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LOSS OF GRAIN AT HARVESTING WHEAT WITH A COMBINE HARVESTER

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Abstract

The article investigates grain losses in wheat harvesting with combine Claas Lexion 660. A thousand grain mean mass has been established, which is 49 g, whereas the mean mass of wheat in 1 m^2 is as follows: at operation speed of 4.5 km/h it is 2.98 kg, at operation speed of 5.2 km/h it is 3.67 kg and at operation speed of 6.7 km/h it is 4.56 kg. In wheat harvesting these are between 0.49% and 0.75%. In addition, by increasing operation speed from 4.5 to 6.7 km/h, losses had increased by 34%. A linear relationship has been established between the percentage of grain losses and the working speed of the combine, as the coefficient of determination is R^2 = 0.9945, i.e. 99% of the change in grain losses is due to the operating speed of the combine.

***Key words**: grain harvester, grain losses, method for loss determination, harvesting wheat, productivity.*

INTRODUCTION

Harvesting is the last stage of all cultivation activities (Delchev et al., 2016). Of great importance is also the timely harvesting. This event is of great importance since the end results of the year-round work are harvested (Vasilevich, 2011). The harvest itself is characterized by campaign nature, high energy intensity, production losses and multivariance (Ishpekov, 2013).

It is one of the main activities in agriculture and should be carried out within short term - a maximum of 10-12 days, in order to avoid high losses from grain spillage and to reduce the risk of crop destroying by natural conditions (Nikolov et al., 1974). Improper harvesting method, delayed harvesting campaign or poor organization may result in significant material losses of the product (Vakarelski et al., 1976; Delchev & Trendafilov, 2013; Li et al., 2013; Petrovna, 2014; Paixão et al., 2016; Trendafilov & Dragoev, 2017; Dragoev, 2018).

In the process of harvesting cereals, different types of losses occur: biological losses, which represent losses due to adverse climatic and natural conditions, and losses of nutrients and physical losses caused by the mechanical impact of machines in the process of crop harvesting. It is known that if cereals remain, for example, 5 days after full maturity, loss from shattering is up to 3.7%, after 10 days they increase up to 21%, and a delay of 20 days leads to losses over 30% (Kolev, 1999).

Grain losses during harvest represent a direct loss of income for the farmer. In some countries it is perceived that the reasonable small grain loss should reach a maximum of 3% of the total crop yield (Delchev & Trendafilov, 2013). By extending harvesting periods, grain losses sharply increase (Kehayov & Mehmedova, 2010).

Harvester losses are not great, they are usually indicated at 2-3% when working with normal load under relatively favourable conditions (Vasilev, 1987). The same author reports that in studies several times higher losses have been found. For example, when harvesting wheat, losses were between 3-6% and losses due to meteorological and organizational reasons were 4-5%.

The testing of the combine harvesters is carried out according to the standard in force for the country. For modern conditions in agriculture it is appropriate to apply the methods specified in the international standard ISO 8210:1989. The main normative provisions of this standard are also laid down in the Russian standard for combine harvesters GOST 28301-2007. The quality of the harvest is one of the mandatory evaluations to be given in the test machine to harvest (Beloev et al., 2018).

The objective of this study is to investigate the grain losses during wheat harvesting with combine Claas Lexion 660 depending on the harvester operation speed.

MATERIALS AND METHODS

The study is carried out during the 2020 harvesting campaign in harvesting wheat (*Renaissance* variety) grown in the region of Byalo pole village, Opan municipality, Stara Zagora District. The total area of the field is 92 ha. The crop was harvested with a Claas Lexion 660 harvester (Figure 1), which had a working width of the header 6.1 m. The average yield was 6.5 t/ha and the average humidity recorded by the on-board hydrometer of the harvester was 12.1%.

Figure 1. Claas Lexion 660 grain harvester

Grain losses were examined. The actual measurements are made at three different harvester speeds of 4.5, 5.5 and 6.7 km/h. The measuring location was always located at a minimum distance of about 50 meters from the end of the section in order to stabilize the operation speed and performance of the harvester. Figure 2 shows the "Mihovi bryasti" plot, where grain losses were measured. The figure clearly shows that grain loss measurements are made at the three measurement points (1, 2 and 3), after which the results obtained were averaged.

Figure 2. Map of "Mihovi bryasti" plot with an area of 92 ha

For the purpose of the study, special trays were made to collect the mass falling behind the harvester with an area of 1 m^2. They were 4 pieces with a diameter of 56 cm. These trays stood under the harvester and after entering 50 meters into the crop, they remained behind it (Figure 3). The fallen mass in the trays was collected in bags. After that grains were separated and counted (Koryčanský, 2010).

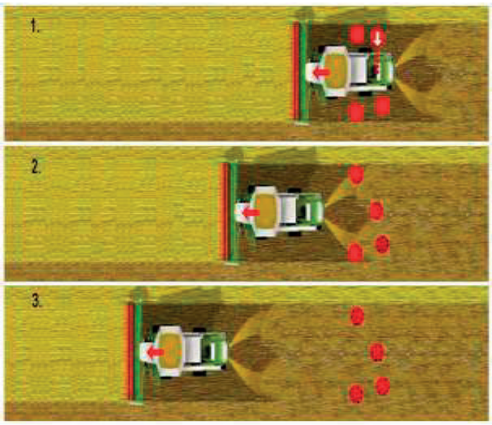

Figure 3. Check of grain losses after the grain cleaning device

After the harvester had been adjusted for wheat harvest, it intuitively set off at a speed that was appropriate for that harvest and for this crop, at this yield and on this terrain. When the harvester enters the crop 50 meters into it, it stops to allow the operator to assess grain losses visually. After he decided that the losses were acceptable for the respective harvest conditions, the harvester was setting off at the speed it had worked before.

The percentage of grain losses was calculated by the formula (Delcev & Trendafilov, 2013):

$$z = \frac{100.A.n}{B.\beta.N.D}, \quad \% \qquad (1)$$

where z are grain losses, %;

A – the width of the sieves of the combine when leaving the straw in the slope or the width of the header of the combine when spreading the straw, m;

n – number of grains in chaff and straw behind the grain harvester, pcs./m^2;

B – working width of the grain harvester header, m;

β – coefficient of utilization of the working width;

N – number of grains in 1 kg of grain, pcs./kg

D – the yield per hectare, t/ha.

To determine the number of grains in 1 kg, 1000 grain taken were from the harvested crop and weighed. On the basis of this the number of grains in 1 кg of grain were determined. A total of 5 samples have been taken and their number was calculated using the formula:

$$N = \frac{100000}{m}, \quad pcs./kg \qquad (2)$$

where m is the mass of 1000 grains, g.

Since losses are collected and reported from an area with width equal to the harvester "tunnel" width and have been obtained from an area the width of which is equal to the width harvested by the harvester, it is necessary to determine the coefficient of utilization of the header working width β. It was determined by the following formula:

$$\beta = \frac{L}{10.B} \qquad (3)$$

where L is the distance measured for 10 harvester moves, m;

B – structural working width of the harvester header, m.

RESULTS AND DISCUSSIONS

Table 1 presents the experimental data of the coefficient of utilization of the harvester working width. For greater accuracy these were made on the basis of 10 harvester moves.

Table 1. Coefficient of utilization of the header working width in wheat harvesting with Claas Lexion 660 harvester

Harvester	Mean value of the length of 10 moves L, m	Coefficient of header utilization β
Claas Lexion 660	56.95	0.93

The table shows that the average value of the utilization coefficient of the header working width is 0.93. It is evident that this coefficient is very low. In this case, the structural working width of the harvester header is 6.1 m, while the actually used one B_{actual}=$B.\beta$= 6.10.0.93 = 5.67 m, i.e. 7 % of the header working width of the grain harvester was not used. This shows that operators did not put enough effort and experience into driving the harvester in the field since high productivity was not a priority. Quite often, when conducting the experiments, we found out that during harvest, there was also a second person next to the harvester operator who was distracting him. It is difficult to find out the real reason for the low utilization of the header working width, but it is a fact. In our opinion, it is mainly due to the fact that high productivity is not a priority. Incomplete use of the header working width leads to a decrease in the harvester productivity.

Table 2 gives the number of grains in 1 kg of wheat. It also shows the mass of 1 grain and 1000 grains. Table 2 shows that the mean mass of 1000 grains is 49 g, which corresponds to 20408 pieces of grain in 1 kg.

Table 2. Number of grains in 1 кg of wheat *Renaissance* variety

Crop	Weight of 1 grain, g	Weight of 1000 grains, g	Number of grains in 1 kg N
Wheat	0.049	49	20408

Table 3 presents the averaged results of the baseline data and parameters used in the study of wheat harvest losses. In order to simplify calculations, the table shows the number of grains per 1 m^2 at the three operating speeds of the harvester. From the samples taken, it can be seen that the mean number of grains ranged from 61 to 93 grains. The average mass of wheat in 1 m^2 at operating speed of 4.5 km/h is 2.98 kg, at a speed of 5.2 km/h it is 3.67 kg and at a speed of 6.7 km/h it is 4.56 kg.

Table 3. Total number of grains and mass of grain in 1 m^2 in various operating speeds of the grain harvester

Operating speed of the grain harvester, v_p , km/h	Total number of grains N, pcs.	Weight, kg / 1 m^2
4.5	61	2.98
5.2	75	3.67
6.7	93	4.56

Table 3 also shows that grain mass differs significantly at the three harvester operating speeds or between 2.98 and 4.56 kg/1 m^2. This difference is due to the fact that the crop was weeded and particles of weeds were sticking on the working surface of the straw sieves, which made the work of the straw sieves (separation system) difficult. This results in a decrease in the separation rate and an increase in grain losses.

Figure 4 shows the percentages of total wheat harvesting losses depending on the grain harvester operating speed. The results obtained shown in Figure 4 reveal that as the working speed of the grain harvester increases, losses increase. Figure 4 also shows in wheat harvest these are between 0.49% and 0.75%. This is perfectly logical and completely confirms the results of other researchers that operating speed is a key factor. In this case, the increase of the operating speed of the grain harvester from 4.5 km/h to 6.7 km/h, i.e. by 2.2 km/h, losses increased by 34%.

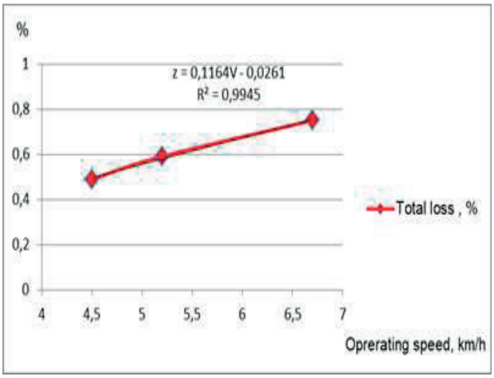

Figure 4. Percentage of total losses in harvesting wheat depending on the working speed of the grain harvester

Separation losses increase with increasing speed of the threshing drum (Zaman et al., 1992). This finding is also supported by Wrublcski & Smith (1980). Data from other authors revealed higher grain losses in Pak 81 - 4.18% than those of Punjab 85 - 3.04% (Zaman et al., 1992).

According to Koryčanský (2010), the lowest grain losses of 0.6% were achieved at an operating speed of the combine of 3 km/h, and the highest of 0.8% at an operating speed of 6 km/h. These results were due to the dense sowing and the fact that the threshing machine was overloaded. Similar results were obtained by Basavaraja (2007) who identified the factors influencing post-harvest losses of rice and wheat. The losses were maximum at the farm level (3.82 kg/q in rice and 3.28 kg/q in wheat) accounting for 73.57 per cent and 75.93 per cent of the total post-harvest losses, respectively.

Davoodi & Houshyar (2010) estimate grain losses on New Holland TC56 combine when harvesting wheat. Their results show that the grain losses were the lowest in the operating speed of the combine of 3 km/h and at a frequency of rotation of the reel of 25 min^{-1} and at 850 min^{-1} turnovers of the rotor. They also suggested that farmers choose them at harvest.

The results presented in figure 4 also show the relationship between the percentage of grain losses and the working speed of the combine. It is evident that the relation between the two parameters is linear one,

$$z = 0,1164.v_p - 0,0261 \qquad (4)$$

i.e. with increasing the working speed of the combine, the percentage of grain losses increases. The regression model is adequate at significance level p=0.05, as the coefficient of determination is R^2 = 0.9945, i.e. 99% of the change in grain losses is due to the operating speed of the combine.

Figure 5 presents graphically the mass of wheat losses from 1 ha depending on the grain harvester operating speed. It can be seen that the mass at an operating speed of 4.5 km/h is 29.8 kg/ha and at an operating speed of 6.7 km/h it is 45.6 kg/ha. The graph also shows that as the harvester operating speed increases, the grain mass increases by 34%.

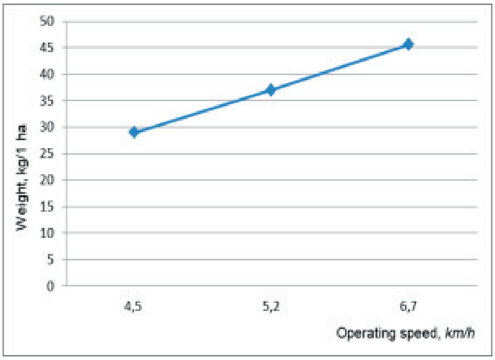

Figure 5. Mass of wheat depending on the grain harvester operating speed

Studies confirm that grain losses at harvest are directly related to the working speed of the combine. In order to achieve a high productivity harvest, a precise calibration of the combine loss reporting system is required.

CONCLUSIONS

It was established that: (i) 7% of the header working width of the grain harvester was not utilized. Incomplete use of the header working width results in a decrease in the harvester productivity; (ii) the mean mass per 1000 grains is 49 g; (iii) mean mass of wheat in 1 m^2 is as follows: at an operating speed of 4.5 km/h it is 2.98 kg, at an operating speed of 5.2 km/h it is 3.67 kg and at an operating speed of 6.7 km/h it is 4.56 kg; (iv) the reported grain losses during wheat harvest are between 0.49% and 0.75%; (v) by increasing the speed from 4.5 km/h to 6.7 km/h losses had increased by 34%; (vi) a linear relationship has been established between the percentage of grain losses and the working speed of the combine, as the coefficient of determination is $R^2 = 0.9945$, i.e. 99% of the change in grain losses is due to the operating speed of the combine; (vii) by increasing the speed from 4.5 km/h to 6.7 km/h, i.e. losses had increased by 34% and grain weight increased by 34%.

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