/10.3329/bjar.v40i2.24569