AM002

Influences of the Field Accessibility to the Performance of Mechanical Sugarcane Harvesting

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Abstract

Sugarcane is an important economic crop of Thailand and world wide. Due to a labor shortage in agricultural section, sugarcane harvesters have become a major machine in sugarcane production. The harvesters are expensive machines with much higher capacity comparing to traditional labor method. However, under typical sugarcane field conditions in Thailand, working performance is limited by many field factors causing unnecessary operating expenses. One major issue is an extra effort for cutting the beginning rows in low accessibility fields. The harvesters, in this case, have to spend time harvesting and traveling back and forth with a limited billet holding capacity in a limited space until having enough room for both harvester and loading truck to be able to travel alongside. The objective of this research is to study the influence of the field accessibility to the field performance of sugarcane harvesters. The study was conducted by installing a GPS tracking system, and a video camera on each of three sugarcane harvesters operated in Nakhon Ratchasima, Thailand (Pimai, Chakkrarat, and Huai Thalaeng districts). Operational information of the harvesting was recorded and analyzed to determine time efficiency and field efficiency. Based on the collected data, when considering the whole field operation from the studied harvesters (with engine power of 240, 290 and 340 Hp) (a) time efficiency were 49.3%, 48.2%, and 56.2%; and (b) field efficiency were 43.9%, 40.8%, and 57.3%, respectively. In the same harvesting fields, when excluding the beginning rows with accessibility constraint, the performance indicators showed improvement in (a) time efficiency of 55.9%, 66.5%, and 60.8%; and (b) field efficiency of 59.7%, 62.4%, and 73.6%, respectively. The results show a significant improvement in performance when harvesting without the accessibility problem. If the field entrances allow the harvester and loading truck to access from the first row conveniently, 6.5%, 18.3%, and 4.6% of the time could be saved, and 15.8%, 21.6%, and 16.3% of field capacity could be improved.

Keywords: field accessibility, sugarcane harvester, time efficiency, field efficiency.

1 Introduction

Sugarcane is an important economic crop of Thailand whose ranks the fourth exporters of the world sugarcane market after Brazil, the European Union and Australia (Office of the Cane and Sugar Board, 2014). In 2016, national income from sugarcane industry was approximately 60 billion baht (Office of Agricultural Economics, 2016).

Due to a labor shortage in the agricultural sector, sugarcane harvesters have become major and necessary machines in sugarcane production system. Even though the harvesters are expensive, they come with a much higher capacity comparing to harvesting with traditional labor method.

However, under typical sugarcane field conditions in Thailand, working performance has been limited by many field factors causing unnecessary operating expenses. One major issue is an extra effort for cutting the beginning rows in low accessibility fields. The harvesters, in this case, have to spend time harvesting and traveling back and forth with a limited billet holding capacity in a limited space until having enough room for both harvester and loading truck to be able to travel alongside.

The objective of this research is to study the influence of the field accessibility to the field performance of sugarcane harvesters.

2 Materials and Methods

In this study, the agricultural machinery tracking system developed by Vasu et al. (2015) was used to record the field activities of each participating harvesters, which include traveling speed, heading, and the timestamp at 5 Hz recording rate. Figure 1 presents the concept of the monitoring system. Also, on each harvester, a video camera (G1W, HD Blackbox, China) (Figure 2) was installed on the harvester's windshield to videotaping all activities for referencing.

Data were collected from 3 harvesters with different engine power - 240, 290 and 340 Hp - during the harvesting season of 2016/17 in Nakhon Ratchasima, Thailand (Pimai, Chakkrarat, and Huai Thalaeng districts). In this article, two operating fields for each harvester were selected to study the field performance including time efficiency and field efficiency.

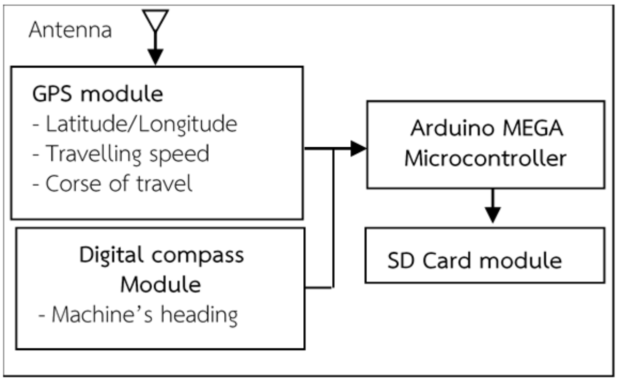

Figure 1 Components of agricultural machinery activity tracking.

All fields chosen for this study had low field accessibility. The harvesting at the beginning rows with the first loading truck was considered working with low accessibility. Operating with later loading trucks was, on the other hand, consider working with high accessibility due to there was enough room for either harvester and loading truck to collaborate with ease.

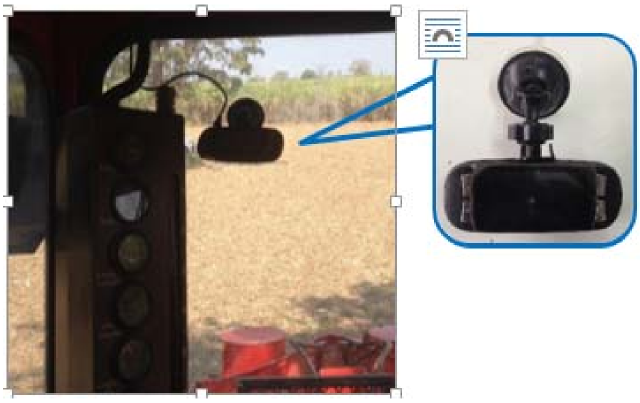

Figure 2 the video camera for activity recording.

To present the influence of field accessibility was to compare between overall efficiency and the efficiency without the beginning rows of harvesting (excluding the first loading truck data).

3 Results and Discussion

3.1. Time Efficiency.

By using both the tracking system and the recorded video, field operations could be classified into two categories, active and inactive operations. The active operations were the machine's works when the cutterbar was operated to cut the sugarcane stalks. Other operations are considered inactive activities. Time efficiency could be, then, determined from the ratio between the active time and the total time.

Table 1 shows time used and time efficiencies from all studied fields. Average time efficiencies for all three harvesters (with engine power of 240, 290 and 340 Hp) were 49.3%, 48.2%, and 56.20% respectively.

When excluding data from the first loading trucks for each field, the harvesters could work with their potential performance. Time efficiency (table 2) became 55.9%, 66.5%, and 60.8%, respectively. If the farmers could manage their farms to have enough space for a good accessibility, 6.5%, 18.3%, and 4.6% of operation time could be saved for each studied harvester, respectively.

Table 1 Overall time efficiencies for all studied fields and harvesters.

Category	240 Hp			290 Hp			340 Hp		
	Field 1	Field 2	average	Field 1	Field 2	average	Field 1	Field 2	average
Total working time (h)	3:29	1:25	-	4:40	3:56	-	3:59	1:46	-
Active time (h)	1:37	0:44	-	2:24	1:45	-	2:04	1:04	-
Inactive time (h)	1:51	0:40	-	2:15	2:10	-	1:55	0:42	-
Time Efficiency (%)	46.6	52.0	49.3	51.7	44.7	48.2	51.7	60.6	56.2

Table 2 Time efficiencies for all studied fields and harvesters when working at good field accessibility (excluding data from the first trucks of each field).

Category	240 Hp			290 Hp			340 Hp		
	Field 1	Field 2	average	Field 1	Field 2	average	Field 1	Field 2	average
Total working time (h)	1:55	0:17	-	2:31	1:39	-	3:04	0:50	-
Active time (h)	1:02	0:10	-	1:51	0:58	-	1:45	0:32	-
Inactive time (h)	0:53	0:07	-	0:40	0:40	-	1:19	0:17	-
Time Efficiency (%)	53.9	57.9	55.9	73.5	59.5	66.5	56.9	64.7	60.8

3.2. Field Efficiency.

Field efficiency is the ratio between actual capacity and the theoretical capacity. Actual capacity is the rate of working area over total time. Theoretical capacity is the harvesting capacity at optimum working speed under working condition. It can be calculated by multiplication between the optimum speed and working width (row width in this case).

To determine the optimal traveling speed, the histogram of forward velocity (collected by the GPS data) was used. Modes of the traveling speed were investigated. Figure 3 shows an example data from a working field. There were two velocity peaks. The tallest one at very low speed (approximately 0.2 km/h) was considered no movement. The small value was due to the sensitivity of the GPS's speed calculation. The second tallest peak was, then, at the suitable and optimal speed to work under each field condition. Table 5 shows optimal speeds for each studied field. Variation of the optimal speed was due to the difference in field and machine conditions.

Table 6 shows field information for calculating of field capacity and field efficiency from all studied fields. Average field efficiencies for all three harvesters (with engine power of 240, 290 and 340 Hp) were 28.8%, 37.3%, and 45.3%, respectively.

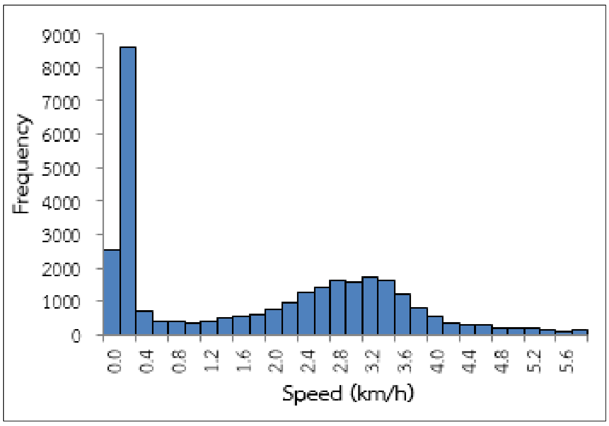

Figure 3 Histogram of the traveling speed from an example field.

Table 5 Optimal working speed determined from the mode of traveling speed of each field.

engine power	Optimal Working Speed (km/h)	
	Field 1	Field 2
240 Hp	3.5	3.2
290 Hp	4.8	3.8
340 Hp	3.6	3.4

When excluding data from the first loading trucks for each field, the field efficiency (table 7) became 44.1%, 73.8%, and 67.4%, respectively. The difference shows improvement in field efficiency when operating with good accessibility. The improvement was 15.2%, 35.7%, and 22.9%, respectively.

Table 6 Overall field efficiencies for all studied fields and harvesters.

Category	240 Hp			290 Hp			340 Hp		
	Field 1	Field 2	average	Field 1	Field 2	average	Field 1	Field 2	average
Total Working Time (h)	3:29	1:25	-	4:40	3:56	-	3:59	1:46	-
Working Area (rai)	4.0	2.0	-	8.5	5.0	-	7.3	3.0	-
Actual Capacity (rai/h)	1.15	1.41	-	1.82	1.27	-	1.83	1.68	-
Optimal Traveling Speed (km/h)	3.5	3.2	-	4.8	3.8	-	3.6	3.4	-
Row Width (m)	1.4	1.4	-	1.4	1.4	-	1.4	1.4	-
Theoretical Capacity (rai/h)	3.06	2.80	-	4.20	3.33	-	3.15	2.98	-
Field Efficiency (%)	37.4	50.3	43.9	43.4	38.2	40.8	58.0	56.6	57.3

Table 7 Field efficiencies for all studied fields and harvesters when working at good field accessibility (Excluding data from the first trucks of each field).

Category	240 Hp			290 Hp			340 Hp		
	Field 1	Field 2	average	Field 1	Field 2	average	Field 1	Field 2	average
Total Working Time (h)	1:55	0:17	-	2:31	1:39	-	3:04	0:50	-
Working Area (rai)	3.5	0.5	-	5.5	4.0	-	6.5	2.0	-
Actual Capacity (rai/h)	1.82	1.68	-	2.18	2.42	-	2.11	1.91	-
Optimal Traveling Speed (km/h)	3.5	3.2	-	4.8	3.8	-	3.6	3.40	-
Row Width (m)	1.4	1.4	-	1.4	1.4	-	1.4	1.4	-
Theoretical Capacity (rai/h)	3.06	2.80	-	4.20	3.33	-	3.15	2.98	-
Field Efficiency (%)	59.4	60.1	59.7	52.0	72.8	62.4	67.0	80.2	73.6

4 Conclusions

5 Field accessibility affected field performance either time efficiency and field efficiency. In this study, if the harvesters and loading trucks could enter the field from the beginning rows with comfortable, the time efficiency and field efficiency would significantly increase by 6.5% to 18.3% and 15.8% to 21.6%, respectively.

6 Acknowledgements

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7 References

Office of the Cane and Sugar Board, 2014. The report the production of sugar cane and sugar.Available at: http://www.ocsb.go.th/th/cms/index.php?SystemModuleKey=cuntry. Accessed on 10 June 2017.

Office of Agricultural Economics, 2016, 2016. Agricultural Statistics of Thailand. Available at: www.oae.go.th.

Vasu Udompaikul et al., 2015. Determination of Sugarcane harvester efficiency using GNSS system. Thai Society of Agricultural Engineering. Proceedings of the Sixteenth National Conference, 429-432.