INVESTIGATION ON ENVIRONMENTALLY FRIENDLY WHEAT HARVEST TECHNOLOGY

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Abstract. Unpredictable weather conditions shorten the harvest period, the harvest itself becomes more and more complicated. During the harvest period, combine harvesters must be used not only at the maximum possible efficiency, but also to protect the environment and apply harvesting technologies that comply with the principles of sustainable agriculture. Harvesting is one of the most important agricultural operations, requiring a lot of equipment, energy resources and manpower. Unfavourable natural conditions can delay harvesting, which would lead to lower grain quality and lower economic benefits. Therefore, new harvesting technologies and ways of solving them are constantly being sought, which help harvest more efficiently and with better quality and at the same time protect the environment. Usually, for grain harvesting, combine harvesters are equipped with cutterbars of various sizes and technological solutions. A little less often, when harvesting grain, a stripper header mounted on the combine is used, thanks to which only the grain ears are scraped off. The purpose of this study is to investigate the technological process of harvesting using a stripper header in order to determine the most optimal working parameters. Combine harvesters CLAAS Lexion 550 with a conventional cutterbar and stripper header harvested wheat. The influence of the working parameters of the stripper header on the quality of wheat harvest and grain losses was studied. It was determined that with the same settings of the harvesters, but equipped with a conventional grain cutterbar and stripper header, the average yield losses were 1.58% and 0.89%, respectively. The results of the research showed that increasing the driving speed increases the yield loss when working with a conventional cutterbar. Meanwhile, by increasing the driving speed, when working with stripper header, grain losses decrease.

Keywords: combine harvester, stripper header, wheat.

Introduction

The harvest periods in our natural area are long enough, but also difficult due to their volatility. During the harvest period, the machines must not only work in the most rational mode, but must also use environmentally friendly harvesting technologies that comply with the principles of sustainable agriculture. Grains are usually harvested by self-propelled grain harvesters [1], with harvesters of various sizes and designs attached to them. A little less often, a stripper header is attached to the combine harvester, with the help of which grain ears or flax heads are combed. When harvesting cereals or other crops in the traditional way, it is a prerequisite that the cereal field is sufficiently dry and that the stalks of the cereals at the cutting line are dry and cut without a crushing effect. If the grain is wet (18-20%), then the conveyors of the feeder house and the threshing drum interfere with the flow of plant mass. Mechanisms are loaded with loads of variable size, and plant crops are not threshed enough, as a result of which grain losses and their injury increase [1]. The duration of the harvest, the quality of the work, and the amount of grain losses depend not only on the meteorological conditions, the condition of the harvested crops, but also on the selected harvesting technology [2]. After the traditional harvest, 5-10 cm high cereal stubble and straw arranged by different methods remain. All these technological processes use fuel.

Scientists say that when harvesting crops with a stripper header, this technology can help speed up the work and improve the efficiency of water absorption in the soil. Straw harvesting time with a stripper header is 1.5 minutes less than the traditional method [3; 4]. Grain harvest with stripper header leaves taller stubble that holds more snow and protects the soil from sun and wind erosion. Researchers are investigating more efficient water use in dryland cropping areas by assessing millet yield and post-harvest plant residue mass using a stripper header. Rainfall conservation efficiency is analysed and losses of wheat using traditional cutting technology compared [5]. Working with a stripper header reduced fuel consumption has been found while maintaining the same yield as by conventional millet harvesting methods [5].

Comparative tests of losses and productivity between the stripper header and the traditional cutterbar have been carried out [6]. Although bell combers are used all over the world, few combinations of operating parameters have been studied or are more limited to the plant stem height, chaff content and fuel consumption studies.

It has been established that the productivity and quality of work of combine harvesters mostly depends on the uniformity of the flow of supplied grain. Studies have shown that the productivity of the harvester increases 1.6 times by supplying only stripped ears. The advantage of this technology is that when supplying the combine with a smaller flow of grain, it can be driven at a higher speed, which shortens the duration of harvesting. In a non-laid crop, almost the entire stem of the plant is left on the soil surface. Due to the significantly lower amount of grain mass passing through the combine, there is less wear on the combine components and the combine can run faster, resulting in a shorter harvest time [7; 8].

The grain ear stripping technology has not spread in wet climates, due to the additional cost of the stripper header and the tall stubble left after harvesting. Managing of the high stubble, when crops harvested by stripper, does not compensate lower fuel consumption and grain losses, higher harvester productivity compared to the conventional technology [2; 9].

Thus, it is still relevant to answer the questions that have arisen, how to adjust and optimize the harvesting parameters in the stripper header, how to obtain the maximum productivity, the lowest yield losses, considering the height of the plants, specific natural conditions and the characteristics of the cultivated plants. Therefore, studies on the parameters of the stripper header remain relevant.

Materials and methods

For the study the CLAAS Lexion 550 combine harvester with 243 kW engine power, fuel tank capacity 800 l was used. Figure 1 shows a view of a combine harvester with a used stripper header.

Fig. 1. **CLAAS Lexion 550 combine harvester with stripper header**

For the research a stripper header of the Shelbourne Reynolds Company was used. The header weight is 1712 kg, working width 6 m. The average driving speed of the combine with the stripper header is 6-12 km·h^{-1}.

In order to determine the optimal working parameters of the stripper header, harvesting of wheat in field conditions was chosen in order to achieve the minimum grain losses. The focus was on the header losses, when the harvester header breaks the grain from the ears or does not pick up the lying grain from the soil surface. Loss of grain usually is caused by too high rotation speeds of the reels at conventional cutterbars. Too deep lowered reels into the grain crop break the grain ears, causing the ears to fall to the ground but not to the harvester, causing even greater yield losses. Inadequate lowering height of the cutterbar prevents picking up of lying crops, etc. Threshing losses, combine losses due to leaks, straw separation and grain cleaning losses are also distinguished.

The purpose of the study is to determine what grain losses we have after replacing the conventional grain cutter with a stripper header. The scheme of grain loss measurement, after passing through the stripper header, is presented in Fig. 2. This is where the first grain losses may occur, which depend on the settings of the stripper itself, on the maturity of the grain field, the moisture content of grain and straw, the degree of laying of the crop, etc.

Grain losses are determined and calculated under real field conditions. Fields were sown with different wheat varieties for comparative experimental field studies of harvesting technologies, using conventional tillage on an organic farm. The seed varieties were selected taking into account the possibility of growing the tested crops on organic farms in the future. The sowing width is selected according to the full working width of the stripper. For the plants and their seeds to mature, the necessary maintenance and monitoring was carried out throughout the season.

A specialized grain loss collecting tray manufactured by Feiffer was chosen for the method of assessing the stripper header cutting losses. For evaluation of the cutting losses, the tray was placed in the wheat crop behind the stripper. Dimensions of the trough: length 50.8 cm, width 500 mm (Bushel products, 2023). The Feiffer grain tray consists of a convenient loss conversion table that can be used together with the "Feiffer grain" program. Measurements were repeated 3 times for each cereal variety. The pick-up location of the grain tray behind the stripper is shown in Figure 2.

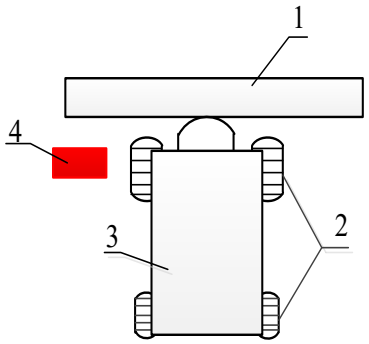

Fig. 2. **Combine harvester with stripper header and grain tray location:** 1 – stripper header; 2 – harvester wheels; 3 – combine harvester; 4 – grain loss measurement tray

After the stripper header pass, the grains, chaff and straw that fell into the tray were poured into bags. Chaff and straw were separated with an air separator manufactured by Bushel. The separator is a fast and efficient device for cleaning grain samples. It cleans the sample in seconds. It blows chaff and straw away from grain kernels. To weigh the separated grain a Bushel digital scale, capacity 500 g, accuracy 0.1 g, was used.

When calculating the combing grain loss, a whole series of grain parameters influencing the loss are determined. Plant density is calculated in units per square meter. Three samples were randomly taken from each plot and the average crop density was calculated. Plant height was measured in 3 randomly selected samples and the average value was calculated. Grain moisture was determined according to the standard methodology using a Grainsense instrument. Three samples of different wheat varieties were taken for moisture determination. ELMOR C1 seed counter and AX423 scale were used to determine the weight of 1000 grains.

When analysing the research data, the statistical reliability of the data, standard errors and the limit of the smallest reliability difference at the $p < 0.05$ level of statistical significance were evaluated.

Results and discussion

Field trials were conducted on an organic farm during the harvest period in Lithuania. The farm uses a crop rotation of 9 plants, does not use mineral fertilizers, so this was very important when conducting research on harvesting technology.

For the assessment of grain losses via the header, which depend on the settings of the stripper itself, the maturity of the grain field, the moisture content of grain and straw, the degree of laying of the crop, etc., the technical parameters of the grain harvester were determined and presented in Table 1.

An observational method was also used for the research, since many influencing factors cannot be evaluated by parameter values alone. The ears of wheat were stripped with high quality even from lying crop. It has been found that the difference in stripping upright and lying crops is the choice of the right angle of travel of the harvester.

Table 1

Technical parameters

Settings of the machine	Unit of measurement	Value
Combine harvester		
Rotation frequency of the threshing drum	min^{-1}	1200
Gap of the concave	mm	3 position
Rotation frequency of the fan	min^{-1}	1200
Upper sieve gap	mm	14
Lower sieve gap	mm	10
Stripper header		
Rotation frequency of the rotor	min^{-1}	600

It is necessary to estimate the minimum losses in the cutterbar by choosing the most suitable height for stripping the stem of the plant, selecting the rotation speed of the stripper rotor and determining the angle of the rotor covering deck for different types of cereals and crop conditions (moisture, crop density, etc.). It was studied how the grain of different humidity affects the operation of the unit and the driving speed of the harvester.

Although different wheat varieties were stripped, the losses were similar around 15 g per tray. Wheat variety No. 1 was slightly higher than the others, but it was found that this parameter did not affect the losses. Wheat variety No. 4 was distinguished by the lowest average weight of 1000 grains (76.83 ± 0.18) at similar moisture content of all spelled wheats.

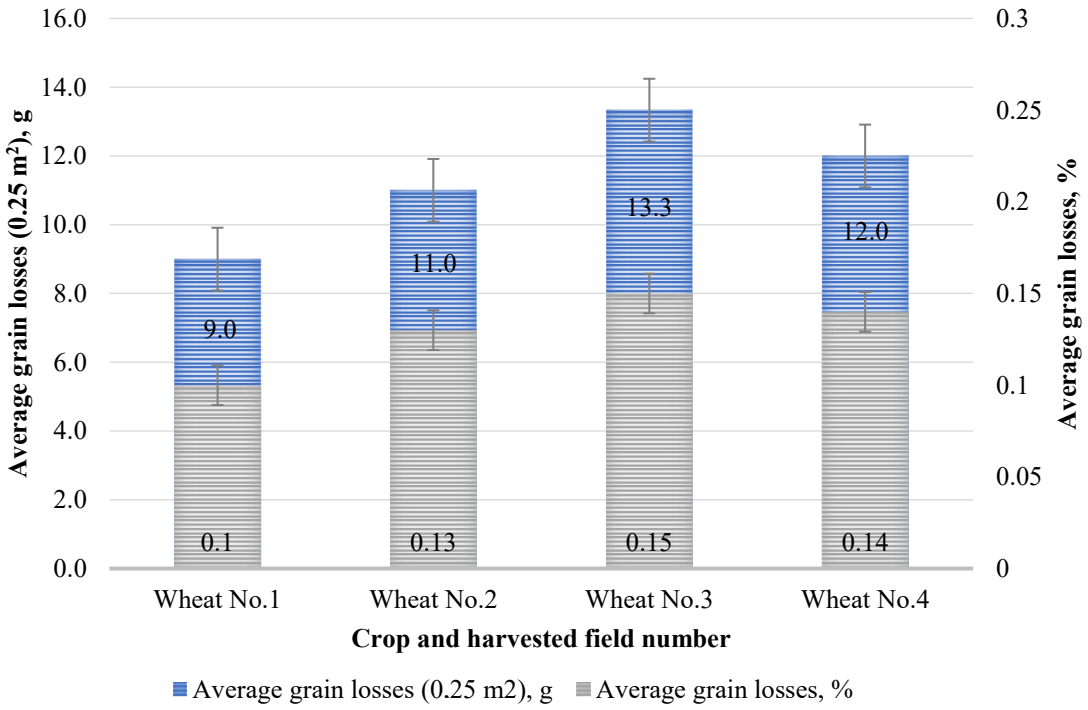

Fig. 3. **Wheat grain losses after stripper header**

Figure 3 shows that average grain losses ranged from 0.8 to 1.3 grains (0.1 to 0.15%) or 9 to 13.33 g in the four wheat test fields. During the evaluation of grain losses, when evaluating the amount of harvested and weighed grains, the results were converted into grain yield in tons per hectare. During the trials, the average yield of the wheat fields was 4.225 $t \cdot ha^{-1}$. After recalculation of combing grain loss in percentage, it was found that the average grain loss of individual fields was from 0.1 to 0.15%. The average grain loss of harvested fields was 0.13%. The results of our study did not exceed the permissible maximum grain losses.

It was observed that when the harvester was running at lower speeds, the bell comb losses were higher than when the harvester was running at higher speeds. This can be explained by the fact that at lower speeds, the stripper rotor fingers have longer contact with the harvested grain.

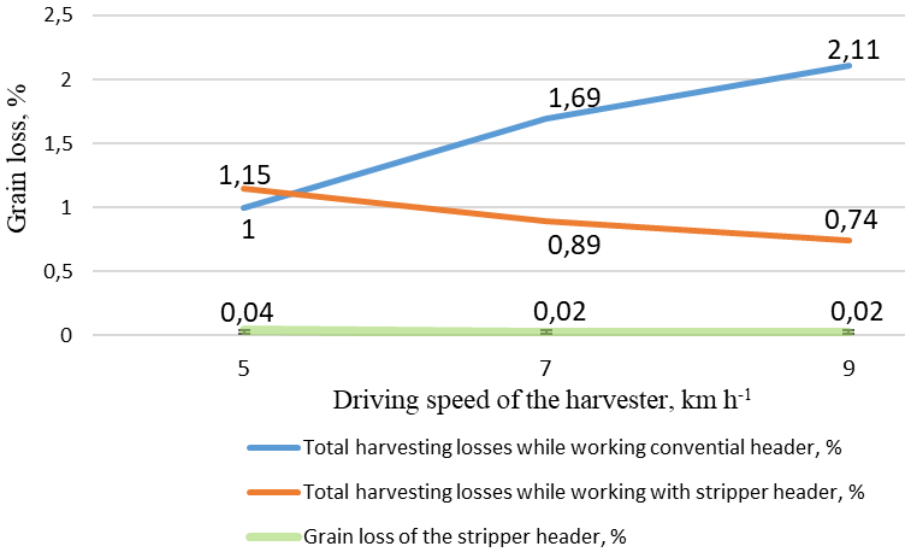

Fig. 4. **Grain loss dependence on driving speed**

Comparing the harvest losses of different cutterbars (Fig. 4), when the combine is driven at different speeds, it was found that the average harvest loss when working with the conventional mower was 1.58%, and when working with the stripper header – 0.89%. The summarized results of the research showed that when the driving speed is increased, the yield loss increases when working with the conventional cutterbar. Meanwhile, increasing the driving speed decreases when working with the stripper header. The obtained results showed that the yield losses when working with the conventional cutterbar are almost twice as high as when working with the stripper header. Researcher Kyle et al. [10] found that harvest losses are 3,5% when working with the stripper header and losses are 6,5% when harvesting with the conventional cutterbar.

The graph (Fig. 4) shows the total harvest losses of the entire harvester, which, as was already mentioned above in the text, consist of the losses of the cutting machine, threshing, separation and cleaning. The lower graph reflects the losses of the stripper header used in the study. The total hervester losses were assessed to determine what losses farmers would incur by purchasing a different type of cutterbars than conventional ones with feeding augers, where the entire mass of straw is fed to the harvester threshing process. So, from the presented graph, we can see that the grain losses of the stripper header itself are not high, they were between 0.02 and 0.04%, when traveling at a speed of 9 to 5 km h^{-1}, respectively. The data obtained during the research showed that when driving at a higher speed, the losses of the stripper header were decreasing and were twice lower than when the combine was driving at a lower speed. So, this just proves once again that it is possible to work at higher speeds and have lower losses with the stripper header.

Conclusions

1. During the study, it was found that the wheat grain losses of the stripper head ranged from 0.1 to 0.15%. The average grain loss of the cutting machine was 0.13%. After comparing the obtained results with the permissible maximum loss of grain yield (0.5%), it was found that the results of the study did not exceed the permissible maximum loss of grain.
2. It was found that when comparing the harvest losses of different cutterbars when the combine is driven at different speeds, the average harvest loss when working with the conventional cutterbar was 1.58%, and when working with the stripper header - 0.89%. The results of the research showed that increasing the driving speed increases the yield loss when working with the conventional cutterbar. Meanwhile, by increasing the driving speed, when working with the stripper header, grain losses decrease.

3. It was established that a higher stubble height has a significant impact on the productivity of the header and lower grain losses.

Author contributions

Conceptualization, E.J. and A.J.; methodology, E.J. and A.J.; software, A.J.; validation, E.J.; A.J. and A.A.; formal analysis, E.J.; A.J. and A.A.; investigation, E.J.; A.J. and A.A.; data curation, E.J.; A.J. and A.A.; writing – original draft preparation, E.J.; A.J. and A.A.; writing – review and editing, E.J.; A.J. and A.A.; visualization, E.J.; A.J. and A.A.; project administration, E.J. and A.J.; funding acquisition, E.J. and A.J. All authors have read and agreed to the published version of the manuscript.

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