

## Quality of raspberry combine harvesting depending on the selected working parameters

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**Summary.** This paper presents the results of the research on the work quality of a tow-behind combine harvester Korvan 930 while picking Canby summer variety of raspberries cultivated on poles. The assumption was to determine the type and size of losses as well as the share of damaged fruits and impurities in the combine-harvested material.

**Key words:** raspberries, combine harvesting, losses, damaged fruits, impurities.

### INTRODUCTION

On a vast majority of raspberry plantations in the world, the fruit are still harvested manually. Until not very long ago in fact, manual harvesting of raspberries was actually the only possible solution to apply. In Poland, due to constantly growing cost of labour and not enough of the labour force, and in connection with growing desire of producers to achieve better yields (especially in the period of peak purchasing prices), as of the beginning of this century first attempts at an automated raspberry harvest have repeatedly occurred [7, 8]. However, raspberry fruit are delicate and therefore susceptible to damage [1, 9, 12, 13, 15], and, what's more, they ripen non-simultaneously, which calls for the need of multiple harvests during one season, thus causing more risk of damage to the fruit. [14]. Even in case of vegetables resistant to damage, machine harvesting (which has been improved for the last several tens of years) still causes inevitable damages and losses of products [10]. A solution to the problem of having too much fruit damaged during the machine harvest is, apart from improving the construction of the machines, introduction of more damage-resistant fruit varieties [2-6].

### AIM AND SUBJECT OF RESEARCH

The aim of the research was to determine the volume of losses and damages of the raspberry fruits as well as the

amount of impurities in the harvested material generated during the automated harvest by means of a tow-behind combine-harvester Korvan 930 manufactured by an American company Oxbo. For the purpose of the research the harvester was aggregated with tractor Władimirec t 25. Examined was the suitability of the above harvester for picking summer variety of raspberry called Canby meant for cold storage.

Korvan 930 harvests fruits by shaking them off the bush (by means of 'fingers' of two vertical beaters and generally resembles the Polish combine harvester Natalia by Weremczuk company [7]. The difference is that the shell adjusting system designed to catch the falling fruits) does not have the rolls sliding on the shoots of bushes. Korvan 930 was designed to pick raspberries and put them in plastic boxes which were placed on the platforms next to inspection carriers attached on both sides of the harvester. The field examination of the harvester was carried out in a village called Kolonia Łubki close to the town of Opole Lubelskie on a 6-year old plantation of a Canby summer variety of raspberry cultivated on poles and linked by metal strings to which the raspberry shoots were attached in the direction opposite to the direction of picking. The research was conducted at the harvester working speed of 1.35 km·h<sup>-1</sup> which was selected as the best for testing purposes and because it was the lowest speed possible to be achieved with the attached tractor. At higher tractor speeds, the operator of the whole aggregate had problems with leading the machine properly.

### RESEARCH METHODOLOGY

While assessing the quality of combine harvester operation, methodology designed by Kowalczyk and Zarajczyk [7, 8] was used and modified. In order to determine the working conditions of the combine harvester, features of the raspberry plantation were examined and described. The

examination involved random measurement of: row spacing, row width, raspberry bush height, width of growing shoots (measured on the ground surface) and minimum height at which fruits were formed, all in one hundred repetitions. Apart from that a number of shoots on 1 meter sections was counted (in thirty repetitions). The raspberry yield (to be potentially harvested during one day) was determined on the measurement fields of 10 m in length, in six repetitions.

Prior to starting the assessment of the combine harvester working quality, its parameters were specified. The amplitude of beating cylinders was measured in the cylinder's axis while the frequency was determined by counting the multiplications of the cylinder inclinations within 10 seconds, all in thirty repetitions. The speed of the cooling fans and cooperating inspection carriers from over which impurities were sucked off, was determined on the basis of regulation knobs.

The quality of the combine raspberry harvest was assessed on previously appointed 10 m long measurement fields (in six repetitions). During tests, picked raspberries were taken to plastic boxes placed individually for every repetition to capture the picked fruit mass. Then the picked raspberries were segregated into: damaged and not damaged (serious damages visible with the naked eye), with and without stalks, and into green fruits and impurities. Then the ripe fruits were weighed. Apart from that, fruits dropped by the harvester were picked up manually from the measurement sections (before the test was started, the measurement sections were cleaned from previously fallen raspberry fruits). After that, shares of particular fractions in percentages were determined, compared to the whole fruit mass harvested. The fractions were weighed by means of Radwag WPT 30/CG and WTE2000p scales. Impurity percentages were calculated in relation to the mass of the entire sample picked by the harvester. Percentage of losses was calculated in relation to the total fruit mass collected by the harvester, lost and fallen from the previous harvest.

The research results were made subject to a statistical analysis by means of the Excel spreadsheet. The CV variability ratio was calculated:

$$CV = \frac{\delta}{n} \cdot 100\%,$$

where:

$d$  – standard deviation,

$n$  – mean value.

Destructive changes in fruits were determined based on the observation of raspberry juice leakages, in accordance with the methodology adopted by Kuczyński and Rybczyński [9].

## RESULTS AND DISCUSSION

The results of the measurement of the raspberry plantation characteristics, on which tests of combine harvester Korvan 930 were carried out, were summarised in Table 1.

**Table 1.** Characteristics of the raspberry plantation of Canby variety

Specification	Measurement unit	Average results	Variability ratio, %
Row spacing	cm	316,0	2,1
Distances between bushes in a row	cm	30,0	5,4
Width of growing shoots	cm	31,1	7,3
Number of shoots per 1 linear metre	shoots	29,3	23,4
Height of raspberry plants	cm	176,3	11,0
Row width	cm	102,3	8,6
Minimum height at which fruits are formed	cm	35,0	28,5
Average weight of 100 fruits	g	271,7	0,8
Fruit mass volume	$\text{g} \cdot (250 \text{ cm})^{-3}$	106,6	7,0
Raspberry potential yield	$\text{kg} \cdot \text{ha}^{-1}$	643,8	7,16

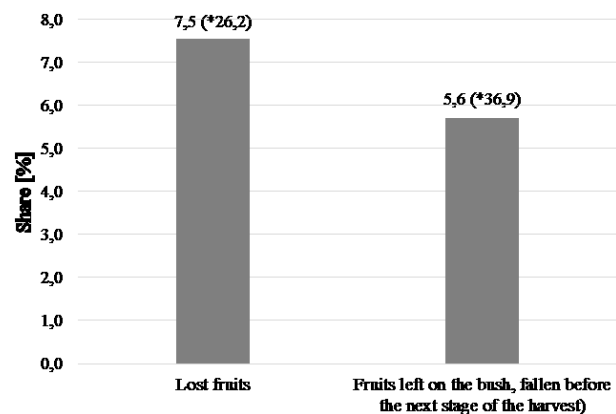
Raspberries were seeded in rows spaced at 316 cm and the distance between the bushes in a row was 30 cm. On 1 linear metre 29.3 shoots grew. Plants formed a lane 176.3 cm high and 102.3 cm wide, and the lowest fruits were formed at the height of 35.0 cm. The average weight of 100 fruits was 271.7g and their mass volume  $106.58 \text{ g} (250 \text{ cm})^{-3}$ . The potential yield was  $643.8 \text{ kg} \cdot \text{ha}^{-1}$ .

Work parameters of combine harvester Korvan 930 were presented in Table 2.

**Table 2.** Work parameters of combine harvester Korvan 930

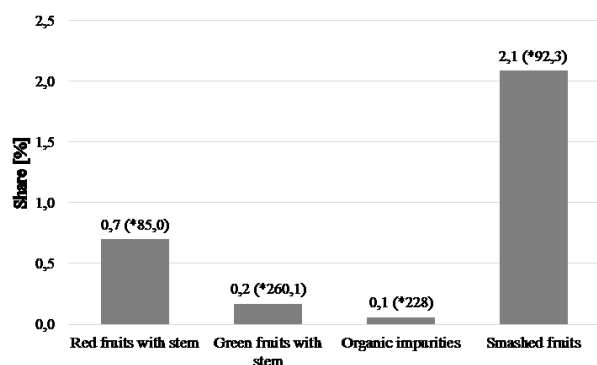
Specification	Measurement unit	Average results	Variability ratio, %
Shaking amplitude	cm	4,0	35,4
Frequency of shaking	Hz	4,6	0,1
Fan speed	6 on scale 0-10		
Speed of inspection carriers	0 on scale 0-10		

Research results related to the assessment of work quality of combine harvester Korvan 930 while harvesting Canby variety raspberries were presented on charts 1 and 2.



\* variability ratio

**Fig. 1.** Losses occurring while harvesting Canby variety raspberries by means of combine harvester Korvan 930



\* variability ratio

**Fig. 2.** Damages and impurities occurring while harvesting Canby variety raspberries by means of combine harvester Korvan 930

Tests showed significant share of lost fruits of which majority i.e. 7.5% were fruits dropped out by the harvester at the junction of the adjusting system. The shells of the adjusting system could not touch each other due to significant width of the growing shoots (31.1 cm). Although we could have plantations with tighter rows and thus reduce the rate of the dropped out fruits but they would produce lower yields per hectare and in consequence be less profitable. Lost fruits were also ripe fruits left on the bushes and fallen before the next stage of the harvest – there were 5.7% of those. In reference to the results achieved by Rabcewicz [11] the amount of the losses can be decreased by increasing the frequency of shaking but such a technique would also cause the increase of damaged fruits, unwelcome by the cold storage industry.

The collected material was only very little contaminated with impurities such as stems (0.7%), green fruits (0.2%) and minute organic impurities (0.1%). These impurities can be eliminated entirely by having two workers remove them manually, each one at each inspection carrier on the harvester.

Combine harvester Korvan 930 also caused mechanical damages to the fruits. 2.4% of them were smashed. However, no destructive changes of the fruits were observed.

## CONCLUSIONS

1. During combine harvesting of Canby variety raspberries by means of Korvan 930 two types of losses were observed: the machine lost/dropped 7.5% of fruits and did not properly pick all ripe fruits leaving 5.7% on the bushes.
2. Combine-harvested fruits were contaminated very little, i.e. there were only 0.7% of fruits with stem, 0.2% of green fruits and 0.1% of organic impurities%.
3. Fruit damages were 2.1%.
4. Tow-behind combine harvester Korvan 930 of Oxbo company may in friendly conditions be successfully used to harvest Canby variety raspberries meant for cold storage.

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W ZALEŻNOŚCI OD WYBRANYCH PARAMETRÓW  
ROBOCZYCH

**Streszczenie.** Przedstawiono wyniki badań dotyczące jakości pracy przyczepianego kombajnu Korvan 930, przy zbiorze

letniej maliny odmiany Canby, prowadzonej na podporach. Określano rodzaj i wielkość strat owoców oraz udział uszkodzonych owoców i zanieczyszczeń w materiale zebranym kombajnem.

**Słowa kluczowe:** maliny, zbiór kombajnowy, straty, uszkodzenia owoców, zanieczyszczenia.