Lost times of harvesting processes of the Thai combine harvesters

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Lost times of harvesting processes of the Thai combine harvesters

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Abstract. The loss of time during harvesting processes can affect the effective field capacity. This study aimed to observe and analyse the time that is lost during harvesting processes utilizing Thai combine harvesters. The random data was collected in November 2017 from 28 Thai combine harvesters harvesting Khao Dowk Mali 105 and in May 2017 from 27 Thai combine harvesters harvesting Phitsanulok-2. The theoretical field time, the headland turning time, the un-harvest moving and unloading time, the adjustment and maintenance time, and the bund crossing time were all recorded. The results indicated that the headland turning time and the un-harvest moving and unloading time had been the major influences that had been responsible for the increases in total time and had resulted in decreases in the effective field capacity. The times for adjustment and maintenance and for bund crossing had shown only minor losses.

1. Introduction

Thailand is an agricultural country which produces tens of millions of tons of rice grains every year [1]. Presently, the rice production region of the country is facing serious problems, such as labour shortages, an ageing population, and raises in wages, all of which have influenced the quality and quantity of rice grains and timeliness [2, 3]. Given these current problems, the use of TCH is increasingly becoming more popular for harvests instead of utilizing manual labourers. The reasons are that the TCH can quickly complete the harvesting and its multifunction technology includes the processes of cutting, threshing, separating, and cleaning [4, 5]. However, at present, most Thai farmers (or field owners) still do not own personal combine harvesters, which means that during the harvesting season, they have to hire the TCH. Many harvesting providers are controlled and managed by local agencies. Usually, these local agencies carry out their job based on their previous experience. As such, they only focus on the profits they can earn, but are unconcerned about the performance of the machines. For example, they are not bothered by product losses, quality losses, or EFC [6].

EFC is an especially important indicator that determines the total area that a combine harvester can harvest in an hour. Before hiring the combine harvester to harvest their fields, most field owners want to know the EFC. It is calculated by the ratio of the total field area and the Ttotal. Moreover, the Ttotal is the summation of the Tth and TL. If the TL decreases, the EFC will be increased. Conversely, if the TL is zero, the EFC will be the maximum [4]. However, during the harvesting practices, there is no harvesting machine, such as the combine harvester, that can complete the harvest without encountering some lost time. This is because there are many uncontrolled factors in the rice fields, including the sizes of rice fields or the yields [7-9]. Therefore, the TL is defined by ASAE Standards [10], meaning that is combined by using the Tn, Tf, Tm, and the Tb. Therefore, if these periods of lost time were to be analyzed in order to discover the major impacts to the EFC, future studies could be carried out to find solutions to reduce them, which would allow the EFC of the TCH to increase. There have been many previous studies, which have examined grain losses [5, 11-15], power and energy requirements [16, 17], ages [18], external factors [8, 19-21], and weather [9] and how they can affect the performance of the combine harvesters. Yet, only a few of them have focused on the effects of lost time on the EFC of the TCH.

Thus, the objective of the research was to observe and analyze the lost time in the harvesting processes of TCH when KDML105 and PSL2 were being harvested. The outcomes of this research study, which focused on the importance of decreasing lost time, can be transferred to the harvesting providers and the information can be used to establish future agricultural policies for Thailand.

Table 1. Notations.

Abbreviations	Descriptions
KDML105	Khao Dowk Mali 105 rice variety
PSL2	Phitsanulok-2 rice variety
TCH	Thai combine harvester
EFC	effective field capacity
Tth	theoretical field time (sec)
TL	total lost time (sec)
Tn	headland turning time (sec)
Tf	un-harvest moving and unloading time (sec)
Tm	adjustment and maintenance time (sec)
Tb	bund crossing time (sec)
Ttotal	total working time (sec)
$Ttotal_{KDML105}$	Total working time when harvesting the Khao Dowk Mali 105 rice variety
$Ttotal_{PSL2}$	Total working time when harvesting the Phitsanulok-2 rice variety rice variety

2. Material and methods

This research exclusively focused on TCH, which were being used to harvest rice fields in Khon Kaen, Kalasin, Maha Sarakham, and Roi-Et Provinces during the months of May and November of 2017. The varieties of KDML105 and PSL2 were used as samples because these two varieties are very popular for field owners in both the wet and dry seasons. The TCH, performing the harvests, were randomly selected to collect the data, which included the machine, field, crop, the Tth, and the TL. The Tth and the TL (the Tn, Tf, Tm and Tb) were recorded using a stopwatch.

Firstly, the Tn was collected from the moment when the TCHs' header was lifted until when the header was dropped and harvesting continued. Secondly, the Tf was collected when the TCH had been temporarily stopped, had travelled to a truck trailer or had unloaded the grain, until the time when the TCH started to harvest again. Thirdly, the Tb would only take place with the large rice, which had been separated by the field owner in order to conserve and manage water. Therefore, the Tb would only be collected when the TCH had lifted the header, had crossed the bund to another field, and until the TCH had begun to harvest again. Next, the Tm rarely took place during the harvesting process because before the harvesting season would begin, most of the providers would completely prepare their machines. However, it was possible to measure the Tm during the period when the TCH had been temporarily stopped until the harvesting had once again been started. The Tth value could be calculated by using the Ttotal and the TL. Furthermore, data from the Tth, Tn, Tf, Tm, and the Tb was analysed by using the multiple linear regression technique and using IBM SPSS Statistics version 19. The prediction model of the standard score can be seen in equation 1. Finally, the percentage of lost time is shown in the final section.

$$Z/\ Y = \beta_1 Z_1 + \beta_2 Z_2 + \ldots + \beta_k Z_k \qquad (1)$$

in which $Z/\ Y$ = total time
$\beta_1, \beta_2 \ldots \beta_k$ = regression coefficient
$Z_1, Z_2 \ldots Z_k$ = lost time in harvesting
k = the amount of lost time in harvesting

3. Results and discussion

3.1. Overall data from observation

All data from the machines and the field and crop parameters is shown in table 2. The average values of Tth, Tn, Tf, Tb, Tm, and Ttotal for KDML105 and PSL2 were collected and are shown in table 3. The average values of the Tth, Tn, Tf, Tb, Tm, and the total time for the KDML105 variety were 2,679.27, 494.98, 606.60, 301.99, 20.64, and 4,103.48 sec, respectively. The average values of the Tth, Tn, Tf, Tb, Tm, and the total time for the PSL2 variety were 1,691.75, 533.37, 771.45, 260.93, 9.83, and 3,267.33 sec, respectively.

Table 2. Data from the machines and the field and crop parameters for the KDML105 and PSL2 varieties.

Parameters	Units	Varieties	
		KDML105	PSL2
Machine Parameters			
number of combine harvesters	machines	28	27
average header width	m	3.18	3.06
average horsepower	hp	231.33	258.33
Field Parameters			
number of fields	fields	28	27
average field areas	m^2	8,168.20	5,661.85
average width of field areas	m	47.84	42.13
average length of field areas	m	170.74	134.39
Crop Parameters			
average yields	kg/m^2	0.24	0.44
average moisture content of paddies	%wb	24.60	25.78

Table 3. The averages of the Tth, Tn, Tf, Tb, Tm, and the Ttotal for the KDML105 and PSL2 varieties.

Parameters	Units	Varieties	
		KDML105	PSL2
Tth	sec	2,679.27	1,691.75
Tn	sec	494.98	533.37
Tf	sec	606.60	771.45
Tm	sec	301.99	260.93
Tb	sec	20.64	9.83
Ttotal	sec	4,103.48	3,267.33

3.2. Analysis of the lost time affecting the total time

The data of Tth, Tn, Tf, Tm, and the Tb for both the KDML105 and the PSL2 varieties was analysed by using the multiple linear regression technique and the prediction model of Ttotal for the KDML105 and the PSL2 varieties and is shown in equations 2 and 3, respectively.

$$Ttotal_{KDML105} = 0.635\ (Tth) + 0.108\ (Tn) + 0.152\ (Tf) + 0.221\ (Tm) + 0.017\ (Tb) \quad (2)$$

$$Ttotal_{PSL2} = 0.599\ (Tth) + 0.146\ (Tn) + 0.265\ (Tf) + 0.311\ (Tm) + 0.009\ (Tb) \quad (3)$$

Both equations 2 and 3 were analysed, and the percentages of theoretical and lost time for KDML105 and PSL2 are shown in figures 1 and 2, respectively. The percentages of Tth, Tn, Tf, Tm, and Tb for KDML105 were 65.29, 12.06, 14.78, 7.36, and 0.50 %, respectively. Moreover, the percentages of Tth, Tn, Tf, Tm, and Tb for PSL2 were 51.78, 16.32, 23.61, 7.99, and 0.30%, respectively.

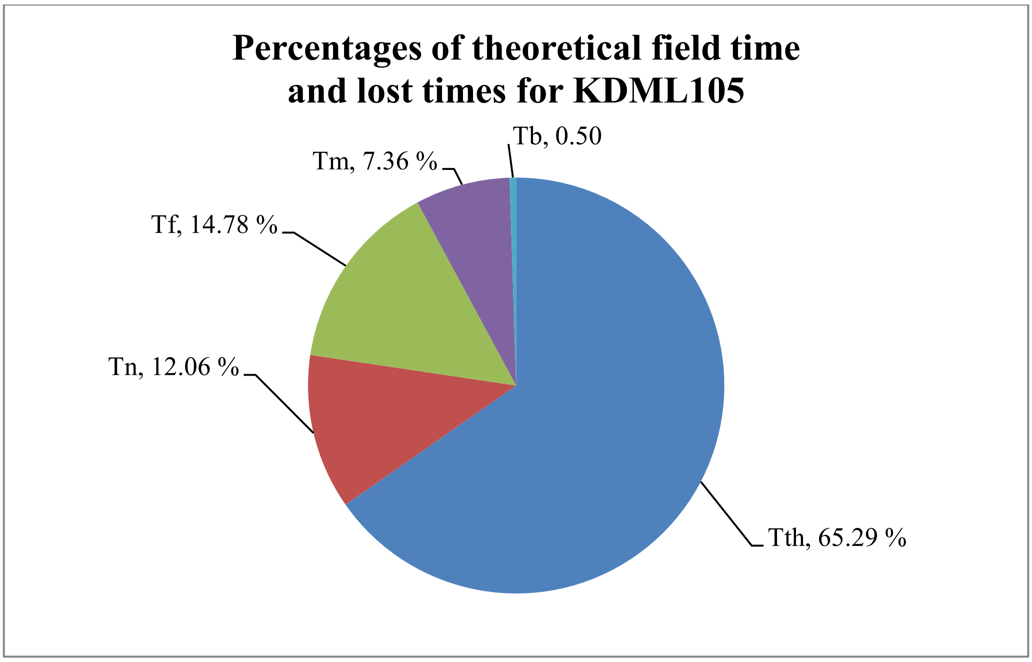

Figure 1: Percentages of theoretical field time and lost time for the KDML105 variety

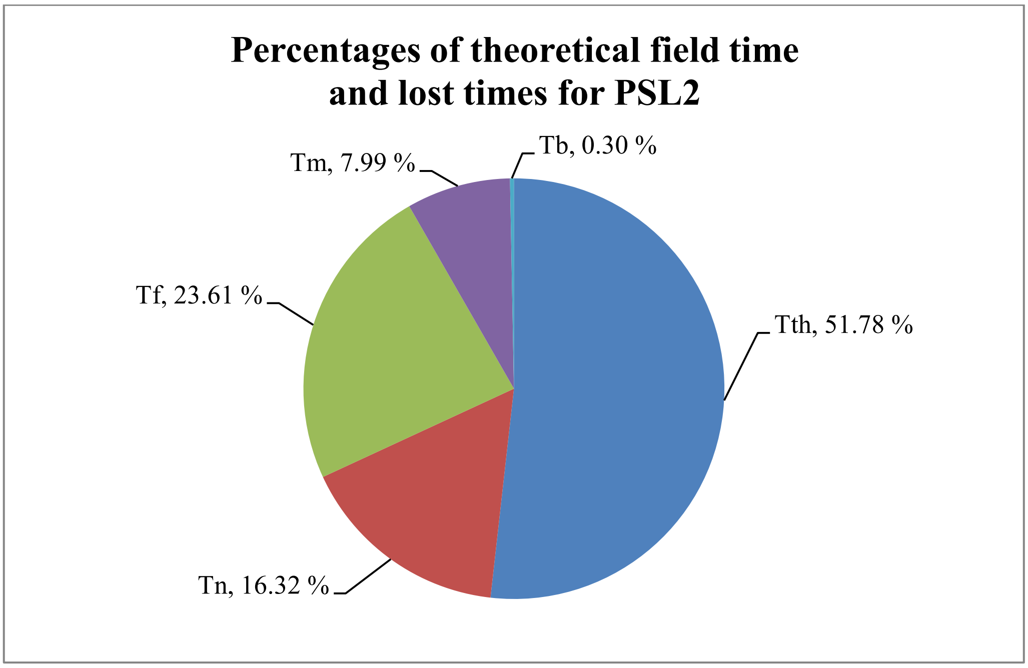

Figure 2: Percentages of theoretical field time and lost time for the PSL2 variety

Moreover, figures 1 and 2 show that the percentage of Tth for the KDML105 variety was higher than that of the PSL2 variety due to the influence of the size of the field areas. For this reason, the TCH had taken a longer time to harvest a larger field and had shown better efficiency than when the harvest had been carried out in a small field [7]. Moreover, not only had the size of the field area influenced the Tth, but it had also influenced the Tn. The percentage of Tn for the PSL2 variety was higher than the KDML105 variety because when harvesting was being carried out in small fields, the TCH often had to turn at the headland and at the field corners, which had caused an increase in the Tn [8]. However, it is possible to decrease the Tn by increasing of the size of the field area.

The percentage of the Tf of the PSL2 variety was higher than the KDML105 variety due to the influence of the yield [6]. This idea is supported by the fact that the TCH, which are used to harvest rice fields with higher yields, can obtain more rice grains, which means that the grain tank will quickly become full. Thus, the TCH had to make frequent trips in order to unload the grain. The Tf could be decreased by increasing the capacity of the grain tanks or by speeding up the unloading system. In the future, both of these options will need to be studied. However, it was found that the Tm and the Tb had only slightly affected the Ttotal.

4. Conclusions

The TL had affected the performance of the combine harvest, such as the EFC. The study's results indicated that the Tth and Tn had been affected by the size of the rice field areas, but the Tf had been affected by the yield.

This paper presents two ideas, which can be used to solve the effects of these two factors. Firstly, by combining fragmented rice fields and making them into one big rice field, the Tth can be increased and the Tn can be reduced. Secondly, if the capacity of the grain tank could be increased, which would increase the speed of the unloading system, the Tf may then decrease. Thus, these two ideas should be studied in the future.

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