INFLUENCE OF WORKING PARAMETERS OF THE "NATALIA" COMBINE HARVESTER MANUFACTURED BY THE WEREMCZUK COMPANY ON THE HARVEST QUALITY OF RED RASPBERRIES

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Summary. Investigated was the influence of the "Natalia" combine harvester forward speed (in the range of 0.19-0.37 $m \cdot s^{-1}$) of on the harvest quality of the Canby raspberry. The most advantageous speed was found the lowest examined, i.e. 0.19 $m \cdot s^{-1}$, at which 71.6% of ripe fruit possible to be collected on the research day was collected. The ripe fruit which remained uncollected was not altogether lost because it could be collected during the next harvester round. Statistical analysis showed significant differences between the results obtained at the speeds of 0.19 and 0.37 $m \cdot s^{-1}$ as well as 0.29 and 0.37 $m \cdot s^{-1}$. Average losses caused by the fruit falling to the ground were below 7% while the organic impurities in the harvested fruit approximated 0.6%.

Key words: red raspberry, harvester forward speed, harvest quality.

INTRODUCTION

First red raspberry harvesters appeared about 30 years ago. However, only in the last decade or two the combine harvester construction was improved enough to prevent significant reduction of the harvested fruit quality or damage to the raspberry sprout [Zmarlicki 2003, Hołownicki 2005]. Majority of raspberry plantations in Poland are established for manual picking which accounts for as much as 2/3 of the total annual labour input. For raspberries grown with wire support it is assumed that to produce an average of 7-8 $t \cdot ha^{-1}$ of fruit and conduct necessary tillage operations during the harvest period the labour input of 1250-1400 $h \cdot ha^{-1}$ is required. Theoretically this corresponds to the work of 7-8 people, effectively collecting fruit for 8 hours 22 working days [Zmarlicki 2003, Mochecki and others 2003]. It must be stressed that the costs of manual fruit picking are constantly growing and it becomes more and more difficult to find workers. The only way to lower the respective labour costs, especially on large raspberry plantations, is the introduction of combine harvesters, which makes it possible to extend the raspberry cultivation areas and increase profitability of their production [Hołownicki 2005, Danek 2004, Ben 2000].

OBJECTIVE AND SUBJECT OF INVESTIGATIONS

The main objective of the research was to determine the influence of combine harvester forward speed on the quality of the collected fruit. The object of the research was combine harvester "Natalia" designed and manufactured by the Weremczuk company (Fig. 1). It enables multiple harvests during one year on plantations ranging from 6 to 8 ha.

Phot. 1. Side view of "Natalia" raspberry combine harvester of Weremczuk Company [www.firmaweremczuk.com.pl]

The "Natalia" combine harvester is a tractor-drawn machine, designed for harvesting raspberries grown in a hedgerow system. The hedgerow width at the base should not exceed 50-80 cm. The height of plants should be in the range of 110-200 cm. The combine harvester consists of the following main working assemblies (Fig.1): sealing assembly, shaking assembly, assembly conveying the picked fruit to boxes and cleaning assembly. The crew consists of two people plus the tractor driver.

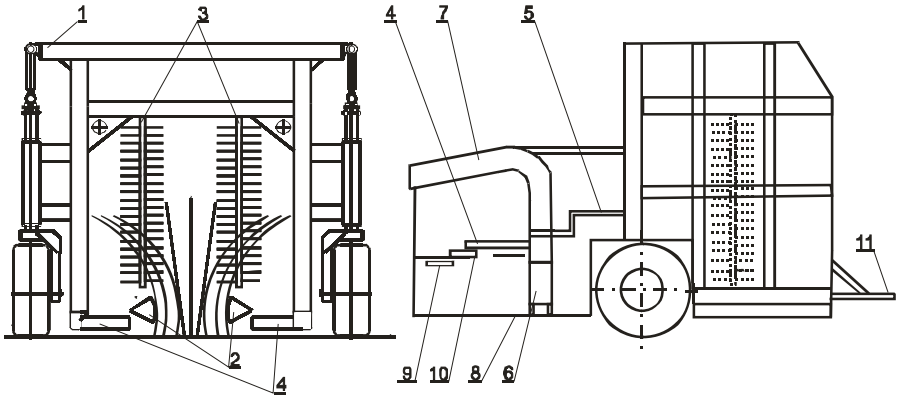

Fig. 1. Schema of a raspberry "Natalia" combine harvester: 1- frame, 2- sealing assembly, 3- shaking barrels, 4- fruit openwork-ply conveyors, 5- platform for boxes, 6- ventilator, 7- air channel, 8- platform for servicing personnel, 9- seat, 10 - fruit box, 11- catch

After moving the harvester into the field it straddles a raspberry hedgerow (Phot. 1), the sealing assembly (roller-scale) is pressed against the lower part of shoots where there are no fruits. The shaking cylinders fitted with plastic fingers, placed on both sides of the hedgerow, shake the

shoots, causing the ripe fruits to separate. The fruits fall on the scales of the sealing assembly and then they roll down to the conveyors which transport them into the boxes placed on the platforms. Under the conveyors there are fans which take the impurities through the air channels outside the harvester. The workers remove the rest of impurities and green fruit which were not taken away by the ventilators, collect the boxes filled with fruit and replace them with empty ones. The research was conducted on a plantation of the Canby summer raspberry variety which is well suited for mechanical harvest since the bond strength of fruits with the receptacle diminishes as the fruits ripen. The separation strength of the fruit is a variety dependent trait and depends mainly on the size and shape of the receptacle and the ripeness of the fruits. Sometimes it is also dependent on the weather conditions [Rybczyński i in. 2001, Hołownicki 2005].

METHOD AND INVESTIGATION CONDITIONS

The researches on the machine raspberry harvest were conducted at three forward speeds which were: 0.19; 0.29 and 0.37 $m \cdot s^{-1}$. During the tests the machine was drawn by a Lamborgini tractor. The vibration frequency of the shaking fingers was 50 Hz while the amplitude was 10 cm. In order to determine the working conditions of the combine harvester a characteristic of the raspberry plantation was made. In 100 repetitions, at random, the following parameters were measured: shoot height, minimum height of fruit set, in-row shoot spacing, row width and span. On the basis of the obtained measurements, standard deviations were calculated. On randomly selected 10-meter traversing lengths of the plantation the forward speed of the combine harvester was measured in five repetitions and the picked fruit was weighed. Next, the organic impurities were separated. After that, the ripe fruits left on shoots and the fruits which fell to the ground while the harvester was run were collected manually from the traversing lengths and their mass was determined. The obtained results were expressed as % of the total yield of ripe fruit collected on the research day. They were statistically analysed based on the variance analysis and T-Tukey's multiple confidence intervals at the significance level $\alpha = 0{,}05$.

RESEARCH RESULTS AND DISCUSSION

The results of measuring the selected properties of Canby raspberry plantation on which the "Natalia" combine harvester manufactured by Weremczuk was examined have been presented in Table 1.

Table 1. Characteristics of the selected properties of Canby raspberry plantation

Specification	Unit of measure	Mean	Standard deviation
Raspberry shoot height	cm	200	0.1
Minimum height of fruit setting on shoots	cm	21.7	7.7
Width of shoots in a row at the base	cm	115	0.09
Row span	cm	315	0.09

Table 1 shows that the average Canby raspberry shoots height was 200 cm, minimum height of fruit setting on shoots 21.7 cm, width of shoots in a row 115 cm and row span 315 cm. The results of the raspberry harvest quality research by means of "Natalia" combine harvester have been presented in Table 2.

Table 2. Quality of Canby variety raspberry harvest with "Natalia" combine

Harvester forward speed ($m \cdot s^{-1}$)	Harvester picked fruit (%)	Ripe fruit left on the shoots (%)	Fallen fruit (%)	Organic impurities in collected fruit (%)
0.19	71.6^{a}	20.2^{a}	8.2^{a}	0.7^{a}
0.29	62.0^{a}	32.6^{a}	5.4^{a}	0.6^{a}
0.37	56.5^{b}	36.2^{a}	7.3^{a}	0.6^{a}

Different letters used as upper indexes indicate that at the tested speeds of the combine harvester significant differences occurred between the analyzed properties at the level α=0,05

Table 2 shows that the best forward speed of the combine harvester was the lowest tested, i.e. 0.19 $m \cdot s^{-1}$ at which 71.6% of the total ripe fruit available on the research day was collected. At the remaining speeds the following results were obtained: at the speed of 0.29 $m \cdot s^{-1}$ – 62% and at the speed of 0.37 $m \cdot s^{-1}$ – 56.5%. The statistical analysis showed important differences between the results obtained at the speeds 0.19 and 0.37 $m \cdot s^{-1}$ as well as 0.29 and 0.37 $m \cdot s^{-1}$. It must be stressed that the ripe fruit which remained uncollected was not altogether lost because it could be collected during the next harvester round.

The figures expressing the fruit fallen to the ground during the harvesting operation were the following for the respective tested speeds: 0.19 $m \cdot s^{-1}$ – 8.2%, 0.29 $m \cdot s^{-1}$ – 5.4% and for 0.37 $m \cdot s^{-1}$– 7.3%.

The total yield harvested at any of the forward speeds contained only from 0.6 to 0.7% of the organic impurities. It should be stressed that in the test runs the crew did not remove the impurities from the harvested fruit which would be normal practice at the real harvest.

CONCLUSIONS

1. The most advantageous of the tested forward speeds of the "Natalia" combine harvester was 0.19 $m \cdot s^{-1}$ at which 71.6% of the ripe fruit was collected. Ripe fruit which remained uncollected was not altogether lost because it could be collected during the next harvester round.
2. Losses constituted by fruit fallen to the ground at particular speeds were below 7% on average.
3. Approximately 0.6% were the organic impurities in the total mass picked by the combine harvester.

REFERENCES

Ben J., 2000. Zbiór i przechowywanie owoców jagodowych. Sad Nowoczesny, 6, 25-26.

Danek J., 2004. Uprawa maliny i jeżyny. Wyd. Hortpress, Warszawa.

Hołownicki R., 2005. Maliny także można zbierać kombajnem. Hasło Ogrodnicze, 2, 83.

Mochecki J., Danek J., 2003. Maliny. Integrowana produkcja owoców (Proekologiczne technologie produkcji owoców). Wyd. ISiK, Skierniewice.

Rybczyński R., Dobrzański B., Wieniarska J., 2001. Właściwości mechaniczne owoców maliny. Acta Agrophysica, 45, 167-175.

Salamon Z., 1992/93. Mechaniczny zbiór owoców porzeczek przy pomocy kombajnu. Prace Instytutu Sadownictwa i Kwiaciarstwa Seria A, 31, 203-216.

Salamon Z., Wawrzyńczak P., Rabcewicz J., 1997. Maszynowy zbiór owoców z krzewów jagodowych. Problemy Inżynierii Rolniczej, 1, 61-68.
Zmarlicki K., 2003. Ekonomiczne aspekty mechanicznego zbioru malin. Hasło Ogrodnicze, 10, 50-52.

WPŁYW PARAMETRÓW ROBOCZYCH KOMBAJNU „NATALIA" FIRMY WEREMCZUK NA JAKOŚĆ ZBIORU MALIN

Streszczenie. Badano wpływ prędkości roboczej kombajnu „Natalia" w zakresie 0,19-0,37 $m \cdot s^{-1}$ na jakość zbioru malin odmiany Canby. Stwierdzono, że najkorzystniejszą prędkością roboczą kombajnu była najniższa badana prędkość wynosząca 0,19 $m \cdot s^{-1}$, przy której zebrano 71,6% dojrzałych owoców, możliwych do zebrania w dniu badań. Dojrzałe owoce pozostałe na pędach nie stanowią ostatecznych strat, ponieważ mogą być zebrane przy następnym przejeździe kombajnu. Analiza statystyczna wykazała istotne różnice między wynikami dotyczącymi ilości zebranych dojrzałych owoców przy prędkościach 0,19 i 0,37 $m \cdot s^{-1}$ oraz 0,29 i 0,37 $m \cdot s^{-1}$. Średnie straty spowodowane opadnięciem owoców na ziemię wynosiły poniżej 7%, zaś zanieczyszczenia organiczne w masie zebranej kombajnem około 0,6%.

Słowa kluczowe: maliny, prędkość robocza kombajnu, jakość zbioru.