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IMPACT OF WORKING PARAMETERS OF Z056 BIZON SUPER ON QUANTITY AND QUALITY LOSSES OF SEEDS DURING SOYA HARVESTING

Summary

We assessed the impact of working parameters of Z056 Bizon Super on the quantity and quality losses of seeds during soya harvesting. We investigated soya of Merlin variety cultivated in Leszczany (51°021□N; 23°602□E). We found out that the lowest total quantity losses of soya (11.6%) occurred at the working speed of a harvester of 4 km·h^{-1}, slightly higher (11.78%) at the speed of 2.5 km·h^{-1}, and the highest (12.41%) at the speed of 6 km·h^{-1}. We reported the lowest macro-damage of soya seeds (7.8%) at the working speed of a harvester of 6 km·h^{-1}, slightly higher (9.3%) at the speed of 4 km·h^{-1}, and the highest (10.3%) at the speed of 2.5 km·h^{-1}. We reported the highest purity of seeds (92.3%) in the harvester tank at the speed of 2.5 km·h^{-1}, slightly lower (90%) at the speed of 4 km·h^{-1}, and the lowest (89.3%) at the speed of 6 km·h^{-1}. Taking into consideration a statistic insignificance of differences between the total losses which occur at the working speeds of ZO56 Bizon Super harvester assumed for research, we may find it useful for harvesting soya seeds of Merlin variety within the speeds of 2.5-6 km·h^{-1} at the losses of seeds below 12.5%. However, these losses are high.
***Key words**: damage to seeds, harvesting seeds, combine harvester*

WPŁYW PARAMETRÓW ROBOCZYCH KOMBAJNU Z056 BIZON SUPER NA STRATY ILOŚCIOWE I JAKOŚCIOWE NASION PRZY ZBIORZE SOI

Streszczenie

W pracy dokonano oceny wpływu parametrów roboczych kombajnu Z056Bizon Super na straty ilościowe i jakościowe nasion przy zbiorze soi. Badania wykonano na soi odmiany Merlin uprawianej w miejscowości Leszczany (51°021□N; 23°602□E). Stwierdzono, że najniższe całkowite straty ilościowe nasion soi (11,16%) wystąpiły przy prędkości roboczej kombajn 4 km·h^{-1}, nieco wyższe (11,78%) przy prędkości 2,5 km·h^{-1}, zaś najwyższe (12,41%) przy prędkości 6 km·h^{-1}. Najniższe makrouszkodzenia nasion soi (7,8%) stwierdzono przy prędkości roboczej kombajnu 6 km·h^{-1}, nieco wyższe (9,3%) przy prędkości 4 km·h^{-1}, zaś najwyższe (10,3%) przy prędkości 2,5 km·h^{-1}. Najwyższą czystość nasion soi (92,3%) w zbiorniku kombajnu stwierdzono przy prędkości 2,5 km·h^{-1}, nieco niższą (90%) przy prędkości 4 km·h^{-1}, zaś najniższą (89,3%) przy prędkości 6 km·h^{-1}. Biorąc pod uwagę statystyczną nieistotność różnic między całkowitymi stratami powstającymi przy przyjętych do badań prędkościach roboczych kombajnu Z056 Bizon Super można uznać, że może on być stosowany do zbioru nasion soi odmiany Merlin w zakresie prędkości 2,5-6 km·h^{-1}, przy stratach nasion poniżej 12,5%. Jednak straty te są na wysokim poziomie.
***Słowa kluczowe**: uszkodzenia nasion, zbiór nasion, soja, kombajn zbożowy*

1. Introduction

Soya is one of the most precious plants cultivated around the world. Its seeds contain approximately 40% of the full value protein, approximately 20% of fat with high utility as food, lecithin and vitamins, mainly from A and B group. They are commonly used for production of food for people and feed for animals. Soya cultivation also influences structure formation in case of soil and enriches it with nitrogen [7, 8, 11, 12].

Low location of bottom pods on a plant is a disadvantageous feature of soya from the point of view of mechanical harvesting. It causes considerable losses of seeds at harvesting [1, 2, 8, 9, 10]. Their size mainly depends on the height at which the plant is cut. In order to reduce this group, harvesting units of harvesters are equipped with the so-called tracing or elastic cutting units [1, 8, 10]. Replacing classic harvesting units with special row adapters for soya harvesting is another method [4, 10]. The quality of soya seeds harvesting depends also on working parameters of a harvester [5, 7, 8, 10, 11].

In Poland, interest in soya cultivation has risen in recent years. This interest is mainly a consequence of the need of obtaining high-protein fodder from plants, which are not genetically modified, and a valuable plant in crop rotation. Therefore, it is important to carry out research concerning mechanization of harvesting of this plant in the aspect of incurred losses and quality of seeds.

2. Objective, methods and conditions of research

The objective of the research was to determine the quality of the soya seeds harvesting with Z056 Bizon Super combine harvester equipped with a harvesting unit in a manufactured version. We carried out the investigations based on the methodology of research of combine harvesters developed in the Institute of Construction, Mechanization and Electrification of Agriculture (2) which was adjusted to the assumed objective and the scope of research.

The research was carried out on 9th September 2016 on Merlin soya variety plantation located in Leszczany (51°021□N; 23°602□E) at three working speeds of the harvester (2.5; 4.0 and 6.0 km·h^{-1}). We presented the remaining working parameters of the harvester in table 1.

Table 1. Working parameters of Z056 Bizon super harvester at harvesting of Merlin soya variety
Tab. 1. Parametry robocze kombajnu Z056 Bizon Super przy zbiorze soi odmiany Merlin

Specification	Unit of measure	Working parameters of a harvester Z056 Bizon Super		
Working speed of a harvester	km·h^{-1}	2.5	4.0	6.0
Circumferential speed of a gathering unit	rot·min^{-1}	38		
Rotational speed of a threshing drum	rot·min^{-1}	500		
Size of a threshing slot /acc. to the scale/	-	8		
Size of the opening of screens - upper one - bottom one	mm	 8 6		
Rotational speed of a fan /acc. to the scale/	-	5		
Setting of air stream fan vanes	-	parallel to the bottom of the outlet conduit		

Source: own work / Źródło: opracowanie własne

We carried out investigations of the harvester at the rotational speed of a threshing drum of the harvester of 500 rot·min^{-1}, size of the threshing slot at the outlet of 8 mm, opening of screens: the upper - 8 mm and the bottom one - 6 mm and at the maximum rotational speed of a fan.

In order to determine conditions of the combine harvester we described the plantation. Description consisted in a random measuring in thirty iterations of the following features:
- distance between plants in a row, cm,
- plant and field height, cm,
- height of location of first pods on plants, cm,
- number of pods on a plant, items,
- length, width and thickness of pods, mm.

Then from the surface area of 1 m^2, in 5 iterations, all plants and weeds were cut off. After we had prepared and weighted particular samples, we calculated a biological yield of seeds, straw and weeds (kg/ha). Moisture of seeds (%) was determined according to the standard PN-79/R-65950.

During the research, the following indices of the harvester operation quality were determined:
- losses of the harvesting unit and the threshing unit, kg/ha, %,
- damage to seeds, kg/ha, %,
- purity of seeds, %.

In order to determine losses of the harvesting unit after the harvester crossed a measuring distance of 20 m at the assumed working parameters and after it caught straw fraction on the tilt, a measuring frame with dimensions of 1x4 m was placed randomly on a stubble field with a shorter side parallel to the driving direction of the harvester (in five iterations). Then, loose seeds, loose seeds from pods and cut plants but not gathered by the harvester and pods connected to the stubble field were collected separately within the frame. Fractional and total losses of the harvesting unit were calculated after weighting of a particular group of seeds. They were expressed in kg/ha and %.

In order to determine losses of the threshing unit of the harvester, straw fractions from the measurement field were processed. Underthreshed material and loose seeds in straw and waste formed losses of the threshing unit. They were expressed in kg/ha and %. Macro-damage of seeds and purity of the collected material was determined from samples collected from the harvester tank on particular measuring fields. We included damage of seeds visible with a naked eye to macro-damage. Purity of seeds (%) was determined according to the standard PN-79/R-65950.

We applied Shapiro-Wilk test to determine regularity of distribution of variables. Statistical analysis of the research results was carried out with the analysis of the univariate analysis of variance and T-Tukey's multiple confidentiality intervals at the assumed level of significance of $\alpha = 0.05$.

3. Results of research and analysis

We presented the results of measurements of the selected properties of Merlin variety of soya field in table 2.

Table 2. Description of soya plantation of Merlin variety
Tab. 2. Charakterystyka plantacji soi odmiany Merlin

Specification	Unit of measure	Results of measurements	*V* [%]
Width of interrows	cm	12.5	-
Distance between plants in a row	(cm)	7.61	76
Field height	(cm)	52.7	21
Plant height	cm	53.5	21
Lodging index of plants	%	1.5	-
Height of the first pod on a plant	cm	10.8	31
Number of pods on a plant	items	12.3	49
Number of seeds in a pod	items	2.7	20
Dimensions of pods: - length - width - thickness	cm	 4.14 0.82 0.59	 9 10 15
Mass of a sample from 1 m^2: - of seeds - stalks	g	 295.0 416.7	 12 47
Relation of the mass of seeds to the mass of stalks	-	1:1,41	-
Moisture of seeds during harvesting	%	13.6	-
Biological yield calculated into 14% moisture)	kg/ha	2963.7	-

Source: own work / Źródło: opracowanie własne

Merlin soya was cultivated in interrows with the width of 12.5 cm. The average height of plants was 53.5 cm and their lodging index - 1.5%. The first pods were located on plants at the average height of 10.8 cm. Moisture of seeds during harvesting was 13.6%. A biological yield of soya calculated per 14% of moisture was 2963.7 kg·ha^{-1}. Majority of properties describing a plantation had an average or low variability, which may be proved by the value of the variability coefficient *V* (tab. 2). Only the distance between plants in a row, number of pods on a plant and the weight of stalks from 1 m^2 was highly variable. Soya plantation was not weeded.

The results of the harvesting quality of soya seeds varieties with Z056 Bizon Super harvester with their statistical analysis was presented in table 3.

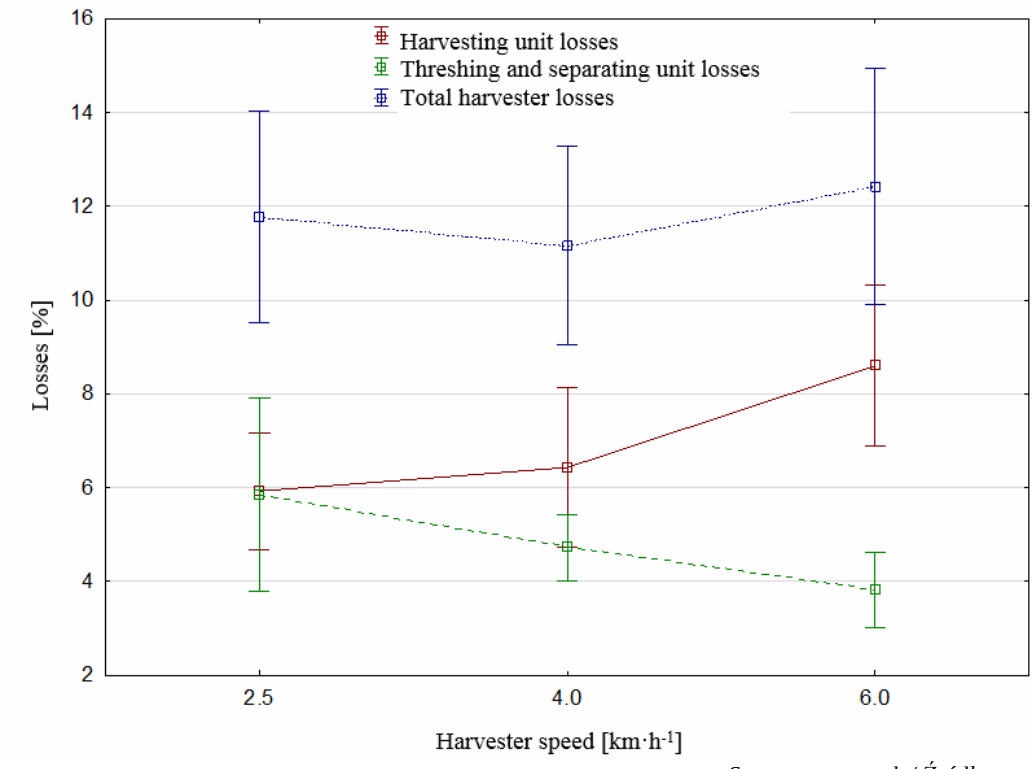
The lowest total losses of the harvester (11.6%) were reported at the working speed of 4 km·h^{-1}, the lowest losses of the harvesting unit (5.85%) at the speed of 2.5 km·h^{-1}, and the lowest losses of the threshing and separating unit (3.82%) at the speed of 6 km·h^{-1} (fig. 1). We reported the highest macro-damage of soya seeds (10.3%) at the working speed of the harvester of 2.5 km·h^{-1}, slightly higher (9.3%) at the speed of 4 km·h^{-1}, and the lowest (7.8%) at the speed of 2.5 km·h^{-1}.

Table 3. Results of the quality of soya seeds harvesting with Z056 Bizon Super combine harvester
Tab. 3. Wyniki jakości zbioru nasion soi kombajnem zbożowym Z056 Bizon Super

Specification	Unit of measure	Working speed of harvester km·h^{-1}		
		2.5	4.0	6.0
Stubble field height	cm	6.8	10.7	11.7
I. Quantity losses of seeds*				
Losses of the harvesting unit, including:	kg·ha^{-1}	174.9a	189.6a	253.6b
– resulting from losing seeds		51.3a	64.3a	93.1b
– resulting from losing pods and cut plants		93.2b	63.1a	87.3a
– related to the height of plant cutting		30.4a	62.2b	73.2b
Losses of the harvesting and separating unit, including:	kg·ha^{-1}	172.4b	139.5ab	112.6a
– loose seeds in straw and waste		93.1b	87.3ab	73.1a
– underthreshed material		79.3b	52.2a	39.5a
Total losses of a harvester	kg·ha^{-1}	347.3a	329.1a	366.2a
II. Quality of the collected material*				
Macro-damage to seeds	%	10.3b	9.3ab	7.8a
Purity of seeds	%	92.3a	90.0a	89.3a

* values marked with the same letter do not differ significantly at $p < 0.05$

Source: own work / Źródło: opracowanie własne



Source: own work / Źródło: opracowanie własne

Fig. 1. Working speed and losses of soya seeds
Rys. 1. Prędkość robocza a straty nasion soi

The number of macro-damages, which occurred at the lowest speed, differed significantly from the number of macro-damages which occurred at the highest working speed of the harvester. The highest purity of seeds (92.3%) was obtained at the harvester speed of 2.5 km·h^{-1}, slightly lower (90%) at the speed of 4 km·h^{-1}, and the lowest (89.3%) at the speed of 6 km·h^{-1}. We did not report the impact of the working speed on the purity of seeds by means of statistics.

The highest losses caused by losing seeds were reported at the highest speed of the investigated speeds and they differed significantly from the losses which occurred at the speed of 2.5 and 4.0 km·h^{-1}. On the other hand, losses, which occurred as a result of losing pods and cut plants, occurred at the lowest speed of the investigated speeds and also differed from this type of losses which occurred at the remaining investigated working speeds of the harvester. Losses of soya seeds caused by the cutting height of plants at the harvester speed of 4.0 and 6.0 km·h^{-1} were almost 2 times higher than at the speed of 2.5 km·h^{-1}.

Holtz and Reis [6] investigated seeds losses at the working speed of 6.0 km·h^{-1} of New Holland 57 and reported the maximum losses of 160.1 kg·ha^{-1}. There were losses almost 2 times higher than in the presented research. Schanoski et al. [11] investigating losses at mechanical harvesting state that the highest losses take place in the harvesting unit and losses over 240 kg·ha^{-1} caused by incorrect regulation of the total work of the harvester and in particular of the threshing, separating and cleaning unit. Compagnon et al. [2] when analysing losses of soya seeds during harvesting with NH CR9060 harvester with an autonomous regulation of the working units operation reported losses from 35.2 to 98.1 kg·ha^{-1} at the yield of 3470 kg·ha^{-1}. There were almost threefold lower losses than at harvesting with Z056 Bizon Super harvester.

4. Conclusions

1. Cultivation of Merlin variety soya in interrows of 12.5 cm in 2016 allowed obtaining a biological yield at the level of 2964 kg·ha^{-1}.
2. We found out that the lowest total quantity losses of soya (11.6%) occurred at the working speed of the harvester of 4 km·h^{-1} slightly higher (11.78%) at the speed of 2.5 km·h^{-1}, and the highest (12.41%) at the speed of 6 km·h^{-1}.
3. We reported the lowest macro-damage of soya seeds (7.8%) at the working speed of the harvester of 6 km·h^{-1}, slightly higher (9.3%) at the speed of 4 km·h^{-1}, and the highest (10.3%) at the speed of 2.5 km·h^{-1}.
4. We reported the highest purity of seeds (92.3%) in the harvester tank at the speed of 2.5 km·h^{-1}, slightly lower (90%) at the speed of 4 km·h^{-1}, and the lowest (89.3%) at the speed of 6 km·h^{-1}.
5. Taking into consideration a statistic insignificance of differences between the total losses which occur at the working speeds of ZO56 Bizon Super harvester assumed for research, we may recognize that it may be used for harvesting of soya seeds of Merlin variety within the speeds of 2.5-6 km/h at the losses of seeds below 12.5%. However, these losses are high.

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