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Peg-tooth spacing and guide vane inclination of a Thai combine harvester affecting harvesting losses

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Abstract

Peg-tooth spacing and guide vane inclination of Thai combine harvesters are important parameters affecting harvesting losses. The harvester owners often adjust the peg-tooth spacing and guide vane inclination before harvesting. This study aimed to evaluate how harvesting loss are affected by the peg-tooth spacing and guide vane inclination of a Thai combine harvester. The results showed that increasing of peg-tooth spacing resulted in linearly increasing threshing unit loss. Threshing unit losses of Khao Dok Mali 105 (KDML 105) and Chainat 1 rice varieties were 0.0045 and 0.0306%/mm of spacing, respectively. Increasing of the guide vane inclination resulted in a linearly decreasing threshing unit loss. Threshing unit losses of KDML 105 and Chainat 1 rice varieties were 0.0575 and 0.3112%/degree of the guide vane, respectively.

Keywords: Thai combine harvester, Harvesting losses, Peg-tooth, Guide vane

1. Introduction

Currently, combine harvesters play an important role in rice harvesting in Thailand, which is a major rice exporter. The harvesters used in Thailand are a local design and they use an axial flow threshing unit [1], so they are called "Thai combine harvesters". Most harvesters are used for contract harvesting.

Harvest loss is important. Loss occur in many parts of the harvester. The threshing unit affects a rather high harvesting loss due to ineffective threshing and incomplete separation of the seeds from the straw, so some threshed and unthreshed seed is found in the straw flowing out of the straw exit chute. The causes of this loss are a high diversity of crop conditions, utilization of the combine and improper machine adjustment [2].

Chuan-Udom [3] studied the important parameters of an axial-flow threshing unit using a native rice variety, KDML 105, and found that the guide vane inclination (Figure 1) caused the most threshing unit losses (40.66%), followed by the threshing drum speed (39.6%). The losses were affected by the feed rate, moisture content and the grain/straw ratio were 8.67%, 5.68% and 5.38%, respectively. For the hybrid rice variety, Chainat 1, grain moisture content caused the highest loss (53.11%) followed by the guide vane inclination (38.56%). The threshing drum speed and feed rate caused lower losses, 4.52% and 3.81%, respectively. The research data indicated that the guide vane inclination caused rather high threshing unit loss for both native and hybrid rice varieties.

The guide vane affects threshing performance [4-6]. Material flows along the threshing drum shaft faster or slower due to the smaller or higher inclination of guide vane. High inclination causes slower material flow into threshing unit resulting in more threshing and more seed separation from the straw. This results in reducing threshing unit losses but increasing power required for threshing [7].

Additionally, the peg-tooth spacing of the threshing drum is an important parameter when threshing grain from straw. With larger spacing, higher losses results in inefficient threshing but lower power required for threshing. Using more power also increases harvesting costs.

In Thailand, a harvesting contractor is paid on the basis of the working area. Contractors often reduce guide vane inclination and increase peg-tooth spacing to increase threshing capacity. This results in higher threshing loss.

Guide vane inclination and peg-tooth spacing are important parameters affecting harvesting losses and Thai combine harvesters only use the peg-tooth design equipment. This study aimed to evaluate harvesting loss due to peg-tooth spacing and guide vane inclination. Knowledge gained from this study will be useful to the government for policy planning on the use of the Thai combine harvester and to provide harvester owners with an optimum guide vane inclination and peg-tooth spacing to reduce harvesting loss.

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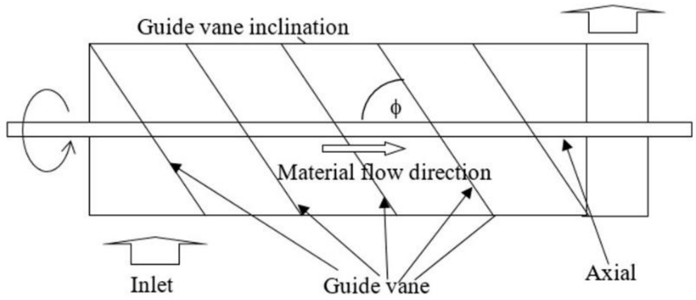

Figure 1 Guide vane inclination (top view)

Figure 2 Sample Collection of harvesting losses from a Thai combine harvester

2. Materials and methods

2.1 A Thai combine harvester

The study was conducted using a 194 kW Thai combine harvester with 3 m width. The axial flow threshing unit was comprised of a threshing drum, 1.92 m long with a 0.62 m diameter (measured from the tip of peg-tooth) and peg-teeth that were 11 mm in diameter and 82 mm long. The threshing concave was comprised of 7 mm diameter rod with 17 mm concave clearance. There were five guide vanes on the upper concave.

2.2 Materials and conditions

The test was conducted in an irrigated field in Khon Kaen province in Northeast Thailand. For the KDML 105 rice variety, the average moisture content of the grain and straw were 25.5% and 63.0%wb, respectively. The average crop density, average height and vertical tilted angle of the stalks were 144.7 per m^2, 1.05 m and 22.1^o, respectively. The grain/straw ratio was 0.93. The average feed rate for the combine harvester was 7.5 tonnes/hour.

For the Chainat 1 rice variety, the average moisture content of grain and straw were 22.8% and 54.2%wb, respectively. The average crop density, average height and vertical tilted angle of stalk were 351 per m^2, 0.68 m, and 20.8^o, respectively. The grain/ straw ratio was 0.82. The average feed rate for the combine harvester was 9.5 tonnes/hour. Both rice varieties were tested at a threshing drum velocity (at the tip of peg-tooth) of 17.5 m/s.

2.3 Factors and experiment method

Factors studied for threshing the two rice varieties were three spacings of peg-teeth: 70, 140 and 210 mm and three guide vane inclinations: 64^o, 68^o and 72^o. The test was conducted with three replicates. For each replicate, data was collected 10 m behind the combine harvester after the harvester had travelled continuously for at least 15 m to obtain uniform operation.

Sample material ejected from threshing unit was collected in a mesh bag (Figure 2). After that, straw was separated to find threshing unit losses, which included unthreshed seeds (threshing losses) and threshed seed (separation losses).

3. Results and discussions

3.1 Effect of peg-tooth spacing on threshing unit loss

From Table 1, as the peg-tooth spacing was varied between 70-210 mm, the threshing unit losses of KDML 105 and Chainat 1 were 0.42% to 1.05% and 3.46% to 7.74%, respectively.

The relationship between the peg-tooth spacing and the threshing unit loss depicted in Figure 3 show that as the peg-tooth spacing increased, the threshing unit losses increased linearly, with R^2=0.99 and R^2=0.88 for KDML 105 and Chainat 1 rice varieties, respectively. From Figure 3, peg-tooth spacing increased as some peg-teeth were removed resulting in increased threshing unit losses.

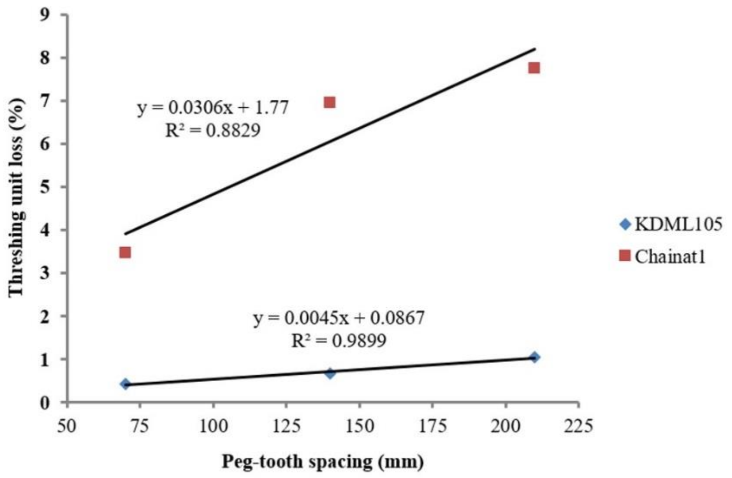

Figure 3 Relationship between peg-tooth spacing (70-210 mm) and threshing unit losses

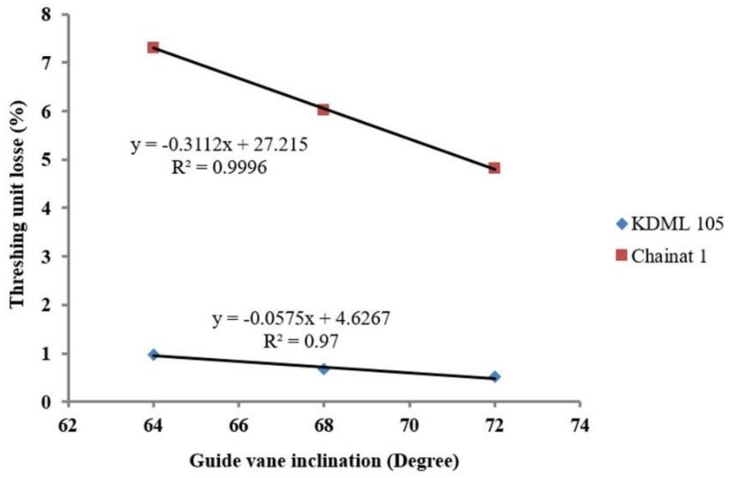

Figure 4 Relationship between guide vane inclination (64-72^o) and threshing unit losses

Table 1 Threshing unit losses (%) of the KDML 105 and the Chainat 1 rice varieties at 70, 140 and 210 mm peg-tooth spacings

Peg-tooth spacing	Threshing unit loss (%)	
(mm)	KDML 105	Chainat 1
70	0.42	3.46
140	0.68	6.95
210	1.05	7.74

Table 2 Threshing unit losses of KDML 105 and Chainat 1 rice varieties at 64^o, 68^o and 72^o guide vane inclinations

Guide vane inclination	Threshing unit losses (%)	
(degrees)	KDML 105	Chainat 1
64	0.97	7.31
68	0.67	6.02
72	0.51	4.82

Increasing the peg-tooth spacing by decreasing the number of peg-teeth resulted in lower threshing power and increased numbers of unthreshed seeds [1]. This resulted in higher threshing unit losses. The threshing unit losses for the Chainat 1 variety were greater than for KDML 105 since Chainat 1 is a hybrid variety that is harder to thresh than KDML 105 [8].

From Figure 3, the test was conducted under field conditions. Increased peg-tooth spacing resulted in increasing threshing unit losses of 0.0045% and 0.0306%/mm for KDML 105 and the Chainat 1, respectively.

3.2 Effect of guide vane inclination on threshing unit loss

For guide vane inclinations between 64^o and 72^o, the threshing unit loss of KMDL 105 and Chainat 1 were 0.51% and 0.97%, respectively (Table 2).

The relationship between guide vane inclination and threshing unit loss is shown in Figure 4. As the guide vane inclination was increased, there were linearly increasing threshing unit losses. The values of R^2 were 0.97 and 0.99 for KDML 105 and Chainat 1, respectively. Increased guide vane inclinations resulted in decreased threshing unit losses.

Table 3 Losses and value loss of the KDML 105 and the Chainat 1 rice varieties affected by increased peg-tooth spacing and decreased guide vane inclination

Variety	Loss				Total loss	
	Peg-tooth spacing		Guide vane inclination		%/mm + %/degree	10^6 US$/mm
	%/mm	10^6 US$/mm	%/degree	10^6 US$/mm		
KDML 105	0.0045	15.9	0.0575	203.7	0.062	219.6
Chainat 1	0.0306	146.9	0.3112	1493.8	0.3418	1640.7

Note: 1) The average total production of rice KMDL105 and white rice were 8 and 21 million tons per year [6, 7].
2) The average price of rice KMDL105 and white rice were 442.9 and 228.6 US dollars/ton, respectively [8].
3) Exchange rate 35 Baht = 1 US $

An increased inclination allowed longer threshing and separating times for the material that resulted in decreasing threshing unit losses [2, 9-12]. From Figure 4, the test was conducted under field conditions. Increasing guide vane inclination resulted in decreasing threshing unit losses of 0.0575% and 0.3112%/degrees for KDML 105 and Chainat 1, respectively.

3.3 Assessment of value losses from peg-tooth spacing and guide vane inclination adjustment

For assessment of value losses from peg-tooth spacing and guide vane inclination adjustment, the average total production of rice KMDL 105 and white rice were 8 and 21 million tonnes per year [13-14] which was valued at 4,800 million US dollars (average price of rice KMDL 105 and white rice were 442.9 and 228.6 US dollars/tonne, respectively) [15], respectively. The harvesting loss from combine harvesting of all white rice was estimated as Chainat 1 losses.

If all of KMDL 105 and white rice were harvested by combine harvester, the value losses should be as follows (Table 3):

1. Value losses due to increasing peg-tooth spacing for KMDL105 and Chainat 1 were 15.9 and 164.69 million US dollars/mm of peg-tooth spacing, respectively.
2. Value losses due to decreasing guide vane inclination for KMDL105 and Chainat 1 were 203.7 and 1493.8 US dollars/degree of guide vane inclination, respectively.
3. The total value losses due to both increasing of peg-tooth spacing and decreasing of guide vane inclination were 219.6 and 1640.7 US dollars, respectively**.** So, the annual total loss was 1,860.3 US dollars.

Not all planted area of the KMDL 105 and white rice was harvested by combine harvesters due to some restrictions**.** So, for an estimated 70%, 80% and 90% of the total area harvested by combine harvester, the total annual values of losses were 1,302.2, 1,488.2 and 1,674.3 US dollars, respectively**.**

It is obvious that peg-tooth spacing and guide vane inclination of Thai combine harvesters are greatly affected and result in high harvesting losses and value. So, the government should have a policy to inspect combine harvesters emphasizing peg-tooth spacing and guide vane inclination.

4. Conclusions

Peg-tooth spacing and guide vane inclination of a Thai combine harvester affect threshing unit losses. The conclusions are as follows:

1. Increasing peg-tooth spacing resulted in linearly increasing threshing unit losses with R^2 equal to 0.99 and 0.88 for KMDL105 and Chainat 1, respectively.
2. Decreasing guide vane inclination resulted in linearly increasing threshing unit losses with R^2 equal to 0.97 and 0.99 for KMDL105 and Chainat 1, respectively.
3. Increasing peg-tooth spacing resulted in decreasing threshing unit losses of 0.0045 and 0.0306% per mm for KMDL 105 and Chainat 1, respectively.
4. Decreasing guide vane inclination resulted in increasing threshing unit losses of 0.0575 and 0.3112%/degree for KMDL 105 and Chainat 1, respectively.
5. Each increasing peg-tooth spacing 1 mm and decreasing guide vane inclination 1 degree resulted in decreasing threshing unit losses of 0.062% and 0.3418% for rice KMDL 105 and Chainat 1, respectively.

5. Acknowledgements

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