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Original Article

Operating factors of Thai threshers affecting corn shelling losses

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Abstract

The objective of this research was to study the operating factors of Thai threshers affecting corn shelling losses, which comprised rotor speed (RS), louver inclination (LI), grain moisture content (MC), feed rate (FR), and grain to material other than grain ratio (GM). Seventeen Thai corn-shelling threshers were random-sampled during the late rainy season crop of 2008 and ten threshers were sampled in the early rainy season crop of 2009 in Loei province, Northeast of Thailand. The results of this study indicated that LI and MC affected shelling losses whereas RS, FR and GM did not affect losses. Increased LI or decreased MC tended to reduce shelling losses. In operating the Thai threshers for corn shelling, if shelling losses have to be kept lower that 0.5%, the moisture content should not exceed 20%wb and the louver inclination should not be less than 85 degrees.

Keywords: Thai thresher, operating factors, corn shelling

1. Introduction

Corn as an animal feed is very important for Thai livestock industry. Presently, Thailand has roughly 1.1 million ha of corn plantations, with a total yield of over 4.6 million tons or 800 million US dollars (OAE, 2010). Corn shelling is an important corn production process, for it eases in transportation, manufacturing, storage, and trading. To date, corn shellers have been developed and used widely, but their use is confined to shelling of corn. Nowadays, Thai axial flow threshers that have been developed and improved are becoming more popular. These threshers, known as Thai threshers, have been modified for both rice threshing and corn shelling (Figure 1), and usage of the rice thresher has increased.

The use of axial flow rice threshers or other plant shelling machines should be adjusted or modified in some of the parts (Tongsawatwong *et al.*, 2003). Previous studies adjusted and modified rice threshers for threshing other crops. Pinitdanklang (2001) conducted a study on the concave rod clearance and the rotor speed that affected sunflower threshing using an axial flow rice thresher. It was shown that with the concave rod clearance of 19 mm and

Figure 1. Thai Thresher in corn shelling

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the rotor speed ranging from 17.27 to 20.42 m/s, loss of sunflower seeds from threshing will be less than 1 percent, breakage less than 1 percent, and efficiency 99 percent. Wongpichet (1991) modified the axial flow thresher for threshing Cuban kapok seeds and found that the length of threshing unit should not be less than 1.15 m and the concave rod clearance should be from 12 to 16 mm, concave clearance between 27.5 to 52.5 mm. and the rotor speed within the range of 13 to 20 m/sec. Vejasit (1991) modified a rice thresher for threshing soybean and found that the rotor speed should be from 10.7 to 14.7 m/sec. The spike-tooth rotor results in less breakage than the rasp-bar rotor. The Division of Agricultural Engineering also developed a mung bean sheller from the principle of a rice thresher (Imprasertsuk, 1991).

In modifying the Thai thresher to shell corn, the threshing unit is the most important component affecting the thresher's capacity. In adjusting the Thai rice thresher, farmers mainly modify the threshing unit before using it to shell corn. This research therefore aimed at studying the operating factors of Thai threshers affecting corn shelling losses.

2. Methodology

This study was conducted by randomly sampling losses from the use of the axial flow thresher in corn shelling, observing the amount of broken grain and cleanliness of products obtained. The experiment was carried out in real working situation of farmers in Phu Kradung District and Pha Khaw District, Loei. Seventeen rice threshers were tested in the late rainy season crop of 2008 and 10 threshers in early rainy season crop of 2009.

2.1 Data collection

Prior to the experiment, data on the grain moisture content (MC) and the grain to material other than grain ratio (GM) were collected in triplicate. Measurement was carried out on the rotor speed (RS), louver inclination (LI), and the feedrate (FR). The products from the grain outlet, straw outlet, and chaff outlet were collected for samples, as shown in Figure 2. The collection was done simultaneously in triplicate. Five kg of seeds from the grain outlet were also collected to find the cleanliness of corn and grain breakage (GB).

Figure 2. Collection of samples of corn shelling losses of Thai threshers

The samples taken from the grain outlet, straw outlet, and chaff outlet were screened until only corn grains remained. Then the total shelling unit losses (TL) and grain breakage were computed based on the Procedure for Evaluation of Corn Shellers (FAO, 1994).

2.1 Analysis of operating factors of Thai threshers affecting corn shelling losses

From the five parameters studied and the effects on losses sampled from threshers, the following linear regression equation was built (Equation 1). The linear regression equation obtained was analyzed in order to find the operation that affected shelling losses using the Backward Elimination technique.

$$Y = A_0 + A_i X_i \quad (1)$$

where Y = dependent variable
X_i = independent variable
A_0, A_i = constant
i = 1, 2, 3, … , k ; (for k factors)

From the obtained parameters, the terms affecting the amount of threshing unit losses were used in the construction of regression equations. Then the equations were applied in analyzing the effects of parameters on the amount of the losses based on the Best Subset Regression method, determining the effect of each parameter on the coefficients of determination (R^2) (Draper and Smith, 1998) by using SPSS Statistics 17.0 Release, SN: 5068054.

3. Results and Discussion

The results from sampling of the effects of operating factors of Thai thresher on threshing unit losses in corn shelling for late rainy season crop of 2008 are shown in Table 1. Length of the sampled threshing units were 1.5, 1.8, 2.1, and 2.4 m. Number of units if each length were 2, 10, 4 and 1 unit, respectively. The rotor speeds ranged from 15.6 to 23.5 m/sec, or an average of 18.0 m/s. The louver inclination was ranged from 82.6 to 89.2, average 86.9 degrees. The feed rates applied ranged from 3.8 to 15.8 T/h, with an average of 9.8 T/h. The grain moisture contents of shelled corn were from 13.5 to 22.7 %wb and an average of 16.8 % wb. The grain to material other than grain ratios were between 3.5 and 5.7, or an average of 4.5. The threshing losses were from 0.007 to 0.779 %, with an average of 0.122%. The breakage ranged from 0.85 to 3.45 %, and an average of 1.98%.

During the early rainy season crop of 2009, length of the sampled threshing units were 1.5, 1.8, 2.1, and 2.4 m. Number of units of each length were 1, 6, 2 and 1, respectively. The rotor speeds applied were from 17.0 to 19.4 m/s, or at an average of 18.2 m/s. The louver inclination was ranged

Table 1. Effects of operating factors of Thai thresher on threshing unit losses in corn shelling for late rainy season crop of 2008

No.	Length of rotor(m)	RS (m/s)	LI (Degree)	FR (T/h)	MC (%wb)	GM (%)	TL (%)	GB
1	1.5	19.2	87.8	8.9	14.7	5.3	0.026	1.15
2	1.5	23.5	88.0	9.2	16.1	5.0	0.007	1.54
3	1.8	17.4	88.0	8.0	15.1	4.8	0.035	1.00
4	1.8	17.5	87.0	8.2	16.8	3.7	0.135	2.30
5	1.8	15.7	85.8	3.8	15.6	3.6	0.205	2.26
6	1.8	15.6	89.2	8.0	22.7	3.5	0.023	2.35
7	1.8	16.4	86.4	11.3	17.7	3.6	0.148	1.54
8	1.8	19.4	82.6	10.3	13.5	4.6	0.779	1.51
9	1.8	17.1	88.0	8.9	16.9	5.4	0.058	2.37
10	1.8	19.0	87.0	5.9	18.9	4.8	0.110	1.53
11	1.8	18.3	87.0	11.1	16.2	4.3	0.124	3.45
12	1.8	16.5	89.2	11.3	18.6	4.8	0.040	2.12
13	2.1	17.0	86.5	11.6	15.3	4.5	0.069	2.50
14	2.1	19.0	87.7	15.8	17.1	4.9	0.053	3.07
15	2.1	18.9	84.7	11.7	21.7	3.5	0.192	2.77
16	2.1	18.4	87.8	9.9	14.6	5.7	0.018	1.28
17	2.4	16.9	84.6	12.1	14.5	5.1	0.060	0.85
Average		18.0	86.9	9.8	16.8	4.5	0.122	1.98

from 82.1 to 86.1 degrees, average 84.5 degrees. The feeding rates ranged from 9.6 to 16.0 T/h, or an average of 11.9 T/h. The grain moisture content ranged from 18.7 to 45.8%wb, with an average of 28.8%wb. The grain to material other than grain ratios were between 1.7 and 2.8, with an average of 2.2. The threshing losses were from 0.227 to 1.216%, or at an average of 0.635%. Grain breakage was between 0.79 and 1.91%, with an average of 1.46%, as shown in Table 2.

From Tables 1 and 2, thresher losses in corn shelling in the early rainy season crop of 2009 (average 0.635%) were higher than the losses in the late rainy season crop of 2008 (average 0.122%). This was due to the corn in the early rainy season crop having greater moisture content than the corn in the late rainy season crop. Moisture is a great obstacle in corn shelling and screening in the threshing unit, resulting in greater losses in corn with high moisture than in corn with low moisture content. Besides, grain breakage was higher than 1%, which is considered a large amount when corn shelling is done in the two seasons. This indicates that corn shelling by Thai threshers is relatively violent. Comparison between the two seasons showed that corn shelling in the late rainy season crop yielded higher grain breakage than in the early rainy season crop because corn in the early rainy season crop had a higher grain moisture content (average 28.8%wb) than corn in the late rainy season crop (average 16.8%wb). This happened because the grain with high moisture content was still not fully mature. The grain was still not solid and had high flexibility when the thresher beat on it; hence, breakage of the grain was low. The grain with low moisture content was more mature and harder, while its flexibility became lower; therefore, the grain was more prone to breakage when beaten, especially in the case of dry grain or grain with low moisture content (Chuan-udom, Chinsuwan, 2011).

3.1 Effects of operating factors of Thai threshers on corn shelling losses

The data from Tables 1 and 2 were used to build a regression equation and analysis was done by the backward elimination method. The results showed that LI and MC are the two parameters affecting shelling losses, whereas RS, FR, and GM of operating factors in general did not have any effect on the losses. The equation is show below those terms significant at the 0.05 probability level, as shown in Table 3.

The parameters in Table 3 were taken to calculate the multiple linear regression using SPSS. The regression equation determined the effect of each operating parameter on losses from corn shelling using Thai threshers as shown in equation 2 with the R^2 value equal to 0.79.

$$TL = 12.22 - 0.141(LI) + 0.011(MC) \quad (2)$$

Refer to the SPSS output, the effects of LI and MC on losses at the thresher were 91.2% and 8.8% respectively as shown in Table 4. It can be seen that when a Thai thresher was used for corn shelling, LI greatly affected losses. MC showed relatively low effect because of the difference in harvesting seasons. The early rainy season crop gave higher grain moisture content than the late rainy season crop.

Table 2. Effects of operating factors of Thai thresher on threshing unit losses in corn shelling for early rainy season crop of 2009

No.	Length of rotor(m)	RS (m/s)	LI (Degree)	FR (T/h)	MC (%wb)	GM (%)	TL (%)	GB
1	1.5	19.4	82.8	12.5	30.0	2.0	1.155	1.64
2	1.8	17.5	85.8	16.0	31.6	1.9	0.466	0.83
3	1.8	17.6	82.1	9.6	27.8	2.7	1.216	1.10
4	1.8	19.2	86.1	10.4	45.8	1.7	0.227	1.64
5	1.8	18.2	84.2	10.2	18.7	2.1	0.555	1.91
6	1.8	17.6	86.1	10.0	23.6	2.8	0.190	1.58
7	1.8	18.0	84.4	13.3	24.6	2.6	0.453	1.65
8	2.1	18.5	84.5	15.2	26.5	2.6	0.675	1.76
9	2.1	19.0	84.2	10.7	20.9	2.0	0.545	1.91
10	2.4	17.0	84.5	11.3	38.9	1.7	0.869	0.79
Average		18.2	84.5	11.9	28.8	2.2	0.635	1.46

Table 3. Operating factors affecting threshing unit losses in corn shelling

Factors	Probability (%)
LI	0.01
MC	0.03

Table 4. Percentage of the effects of louver inclination and grain moisture content on threshing unit losses in corn shelling from SPSS

Factors	%
LI	91.2
MC	8.8

From Equation 2, a correlation graph was plotted to show the effects of LI and MC on TL (Figure 3). It was shown that increased LI led to a decreasing trend of TL. The graph shows that farmers had adjusted the louver inclination until it was almost perpendicular to the threshing unit axis. Increased LI caused decreased the axial traveling speed of corn in the threshing unit. This affects the length of time for the threshing and grain separation process which has a direct effect on TL (Chuan-udom, Chinsuwan, 2009a). The louver inclination adjusted by farmers for corn shelling was in the range of 82.1 to 89.2 degrees (Tables 1 and 2), which was higher than the appropriate louver inclination for rice threshing, i.e., at 68 degrees (Chuan-udom, Chinsuwan, 2009b). This indicates more time required by the corn to be shelled and separated in the threshing unit than by rice. Increased MC results in a tendency for TL to increase because higher levels of MC result in more difficulty in shelling and grain separation of corn in the threshing unit

From the equation 2 and Figure 3, if the TL is required to be lower than 0.5 percent, then use of Thai axial flow thresher for corn shelling should be done when the grain has the moisture content should not exceed 20%wb and the louver inclination not less than 85 degrees.

With respect to grain breakage, when the operations of the five parameters were statistically analyzed, it was found that RS, LI, MC, FR and GM were not correlated. Since sampling was done from the grain outlet, more grain could be broken due to the use of screw conveyor in driving the grain towards the grain outlet. Analysis on this part could not be done.

4. Conclusions

Losses from the use of Thai threshers for corn shelling are low while grain breakage is high. The grain moisture content due to harvesting time affects both losses from threshing and grain breakage using Thai threshers.

The two parameters of Thai threshers, i.e., LI and MC, affect losses from the threshing unit. RS, FR and GM do not have any statistical significant effect on the losses. Increased LI or decreased MC leads to decreasing threshing losses. In operating the Thai thresher, if shelling losses (threshing unit

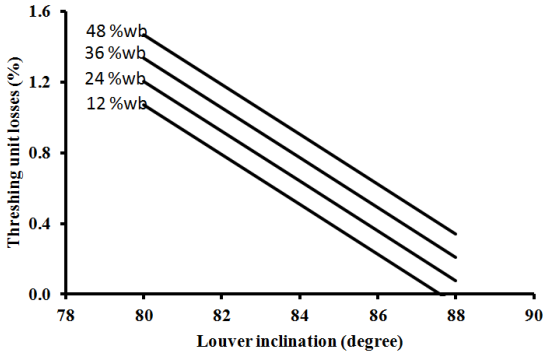

Figure 3. Effect of louver inclination on threshing unit loss at different grain moisture contents

losses) have to be kept lower that 0.5%, the moisture content should not exceed 20%wb and the louver inclination should not be less than 85 degrees.

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Appendix
List of abbreviations used in the paper

RS	Rotor speed (m/s)
LI	Louver inclination (degree)
FR	Feed rate (T/h)
MC	Grain moisture content (%wb)
GM	Grain to material other than grain
TL	Total shelling unit losses (%)
GB	Grain breakage (%)