The Work Quality Evaluation of the Combine Harvesters in Kurdistan province, Iran

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Summary
The combine harvesters pick, thresh and separate grain from MOG (material other than grain) regardless the grain quality and losses. The grain damage is a threat for safe production whilst grain losses impair the rural development and sustainable agriculture. The objective of this study was to evaluate the work quality of the mechanized wheat harvesting in Kurdistan province and develop its result to Iran. The shattering losses and the visible broken grain for the two conventional types of combine harvesters were studied. The amounts of harvested broken grain were measured more than 9.3%. The shattering losses on ground were exceeds from 99 kg/ha.

Key word: broken grain, MOG (material other than grain), shattering losses, wheat

Introduction
Wheat, except those are planted in steep hills, is harvested by grain combine harvesters. Growers financially penalized for selling grain if MOG (material other than grain) be more than that of official market grain grades. The grain damage and dockage, weed kernels and dirt are MOG which decrease the grain quality. Sometimes the MOG is so high that silos do not accept grain after a long time of waiting (often two days) for grain delivery. Producers are forced to separate the MOG from the grain (Fig. 1) or sell the crop for fewer prices to dealers. They mix it with a high quality bulk of grain to reduce the MOG percentage or occasionally winnow the materials again.

Figure 1: Winnowing of harvested wheat.

Broken grains are hidden losses while the grains on ground are true losses. In addition they are the essential criteria for the work quality of grain combine harvesters (Kutzbach and Quick, 1999). Grain quality may be defined by grain grading standards such as cracked or broken grain. Grain damage occurs during threshing, separating and handling (Hanna and Quick, 2007). Although correct adjustment of drum speed can reduce damage in grain but often was avoided by operators due to reduction in the field capacity.
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Damaged kernel reduces germination of grain while increase oxidation rate in storage or reservation (Mohsenin, 1970). Visible grain damage is the kernel damage where the seed coat appears broken to the naked eye (ASABE, 2005). Visual inspection of a grain sample is a method for measuring of grain damage (Srivastava et al., 2006).

Inadequate number of grain harvesters in a region increase machine field capacity more than recommended ranges for the crop harvesting. It reduces desired work quality by increasing in losses. Losses are the percentage of processed grain that exits the machine without being captured as harvested grain (Hanna and Quick, 2007). Header losses are shatter and cutterbar losses (Kutzbach and Quick, 1999 and Srivastava et al., 2006). Typical header losses for small grain crops when the combine is adjusted and operated correctly may vary from 0.5 to 2 percent of the average yield (FMO, 1973). Gathering (shattering) losses are grain heads that fall to the ground due to the action of the reel (Srivastava et al., 2006). It is the weight of unthreshed grain that has been dropped by the header (ASABE, 2005). Proper operation of the reel is critical to minimize header losses. An essential requirement for reel operation is that the reel speed must be greater than the ground speed (Bosoi et al., 1991).

This study was performed to determine the work quality of the wheat harvesting. The conventional combine harvesters with two different thresher units and header widths were considered to evaluate the grain quality and shattering losses of harvesting process. As the combine harvesters cross the wheat farms through south lower latitude to north higher latitudes in the country, this study can simulate the wheat harvesting quality in Iran.

Material and methods

The grain damage and shattering losses were determined for the combine harvesters. The experiments were conducted on the Dehgolan county fields in Kurdistan province during the summer of 2010. This region with 70000 ha wheat fields is one of the main areas for wheat production in the province.

It was assumed that the combine harvesters were properly adjusted by operators. The machine forward speed was 4-5 km/h based on the yield, field unevenness and etc. To get a real data, the combine operators were not aware about the experiment. Data were achieved by moving between fields, finding combine harvesters randomly, and collecting samples.

The experiment was conducted based on a completely randomized design with two treatments at three replications. Two commercial harvesters of differing make and size (treatments) were studied. Threshing units and headers width are different as described in following types:

Type A: a raspbar thresher and a beater with the header width of 4 m.

Type B: a raspbar thresher, a beater and a spike-tooth thresher with the header width of 5 m.

The experimental data were analyzed using a variance analysis to determine the amount of broken grain in the grain tanks and shattering losses on the ground for the combine harvesters. The means of the treatments (damaged grain and shattering losses) were compared with Duncan's multiple range tests at a 5 percent level of significance.

To determine the amount of broken grain, nine samples (3×3) were taken from tank of each combine harvester while different unloading processes (in different depths of grain in the tank). The broken grain was separated from the grain and MOG following by weight measuring (0.0001 kg precision). The amount of broken grain was calculated from the following equation:

$$BG = \frac{W_{BG}}{W_G + W_{MOG}} \times 100$$  \hspace{1cm} (1)

where $W_{BG}$, $W_G$ and $W_{MOG}$ are the weight of broken grain, grain and MOG in kg respectively.

To determine the shattering losses, except preharvest losses, the ears on ground were measured (fig 2). Preharvest losses are the grains on ground and remained on anchored stem before harvesting process. Each experimental plot was 2×2 m² in area, and loss sampling was performed using a 1m² frame.

1 The companie’s name are not mentioned.
Results and Discussion

Damaged Kernels
Table 1 demonstrates that there is a significant difference between type A and B regarding damaged kernels. Using two threshers increase the length and time of threshing process but the amount of broken grain was affected.

Table 1. Variance analysis for the damaged grain in combine harvester tanks.

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>Sum of squares</th>
<th>Degrees of freedom</th>
<th>Mean square</th>
<th>Computed F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Combine harvester type</td>
<td>34.861</td>
<td>1</td>
<td>34.86</td>
<td>7.625</td>
<td>0.008</td>
</tr>
<tr>
<td>Combine quantity (Q)</td>
<td>136.437</td>
<td>3</td>
<td>45.47</td>
<td>9.947</td>
<td>0.001</td>
</tr>
<tr>
<td>(H) x (Q)</td>
<td>261.502</td>
<td>3</td>
<td>87.16</td>
<td>0.542</td>
<td>0.003</td>
</tr>
<tr>
<td>Error</td>
<td>292.620</td>
<td>64</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Grain damage is expressed as the percentage by weight, to the near one-tenth, of kernels in the sample (ASABE, 2005). Fig (3) demonstrates that the broken grain in the type A was 9.3% while in the type B was 10.7%. It confirms that the processing damage, due to unsuitable design or inappropriate adjustment of functional operators, was more than the allowable ranges for the grain.

Figure 3. Comparison of the means of the damaged grain for two types of combine harvesters. Columns with the same letter are not different at a 5 percent level of significance.
A: a raspbar thresher and a beater.
B: a raspbar thresher, a beater and a spike-tooth thresher.

Losses
The results of the variance analysis from the machine losses experiment indicate that the combine type have a significant effect on the shattering losses (Table 2). It was determined that the ears
near to the edges of the header have a chance to go outside the header to soar the losses. There is a significant difference between the combines with respect to header losses as the working age of machine, operator skills, field topography, crop variety and etc. are different.

Table 2. Variance analysis for the ears shattered on ground.

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>Sum of squares</th>
<th>Degrees of freedom</th>
<th>Mean square</th>
<th>Computed F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Combine harvester type (H)</td>
<td>18850.347</td>
<td>1</td>
<td>18850.347</td>
<td>5.938</td>
<td>0.031</td>
</tr>
<tr>
<td>Combine quantity (Q)</td>
<td>30680.813</td>
<td>2</td>
<td>15340.407</td>
<td>4.832</td>
<td>0.029</td>
</tr>
<tr>
<td>(H) × (Q)</td>
<td>25683.004</td>
<td>2</td>
<td>12841.502</td>
<td>4.045</td>
<td>0.045</td>
</tr>
<tr>
<td>Error</td>
<td>15.333</td>
<td>12</td>
<td>0.511</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

A comparison of the shattering losses demonstrated that the type B has better performance than the type A with respect to the shattering losses (fig 4). The header in the later is smaller than the header width of the type B. The shattering losses in the type A were 164.3 kg/ha which is more than 99 kg/ha for the type B. The minimum shattering losses was calculated 2% (the maximum yield of 5000 kg/ha) whereas international standards for wheat set the acceptable loss level at 1% (Kutzbach and Quick, 1999).

Figure 4. Comparison of the means of the losses for two types of combine harvesters. Columns with the same letter are not different at a 5 percent level of significance.
A: header width of 4 m.
B: header width of 5 m.

Unsuitable harvest technology results in extra-cost for farmers and losses at preservation or storage. The evaluation of the shattering losses and broken grain confirms that the machine work quality for the existing commercial combine harvesters is not accepted. Thus modifying and optimizing the design and structure of the conventional combine harvesters is required.

References