ABSTRACT

Grain loss monitors are instruments which are installed on combine harvesters that make possibility to measure grain loss on different parts of combine. The instrument permits combine operator to use proper ground speed to keep grain loss in an acceptable range. There was used an indicator system to measure which flows on straw walker and sieves that indicates loss rate continuously. According to the executive office of wheat in the Ministry of Agriculture, average combine processing losses was reported from 1.72 to 2.41% during years 2005 till 2007 that it's far from ASAE standard was expected, so in order to control this losses the research was necessary in this case as explained. In this study, grain loss monitors was mounted behind the straw walker and sieves of John Deer 955 combine harvester. Crop and machine performance parameters then were measured as grain moisture content, yield, combine ground speed and processing loss, respectively. Combine harvester equipped with grain loss monitor was assessed on the wheat harvest. During harvesting plots, loss rate was measured and indicated using diodes of grain loss monitor to the operator. The loss rate shows combine processing loss. There is sound on monitors that notify to operator that which part has a more loss than standard range. It will be then adjusted and continued to harvesting. In order to evaluate instrument precision, indicated loss with measured loss was compared and investigated. Treatments of this study were: 1- ground speed of combine harvester as a main plot, 2- combine drum (cylinder) speed as a sub plot. Experimental design was split plot in a completely randomized block design with three replications. The results of two years research and study show that the processing loss of combine harvester was about 1% and adapted with ASABE standard No. S343.3 on 10-12% grain moisture content and 750 rpm drum speed. Also, there was no difference between measured and expected processing loss based on zero hypothesis; means loss rate indicated using grain loss monitor adapted with measured processing loss.

Key words: wheat, grain loss, combine, monitor, harvesting

Introduction

Current technology in combine harvesting provides not only grain loss decrease, but also outer materials reduction and presents grain loss in acceptable range. The only problem remained is that machine user must drive it with the least grain loss breaking.

In this matter, the approach is towards new control and automation systems. One of these approaches is development harvesting using grain loss monitors. Some investigation results are indicated as below:

Hafman, et al.[6] indicated in a survey that if combines are used for harvesting different crops then not only grain loss monitors confine improvement speed and decrease grain loss but can be used for feeding combine in order to provide maximum combine capacity. Tyson, et al.[18] reported which modern combines which are equipped with grain loss monitor can have harvesting ability from 97 to 98 percents of grains. Also, losses calculated from
separation curves correlated well with measured losses[7]. Ferreira, et al.[5] described that grain loss monitoring during all harvest season (gathering and processing losses), in the irrigated rice crop, can be used and its results in reducing losses due to immediate adjustments in the combines noted grain loss monitors fully adjust combine, according to crop conditions. In other words, whenever grain loss increases; the new adjustments will decrease the loss. Also, effect of combine operating parameters on harvest loss and quality in rice was performed[1]. Grain loss from the processor with properly adjusted modern combines can be extremely low, for example well below 1% for separation and shoe in corn and soybeans[14] and 3.5 to 30% in Canola[22]. Constructing an accurate prediction model for the quality of separation unit on combine harvesters is difficult since a lot of parameters are influencing this complex process. Therefore, online monitoring system for separation process in combine harvesters are installed, providing feedback to the operator[9]. Comparison of combine grain loss measurement techniques was reported by Siebenmorgen, et al.[16]. Because of the large errors experienced in calculating loss rates when estimating total grain yield with the plot combine, it was calculated that this approach was not appropriate for estimating combine losses from test runs of approximately 6 m in length.

There is no report available that in wheat loss harvesting using grain loss monitors in our country. Thus, it maybe defined there is an influence on precise measurement of combine grain loss because of using grain loss monitors and has importance in combine performance and capacity.

The objectives of this research included: 1. Field assessment of grain loss monitor, 2. Proper option for measuring grain loss in different parts of the combine harvesting.

A considerable contribution of country grain loss in year, occurs in harvesting stage with combine which is issued in 4.81% to 18.1% [1], with installing grain loss monitors in different parts of combine and measuring its loss, first, operator can decrease overall loss of combine and adjust it to standard situation, second, operator can measure the loss of each part separately and adjust it in acceptable range. However, there are lots of reasons for inefficiency that must be distinguished with skillful user. For example, sieve adjustment, in appropriate drum speed, improper feeding rate, are amusing these.

Before adjusting combine assessment for area crops, ground speed decrease in combine movement must not be taken as an easy solution. When the combine is sloping or moving in a direct line, there might be an overloading and the monitor shows grain loss amount. This machine enables drum performance with its maximum capacity in all situations. Using appropriate methods and precision agriculture instruments help to control grain loss and harvesting wastes and decrease to the least amount. Considering the capacity of available combines and reported loss amounts in years of 2004-2005 by wheat plan office following measurements is presented as:

A capacity of combine using available combines is 1-1.15 Ha/h. But using grain loss monitor, this capacity and performance of combine will increase till 1.5-2 Ha/h with 10 hours daily work. According to wheat average yield in year is equal to 3850 kg/ha. There would be a return on investment are equal to 10.1-13.5 million Rials. However, the price of grain loss monitor is 1250 AUS Dollars (11.4 million Rials). In other hand, the number of active combines for harvesting in year of 2004-2005, was 9289 and production of harvested area for wheat and barley was 6400000 ton.

According to mentioned issue in above, using grain loss monitor increase performance and capacity of combines up to 30-35%. Therefore, increasing harvested area will be about 1.92-2.24 million hectare and needs 2789-3254 combine harvesters. In other words, it needs 670-780 milliard Rials credit that shows importance of applying and performing of this research project.

Materials and methods

Materials and methods of this project are as follows:
1. Grain loss monitor
   In the following figures main instrument and related transducers was shown.
   As illustrated in Fig.1, the instrument composed of two transducers which are installed at the bottom of straw walkers and sieves and connected to monitor via wires.
   The monitor with using 12 Volt battery which is located under the driver’s seat, shows grain loss amount in straw walker and sieves separately or together.
2. Grain moisture meter, model Agro Farm
3. Wooden frame of 50*50 cm*cm
4. Wooden frame of 80*50 cm*cm and height of 10 cm with a wooden cover
5. Precision scale (0.1 g) ANB200i

In this research, two different transducers were installed in different parts of sieves and straw walkers (John Deer 955) and performance parameters of crops and combine such as seed moisture content, crop yield, drum speed and processing loss of combine were measured. Then, combine was calibrated with grain loss monitor and was assessed in a wheat field.
During harvesting, an alarm announces to operator which parts has a loss more than usual that can be adjusted for continuing harvesting.

For assessing measurement tools precise, recorded loss in different parts of combine with measurement method as following are compared: Experimental treatments included;
1. Using combine proper forward speed - main plot
2. Drum speed in 3 levels (650, 750 & 850 rpm) – sub plot

Experimental design was split plot in a completely randomized block design with three replications. Measured parameters included:
1. Crop moisture content in the time of harvesting about 12-14%
2. Length of harvesting area 25 m (harvesting area of each replication with 4 m cutting width was 100 cm*cm)
3. Specific area for harvested crop
4. Effective Width of used combine

Grain loss monitor was adjusted with combine average and proper fan speed.

After harvesting experimental plot a frame of 50*50 cm*cm was put on harvested lines, counted number of dropped grains, weighed and average values calculated as a kg/ha.

Three types of grain loss are measured:
1. Pre-harvest loss (PHL): loss that occurs before harvesting because of external factors such as wind, animals and rains
2. Gathering loss (GL): Those are derived from all related combine mechanism to crops.
3. Processing loss (PL): that are caused by beater and cleaner systems of combine

Harvesting loss is equal to the sum of GL and PL. The following parameters were measured:

- Loss amount before harvesting or natural loss are sampled in experimental plots, using frames of 50*50 cm*cm, then measured and recorded
- In order to determine gathering loss (header loss) it would be sampled from both parts of head after harvesting
- For measuring processing loss, during movement a frame of 50*80 cm*cm is replaced between combine’s rare wheels with using a frame 50*50 cm*cm behind latter frame.

There would be a possibility for measuring loss at the middle of combine.

For calculating losses, the following equations were used:
1. Pre-harvest loss (PHL): PHL = PHC * 10 = Pre-Harvest Loss, kg/ha
   PHC = average mass of grains counted in the Pre-harvest loss samples
2. Gathering loss (GL): GL = (GLC - PHC) * 10 = Gathering Loss, kg/ha
   GLC = average mass of grains counted in the Gathering loss samples
3. Processing loss (PL): PL = [(PLC - GLC)/f] * 100 = Processing Loss, kg/ha
   PLC = average mass of grains counted in the Processing loss samples
   F= relationship between the gathering width and the width of the straw belt left by the combine, e.g., gathering width divided by straw belt width.
4. Harvesting loss = GL + PL

As explained, loss in different parts of combine including pre-harvest loss, gathering loss, processing loss were measured and harvesting loss is equal to the sum of gathering loss and processing loss. Obtained data are compared to loss monitor data and system precision is assessed.
Results

First year of performing the project

Resulted data from experimental design was analyzed using SPSS software. Combine ground speed because of a delay in crop harvesting was adjusted in the area of first level, 2.5 to 3 km/h – drum speed treatment with levels of 650, 750 & 850 rpm. The results of variance analysis (ANOVA) are indicated in Table 1 with using F test in levels of 5-1% probability; the F amount is obtained and is resulted. There is a significant difference between treatments.

Table 1: Variance analysis of experimental treatments for ground speed of 2.5 to 3 km/hr

<table>
<thead>
<tr>
<th>S.O.V</th>
<th>df</th>
<th>SS</th>
<th>MS</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rep</td>
<td>8</td>
<td>543.928</td>
<td>67.991</td>
<td>11.319</td>
<td>0</td>
</tr>
<tr>
<td>BS</td>
<td>2</td>
<td>690.873</td>
<td>345.437</td>
<td>57.508</td>
<td>.000 **</td>
</tr>
<tr>
<td>Error</td>
<td>16</td>
<td>96.108</td>
<td>6.007</td>
<td>1.000</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>26</td>
<td>1330.91</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**significant difference between means of treatments was in 1%.

The results indicate that the drum speed effect on combine processing loss in 3 replications in each level with probability level of 5-1% was significant. Data average comparison illustrates the significance of the level of 850 rpm.

Table 2: Comparisons of average data drum speed based on Duncan test (Year 1)

<table>
<thead>
<tr>
<th>Drum speed</th>
<th>No groups</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>850</td>
<td>9</td>
<td>15.6 a</td>
<td></td>
<td></td>
</tr>
<tr>
<td>750</td>
<td>9</td>
<td>22.6 b</td>
<td></td>
<td></td>
</tr>
<tr>
<td>650</td>
<td>9</td>
<td>27.9 c</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Average comparison carried out based on Duncan test and the results show that drum speed of 850 rpm has the least processing loss and is located in significant class of a. As according to standard of ANSI/ASAE S 343.3, obtained loss is less than 1%.

Diagram 1: Input feed rate Vs. Grain loss using grain loss monitor

Diagram 1 illustrates with using grain loss monitor, combine processing loss was controlled by operator and input feed rate will increase from 1 to 2 kg/s using suitable ground speed.

3.2 An analysis of combine processing loss with applying K square, considering measured data and expected standard

Zero hypothesis: there is no different between measured and expected loss
One hypothesis: measured loss differs from expected loss

Calculated $X^2 = 4.26$

Table $X^2 = 45.64$ (1% probability level)

$X^2$ is not significant means zero hypothesis is not rejected.

3.3 Second year of performing the project

The results of variance analysis were shown in Table 3. With using F test in levels of 5-1% probability; the F amount was used and it was resulted, there is significant difference between treatments.

Table 3: Variance analysis of experimental treatments on drum speed

<table>
<thead>
<tr>
<th>S.O.V</th>
<th>df</th>
<th>SS</th>
<th>MS</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rep</td>
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<td>6792.71</td>
<td>849.088</td>
<td>35.851</td>
<td>0</td>
</tr>
<tr>
<td>BTSP</td>
<td>2</td>
<td>348.308</td>
<td>174.154</td>
<td>7.353</td>
<td>.005 **</td>
</tr>
<tr>
<td>Error</td>
<td>16</td>
<td>378.936</td>
<td>23.683</td>
<td>1.000</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>26</td>
<td>7519.95</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**significant difference between means of treatments was in 1%.

The results indicated that drum speed in 3 levels with 3 replications in each level of 5-1% was significant. Table of average data drum speed (Table 4) is showing significant level of 750 rpm drum speed.

Table 4: Comparisons of average data drum speed based on Duncan test (Year 2)

<table>
<thead>
<tr>
<th>Drum speed</th>
<th>No Group</th>
<th>1</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td>750</td>
<td>9</td>
<td>26.03 a</td>
<td></td>
</tr>
<tr>
<td>650</td>
<td>9</td>
<td>32.9 b</td>
<td></td>
</tr>
<tr>
<td>850</td>
<td>9</td>
<td>34.2 b</td>
<td></td>
</tr>
</tbody>
</table>

Average comparison was based on Duncan test and the results show, drum speed of 750 rpm has the least processing loss and is among the significant class of a. However according to standard of ANSI/ ASAE S 343.3, obtained loss percentage was less than 1%.

Fig. 2: Measurement processing loss using grain loss monitor

3.4 Combined analysis of 2 years performing the project
Combined variance analysis results are given in Table 5. With F test applying in level of 5-1% probability; the amount of F was measured. There was significant difference between treatments.

Table 5: Combined variance analysis based on results of two years

<table>
<thead>
<tr>
<th>S.O.V</th>
<th>df</th>
<th>SS</th>
<th>MS</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year</td>
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<td>1084.89</td>
<td>1084.89</td>
<td>2.36</td>
<td>.112</td>
</tr>
<tr>
<td>Error</td>
<td>16</td>
<td>7336.64</td>
<td>458.54</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BS</td>
<td>2</td>
<td>408.07</td>
<td>204.035</td>
<td>13.744</td>
<td>.000</td>
</tr>
<tr>
<td>Y * BS</td>
<td>2</td>
<td>631.112</td>
<td>315.556</td>
<td>21.257</td>
<td>.000</td>
</tr>
<tr>
<td>Error</td>
<td>32</td>
<td>475.043</td>
<td>14.845</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>53</td>
<td>9935.75</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**significant difference between means of treatments was in 1%.

According to results, drum speed in 3 levels with 3 replications in each level of 5 and 1 probability was significant. Data average comparison table (Table 6) indicates significant results of the level of 750 rpm.

Table 6: Comparisons of average data drum speed based on Duncan test for both years

<table>
<thead>
<tr>
<th>Drum speed</th>
<th>No Group</th>
<th>1</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td>750</td>
<td>18</td>
<td>24.3 a</td>
<td></td>
</tr>
<tr>
<td>850</td>
<td>18</td>
<td>24.9 a</td>
<td></td>
</tr>
<tr>
<td>650</td>
<td>18</td>
<td>30.4 b</td>
<td></td>
</tr>
</tbody>
</table>

A comparison of averages according to Duncan test shows drum speed of 750 rpm has the least processing loss and is the same as 850 rpm and both has significant class of a.

Diagram 2 indicates with using of grain loss monitor combine processing loss is controlled by operator, while suitable ground speed increases input feed rate of combine from 0.9 to 1.8 kg/s.

Discussion

The obtained results of data analysis, indicates the least combine processing loss in crop moisture content of 10-12 percent and drum speed of 750 rpm. The issue reflects the fact, that because of grain dryness, the drum speed is suitable and cleaner system is able to separate grain from straws, consequently little amount of grains falls on the ground, so the loss is standard. This is a matter of increasing efficiency and capacity of combine and enables it to choose an appropriate ground speed adjusted with input feed rate of grains. In diagram 2 increasing feed rate and measured loss of combine processing loss are illustrated.

However, data analysis in two years shows that year factor does not have significant influence on performance of monitor or loss while monitor performance in each year can be tested or assessed. Interaction effects of year and drum speed have been significant. In fact crop yield change in different years and different field affect feed rate so, in various grain yield and straw walker rates moving from transducers in sieves and straw walker are different.

For investigating grain loss monitor efficiency, zero hypotheses is taken as a sign of no different between measured loss and expected loss. K square test indicated in spite of measured K square and existed amount in table, zero hypothesis is not denied while this identified no difference between measured losses and expected one. In other words, for measuring combine loss in standard limit, there is used a grain loss monitor in probability level of 1%, while this loss can be controlled with diodes in monitor. In common case, turning on two diodes indicates standard level of processing loss and its 1%.

Conclusion and Suggestion

1. There is no difference between measured and expected loss.
2. Combine processing loss was standard and 1 percent.
3. Cost decrease and precision increase of loss measurement and performance increase, combines capacity.

Suggestions for future research:

4. Performing research design in overall area of wheat production in country
5. Possibility of manufacturing grain loss monitor inside the country
6. Installing and assessing grain loss monitor performance on combines JD1165 was order

References


