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Assessment of losses in wheat harvest

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Abstract: Investigation results on the combine harvester's performance quality in wheat harvest, expressed through the magnitude of the losses and treshed grain quality are presented in this study. The losses on header and tresher, total lossess, moving speed and the quality of treshed grain were assessed. The total losses averaged 1.4 % of the yield. Out of that, those on header and tresher amounted to 0.46 %, and 0.98 % respectively, in that the former losses resulted from the low-performance of cutting table and reel, and the latter ones from the tresher mal-efficiency and its separation parts.
The combine harvester is characterised by high quality performance, with the losses within permissible limits, as well as by only slightly damaged grain and high degree of safety at work.

Key words: harvest, combine harvester, wheat, losses, quality of work

Introduction

Harvest is the final and most significant operational step in the process of wheat production in the field. It can be performed in due course and qualitatively only if modern, highly productive combine harvesters are used.

In an attempt to obtain better and better yields, besides work on selection, cultivation techniques and collection practices, mention should be made of the losses which resulted from wheat harvesting. Unfortunately, as far as we know even our most contemporary combines have been operating with no control over their performance quality at all. They are frequently being driven maladjusted, so

the losses in kernel are exceedingly high. Not until harvested fields have turned green after rainfall, do we realise what tremendeous losses have occurred.

Their magnitude, the quality of treshed matter and the performance depend upon climatic conditions, the state of crops, the time of harvest and its management, associated with the skill of the combine driver to properly adjust the combine harvester parts according to conditions at the moment of harvest.

All the losses in grain could be split up in biological-natural and mechanical. The former losses result from natural factors, inherent to natural-climatic conditions, whereas the latter losses occur due to result from the combine harvester working parts. In both cases, the losses had two aspects: direct and indirect. The former related to quantitative grain losses, occurring either because of natural-biological conditions, such as: shattering of kernel, lodging of crops, diseases and pests etc., or from mechanical ones, such as: loose kernel losses on header, followed by those from spikes, either uncut, cut or fallen off to the ground, then by loose and untreshed grains in chaff and straw. The latter losses related to grain quality, i.e. chemical, technological, commodity and productive quality of grain (biological losses and mechanically damaged grain).

Kernel losses during the harvest are unavoidable, even at high-performance of the combine. However they could be considerably reduced, but to what extent is a question to which an answer is to be continually sought.

Many authors have dealt with this issue since the commencement of mechanised harvest application to date aiming at decrease of losses and improvement of harvest quality. Only a few of these investigations will be mentioned in our study.

Mićić (1975), while studying the combine harvesters „Zmaj-141" in lowlands and highlands, obtained the following results. The combine harvester in the lowlands made total losses of 2.03-3.11 %, and in the highlands of 3.16-4.29 % of the yield. Therefore, the losses on the slopes increased depending on the slope. For example, on the slope of about 13 %, the losses increased by 30 % in relation to those in the lowlands.

Lazić (1986) studied the combine harvester „Đuro Đaković M 1620 H", on which the losses ranged from 0.51-1.26 % of yield at moving speed of about 2.7-3.24 km/h. Tanasić (1985) obtained similar results when studying the same combine harvester. According to Tadić (1994), the combine harvester „Zmaj - 161" achieved output of 5.96-6.30 kg/sec at moving speed of 3.72km/ha, with losses from 0.57-1.65 % of yield. According to Cvjetićanin (1992), the combine „Zmaj-191-H" attained the performance of 5.42-13.33 kg/sec at the speed of 3.4-5.23 km/ha, and thereby caused losses from 0.30-5.62 % of the yield. Under the optimum working conditions, these losses were within permissible limits, from 0.30-1.69 % of the yield. Hence, this combine harvester ranks highly productive and reliable in operation. Patarčić (1972,1975) obtained similar results over the studies on the combine harvester „Zmaj-131" and „Zmaj-141".

The principal objective of this study was to establish the level of losses and work quality in wheat harvest by means of the combine harvester „Zmaj 133" in our conditions.

Material and Methods

Investigations were carried out on production plots of Z.Z. „Samaila“ in wheat harvest by means of the combine harvester „Zmaj-133“.During the harvest, meteorological conditions were favourable, with high daily air temperatures and no precipitations. On the test plots, the crop was erect and slightly weed covered. The cultivar Novosadska Rana 2 was grown. The data on the state of the crops were obtained through sampling from the surface of 1 m^2 with three replications. The state of the crops was as follows:

- the number of plants per 1 m^2	610-670
- grain yield	4,99-5,72t/ha
- grain and straw ratio	1:1,15
- absolute mass	38-49 g
- hectoliter weight	79-83 g
- plant height	73-81 cm
- average spike length	6,1-6,7 cm

During investigating the work quality of the combine harvester „Zmaj-133“ in wheat harvest, there were carefully examined the losses on header and tresher, the combine harvester moving speed, its permeability power and the quality of treshed kernel. Standard-conventional method was used to obtain the cited parameters for estimating the combine harvester work quality, as reported by Lazić (1986).

Technical data on combine harvester

Engine	IMR S-44 A/T
Power of engine	51 kW
Combine harvester length	781 cm
Cutterbar width	305 cm
Reel speed	18-410 r.p.m.
Cutterbar oscillations	500/min.
Cutterbar step	76 mm
Screw conveyor speed	133 and 200 r.p.m.
Cylinder speed	420-1190 r.p.m.
Cylinder width	790 mm
Cylinder diameter	550 mm
Cylinder clearance at entrance	12-32 mm
Cylinder clearance at exit	3-8 mm
Encompassing angle	145°
Straw walker surface	1.97 m^2
Sieve type	closz
Sieve surface	1.5 m^2
Sieve oscillations	327/min
Ventilator	583-692 r.p.m.

Combine harvester adjustment for operation in wheat harvest

The combine harvester was adjusted to the working conditions, primarily to the state of crops, weather conditions, the time of the harvest, configuration of ground, technical-technological abilities to adjust the combine harvester operational parts. The following was adjusted on the combine harvester:

Reel	26-30 r.p.m.
Cylinder	900-980 r.p.m.
Cylinder and concave distance at entrance	24-28 mm
Cylinder and concave distance at exit	6-7 mm
Upper sieve to be opened	1/2
Upper sieve attachment to be opened	3/4
Lower sieve to be opened	1/4
Ventilator	637 r.p.m.
Clearance to be opened	100%

The combine harvester should operate with as fast air current as possible which should be directed toward front part of the sieve. Such adjustment was controlled by an abrupt stopping of the tresher in the course of work. The front part of the upper sieve at this stage had to be clean at length of 35-40 cm, and over the remaining part of the upper sieve, the material had to be evenly distributed.

Air current adjustment always had to follow the sieve adjustment, which was achieved in dependence of kernel size, commonly performed by means of as small holes as possible, so that the kernel could be cleaner, free of mixtures. The sieves had first been adjusted to be closed up fully, with evenly distributed grains, after which, but prior to overall grain sifting, the upper sieve was gradually opened. The lower sieve was handled in the same manner.

Results and Discussion

The combine harvester's performance quality was basically indicated by the grain amounts wasted during the harvest, due to operation of the combine harvester, irrespective of grain shattering per se before the harvest, which is considered negligible with the development of new varieties. The magnitude of the losses during wheat harvest depended on technical properties of the combine harvester, its proper adjustment, the state of the crops (crop stand, cultivar traits, ripening stages, kernel and straw ratio, moisture, weediness and lodging), as well as on working conditions (weather conditions, relief, the height of cutting, working speed and permeability power of the combine).

Table 1 presents the results on testing combine harvester in respect of losses in wheat harvest.

Tab. 1 Magnitude of grain losses in wheat harvest

Assay N°	Moving sped m/sec	kom.	Ratio of gran to spraw	Moisture %	Average t/h	Permeability kg/sec.	Losses on Header kg/ha	%	Losses on tresher kg/ha	%	Total losses kg/ha	%
1.	0,93	3,335	1:0,98	14,11	5,28	2,55	17,42	0,33	40,65	0,77	58,08	1,10
2.	0,83	2,98	1:1,07	13,68	5,72	2,66	30,31	0,53	42,33	0,74	72,64	1,27
3.	0,89	3,20	1:1,11	13,05	5,45	2,38	25,07	0,46	51,23	0,94	76,30	1,40
4.	0,86	3,10	1:0,82	12,17	4,99	2,54	9,48	0,19	36,29	0,73	45,77	0,92
5.	0,79	2,85	1:0,87	12,13	5,43	2,29	26,60	0,48	52,20	0,96	78,80	1,46
6.	0,92	3,31	1:0,84	13,96	5,64	2,91	16,44	0,31	38,25	0,72	54,69	1,02
7.	0,82	2,96	1:1,12	11,88	5,36	2,46	23,30	0,44	59,50	1,12	82,80	1,54
8.	1,01	3,63	1:0,93	11,54	5,52	3,06	33,06	0,60	65,72	1,18	98,78	1,78
9.	0,98	3,53	1:1,15	11,63	5,25	2,51	29,27	0,56	69,90	1,33	99,17	1,89
10.	1,10	3,96	1:1,12	11,92	5,33	3,14	36,25	0,68	73,02	1,37	109,3	2,05
Mean	0,91	3,28	1:1,00	12,61	5,40	2,65	24,72	0,46	52,90	0,98	7,63	1,44

The analysis of total grain losses for all trials shows that they ranged from 45.77 to 109,27 kg/ha or 0.92-2.05 percent, averaging 77.63 kg/ha or 1.44 percent of the yield. The least losses were detected at the speed of 3.10 km/h and permeability ability of about 2.54 kg/sec. The highest losses were registered at the speed of 3.96 km/h, when the combine optimal permeable capacity was achieved, 3.14 kg/sec. Thus, increased moving speed provided higher yields expressed through the flow of crop mass. However, the losses increased, both on header and tresher.

If the grain losses are specially analysed in the light of place of their emergence, it may be concluded that those on header seemed to be minor, rather than those on the tresher.

The losses on header ranged from 9.48-36.25 kg/ha or 0.19-0.68 % of yield. On average, these losses were 24.72 kg/ha or 0.46 % of yield. Such losses resulted from the performance imbalance on one part of the header and from the state of crops. This primarily related to the reel and cutting mechanism performance. So, these were the reasons that led to losses in the form of free grains and those from broken spikes, given as the total losses on the header in this study.

Grain losses on cutting mechanism resulted from shaking of spikes and shattering of kernels during stem undercutting. The level of these losses depended on sharpness and propriety of knife and counter-knife, their clearance, as well as on cutter bar stroke.

Markedly higher losses resulted from percussion of the reel bars on to the spikes, leading to their breaking away and fraction, and thereby shattering of kernels occurred. All the spikes and grains that were shattered in front of the cutting table on to the ground represented a direct loss. Intensity of shaking and shattering of the kernels was in dependence of the power and percussion locus. The percussion locus of the reel bars with the stem was immediately underneath the spike, and such locus was specified by its height by means of hydrostatical device on

the combine. Percussion power and the number of reel bars percussions per stem was subject to rotation speed of the reel. So, the faster the reel rotated, the greater number of percussions of the reel bar per stem was, with ensuing increasing losses. Rotation speed of the reel had to be fitted with the combine rotation speed. Should rotation speed of the combine be bigger, the losses on header increase. Moreover, increasing losses occurred at lower moving speed of the combine harvester, so that the losses were recorded to be greater by 0.17 percent of yield at speed of 2.85 km/h in relation to those emerging at the speed of 3.31 km/h.

The losses on the combine harvester's tresher related to free kernel losses in chaff and untreshed spikes in the straw are commonly encountered in this paper as the losses of tresher. The losses in untreshed spikes and straw occur unless clearance between the cylinder and the concave is fitted, and unless the number of cylinder rotations is fitted with the state of crops and their ripeness.

The greatest losses on tresher occurred at the combine moving speed of 3.96 km/h, amounting to 73.02 kg/ha or to 1.37 percent of the yield. In addition, great losses on the tresher were detected in the trials, in which the share of straw was greater in relation to the total matter when compared to grain (this ratio is regulated in the field through stem cutting height.). Whatever the case, overburdened separation parts and less easier grain separation from thin straw and chaff resulted in increased losses on tresher, which subsequently affected the quality of harvest. So, the least possible losses during wheat harvest were monitored on the tresher in the trials, with slightest ratio between kernel and straw, associated with the lesser moving speed, permeability, and the tresher's parts all properly adjusted. Compared to the losses on header, those on tresher were higher.

Quality of treshed kernel

Besides the established level of losses, an indicator of prime importance to the combine harvester's performance was the quality of treshing, i.e. the degree of damaging and mechanical harmful effects on wheat kernel. They seemed to be regular and unavoidable consequence in the harvest. To what extent these losses can be expressed, depended primarily on the mechanical-physical traits of the grain of individual varieties, followed by kernel moisture and the cylinder rotation number adjustment, as well as by clearance between the cylinder and the concave.

Technical-technological advantages of the combine harvesters were adequate proper as to provide good quality of kernel, which has been confirmed in practice. However, we have not always made use of them sufficiently, so that poor quality of kernel has been unjustified, i.e. with higher percentage of broken and damaged kernels. Treshed wheat grain quality in the harvesting by means of the combine harvester „Zmaj-133" throughout our investigations can be seen from the data in Tab. 2.

Tab. 2 Quality of treshed wheat kernel

Assay, N°	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	Mean
Whole kernel	1,50	2,13	2,53	2,05	1,89	1,35	3,78	2,92	3,31	2,47	2,29
Broken and damaged kernel	98,50	97,87	98,47	97,95	98,11	98,65	96,22	97,08	96,69	97,53	97,71

Based on the data from the above table, it may be inferred that the share of broken and damaged kernels in the total mass ranged from 1.35-3.78 %. The lowest level of damaged and broken kernels was observed in the trials, with higher kernel moisture and appropriately adjusted tresher. Moreover, the whole grain share in the treshed matter averagely amounted to 97.71%, which is considered as good performance of the combine harvester, so it may be successfully used in the seed wheat harvest, irrespective of the losses in yield.

Measures for decrease of losses

The losses in wheat harvest performed by the combine harvester „Zmaj-133", were within permissible limits. On the other hand, aiming at further decrease of the losses in the wheat harvest, and on the basis of the long-term experience, the following measures may be proposed:

- the combine harvester moving speed is to be adjusted to the working conditions;
- all the adjustments on the combine operational parts are to be adjusted in dependence of the state of crops, weather conditions, varietal traits and the the harvest duration;
- adjust the reel rotation speed to the combine operation speed;
- match moving height to the actual working conditions;
- enable combine harvester operation together with as stronger air current as possible, properly directed toward sieves;
- combine harvester is to operate with as few cylinder rotations as possible, together with as great distance as possible between the cylinder and concave, with due control of the treshed kernel quality.

Modern combine harvesters produced in our industry, for better technical equipment, easier operation and higher productivity, the following measures are recommended:

- automatic adjustment of the combine harvester working parts from the driver's seat, with no standstill during work;
- electric control over the combine harvester's working parts;
- control over the losses on the combine operational parts as to enable combine driver to handle the combine properly;
- maintenance and servicing of operational parts should take up less time.

Conclusion

Harvest is the final technological step in the production of wheat, on which largely depends successful growing of this crop. It directly influenced the total amount of collected kernels and their quality, primarily in dependance of properly adjusted working parts of the combine harvester, according to the existing conditions during the harvest.

Principal indicator of the combine harvester quality was the amount of grains lost at harvesting due to low-performance of the combine harvester. The quantity of losses depended on: the state of crops, climatic factors during the harvest, the time of commencement and completion of the harvest, followed by its organisation, technical-technological properties of the combine and training of the combine driver to adjust it properly.

In the course of our investigations, the losses ranged from 77.63 kg/ha, i.e. 1.4% of the yield on the combine harvester „Zmaj-133". Out of that, the losses on header amounted to 24.72 kg/ha, i.e. 0.46% and 152.90kg/ha, or 0.98% respectively. These losses appeared in the form free grains and those from spikes, either cut or broken, due to improper operation cutter and reel, moving speed and state of crops at the moment of harvest. The losses of tresher were actually the losses of free kernels in the chaff, and those in untreshed spikes in the straw. The degree of these losses depends on proper adjustment of the combine harvester treshing and separational parts, as well as on how they are matched with moving speed and the state of crops. So, these are conditions to define the quality of treshed mass and degree of damaged kernel, averaging 2.29% in this case.

The losses of both the tresher and header depended on the combine moving speed and its capacity. At the average moving speed of 3.2 km/ha and average yield of 5.4 t/ha, the combine harvester accomplished the average permeability of 2.65 kg/sec, on average.

It may be concluded that the combine harvester „Zmaj-133" showed good quality performance in our investigations, for the losses ranged within permissible limits, with slightly damaged kernel and assured high degree of safety at work.

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UTVRĐIVANJE VISINE GUBITAKA U ŽETVI PŠENICE

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