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AN INFLUENCE OF THE WORKING PARAMETERS OF ALINA SUPERNOVA COMBINE ON HARVEST QUALITY OF CARROT ROOTS

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Summary. The objective of this research was to determine an influence of one-row Alina Supernova combine on the harvest quality of Volcano variety carrot roots. The research was conducted at three working speeds: 1.5, 1.8 and 3.1 km·h^{-1}. The volume of losses caused by the failure to uproot carrots from the soil at tested speeds was: 2.4, 0.3 and 0.2%, respectively, while root damages were 2.3, 0.9 and 1.1%, respectively. The damages included longitudinal cracks and broken roots. At tested speeds the share of roots with leaves not sheared off was about 3%. The share of organic impurities in the gathered material did not exceed 0.4%. However, a very high content of inorganic dirt (from 22.9 to 29.4%) was noted.

Key words: carrot, harvest, losses, root damages.

INTRODUCTION

Carrot harvesting quality, i.e. the volume of root losses and damages, depends on the construction of the combine and its working parameters as well as the susceptibility of the harvested variety to mechanical damages. Root damages depend also on other factors such as *mycelium* [Finlayson et al. 1989], pests [Lee et al. 2002, Kainulainen et al. 2002], appropriate packaging eg. covering the carrot boxes meant for storage with plastic liner [Crespo et al. 2007]. Research is being conducted in order to develop new carrot varieties, more resistant to mechanical damages than the existing ones. According to research by Stopa and Romański [2007] the shape of the root cross section has no influence on the way the root performs under stress.

World trends in improving carrot combines take different directions. On the market increasingly efficient ploughing combines can be found e.g. Largia by Dewulf, which harvests carrots from four patches of land simultaneously (up to 160 tohn·h^{-1}). Another novelty are caterpillar combines for difficult soil conditions developed by Dewulf and Asa-Lift. In 2008 the latter company put on the Polish market a combine which harvests and bunches carrots [Leszczyński 2008]

Weremczuk, a domestic company manufacturing carrot combines, has also improved their construction. Its most recent product is Supernova, a new version of the Alina combine.

AIM AND SUBJECT OF INVESTIGATIONS

The objective was to determine root losses and damages which occurred while plucking carrots with a one-row Alina Supernova combine harvester. The field research of the combine harvester was carried out in October 2008 in Jakubowice Końskie near Lublin. It was carried out while harvesting Volcano carrots at three working speeds: 1.5, 1.8 and 3.1 $km \cdot h^{-1}$. The researched combine was one of the lifting type [Kowalczuk et al. 2003]. The new version was equipped with an electrohydraulic system of directing the lifting share, a brushing conveyer (its inclination angle is adjustable and it is located under the appliance for shearing off and above the load transmitter), a radiator for the hydraulic oil (it was absent in the previous model, which caused the oil to overheat), and wide wheels with an off-road thread to facilitate driving the combine in a straight line along the row. The combine was also equipped with an appliance for shearing off leaves and was drawn by a Zetor 7745 tractor. Plucked carrots were loaded onto a trailer pulled next to the combine.

METHOD AND INVESTIGATION CONDITIONS

In order to determine working conditions of the combine harvester, the compaction and relative humidity of the soil were determined (six times) and a characteristic of the plantation was made. It involved one hundred random measurements of the height of plants before and after leaves were straightened, protrusion of root heads above the ridge surface, spacing of ridges and the distances between the middles of ridges, rows of plants on a ridge and plants in a row. Next, one hundred random roots were plucked so as to measure their length and maximum diameter. Biological yields of carrots, leaves and weeds per 1 m^2 were measured randomly ten times.

The quality of harvesting roots was determined on 10-meter long stretches of the field (six times) for each of the tested speeds. It was done by picking the roots that the combine failed to pluck from the soil or lost. The roots harvested at particular sections of the field were segregated into undamaged, fractured, broken and unsheared. Next, the losses and damages of roots as well as the roots with leaves were determined as the percentage of the weight of all the collected roots, while dirt was determined as the percentage of weight of all the gathered material.

The obtained results were statistically analyzed based on the variance analysis method and multiple confidence intervals of T-Tukey at the significance level α=0.05.

RESULTS AND DISCUSSION

The results of measurements of the performance of Alina Supernova harvester at the investigated carrot plantation are presented in Table 1.

Table 1. Characterization of the Volcano carrot plantation

Specification	Unit of measure	Mean	Changeability coefficient, %
Height of the plants before the straightening of the top leaves	m	0.320	17.2

Height of the plants after the straightening of the top leaves		m	0.490	26.7
Plant droop index		%	34.8	-
The spacing of the ridges		m	0.729	3.1
The distance between the rows of plants		m	0.111	18.9
The distance between plants in the rows		m	0.046	31.1
Height of the protrusion of root heads above the ridge surface		m	0.013	69.3
The length of roots		m	0.225	17.1
Max diameter of roots		m	0.035	27.2
The number of roots per m^2		-	53.2	25.1
Biological yield	Carrot roots	$t \cdot ha^{-1}$	85.8	1.3
	Top leaves		12.4	9.0
	Weeds		0.0	-

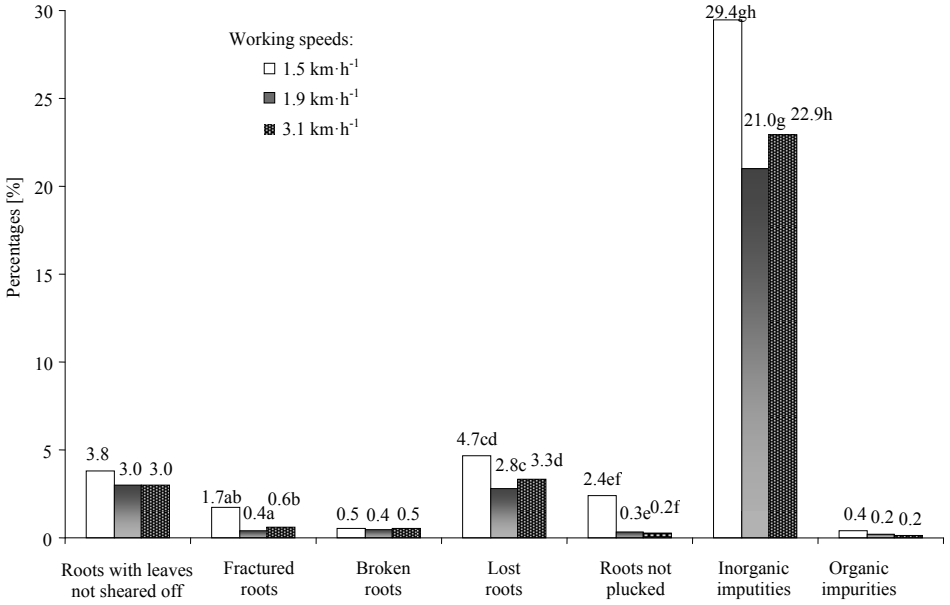
Soil conditions are presented in Table 2.

Table 2. Soil conditions of the plantation

Specification	Unit of measure	Mean	Changeability coefficient, %
Soil compaction	MPa	1.6	23.6
Soil relative humidity	%	19.1	3.0

The obtained results indicated that the conditions were suitable for harvesting with a combine harvester. The height of plants was 0.49 m, the height of plants after the straightening was 0.32 m. and the plant droop index was 34.8%. The spacing between the ridges was 0.729 m. The average length of carrot roots was 0.225 m and their diameter was 0.035 m. The number of roots per 1 m^2 was 53.2. The biological yield of carrot roots was 85.8 $t \cdot ha^{-1}$. The distance between plants in rows was 0.046 m. They grew in two rows, 0.111 m. apart. It was a fairly large distance, considering that the combine plucked up the roots from both rows simultaneously and that could cause leaves to be torn off while they were being caught by the belts to pluck the carrots. Soil conditions were suitable for collecting carrots with a combine harvester. Soil relative humidity was 19.1% and its compaction was 1.6 MPa.

The research results concerning an influence of Alina Supernova forward speeds on the quality of harvesting Volcano carrots are presented in Figure 1.



a, b, c, d, e, f, g, h - statistical significances of differences between the results with these indices

Figure 1. An influence of Weremczuk's Alina Supernova forward speeds on the breakages and losses of Volcano carrots

The Supernova combine caused mechanical damages to carrots (breakages and longitudinal fractures). The highest percentage of fractured roots (1.7%) was noted at the lowest tested speed (1.5 km·h^{-1}). Significant differences were observed between the percentage of fractured roots at the speed of 1.5 km·h^{-1} and at higher speeds, when it was from 0.4 to 0.6%. At higher working speeds the harvester uprooted carrots with a greater kinetic energy, which resulted in better soil crumbling and lower stress when roots were lifted from the soil and, consequently, in a lower number of fractures.

The appliance for shearing off leaves worked properly. Most of the roots which were not completely sheared off (3.8%) were observed at the lowest forward speed (1.5 km·h^{-1}). At the higher speeds (1.9 and 3.1 km·h^{-1}) the share of roots with some leaves left was 3.0%. However, within the examined range of speeds no significant effect of the speed on the thoroughness of shearing was noted.

The highest share of lost roots (4.7%) was observed at the lowest tested speed. At the higher speeds it was significantly lower. At the speed of 1.9 km·h^{-1} it was 2.8% and at 3.1 km·h^{-1} – 3.3%. At the harvesting speed of 1.5 km·h^{-1} the losses caused by the failure to pluck carrots from the earth were also the highest (2.4%). At higher speeds such losses did not exceed 0.3%. It can be explained by a more effective uprooting of the carrots as the speed increases (greater kinetic energy of the digging share enables it to better loosen the soil around the roots so that they can be plucked by the leaves more easily).

Despite a low share of organic impurities in the gathered material (0.2-0.4%), the share of inorganic dirt was very high: from 21.0% at the speed of 1.9 km·h^{-1} up to 29.4% at 1.5 km·h^{-1}, which

was statistically the least favorable speed. The large quantity of earth in the collected sample was mainly caused by a high humidity of the soil (19.1%), which made the argillaceous soil stick to the roots. Even the brushing conveyer used in the combine did not help. Although it was adjustable for the intensity of cleaning, when its inclination angle increased carrots were removed along with the soil.

CONCLUSIONS

1. For the Alina Supernova combine harvester the least favourable of the tested speeds was the lowest of 1.5 $km \cdot h^{-1}$. At that speed the highest losses caused by losing and failure to pluck roots as well as the highest share of fractured roots and inorganic impurities were noted with statistical significance in comparison to higher speeds.
2. At higher forward speeds Supernova combine caused little damage to roots. At the working speed of 1.9 $km \cdot h^{-1}$ damages were 0.8% and at 3.1 $km \cdot h^{-1}$ – 1.1%.
3. The appliance for removing leaves operated properly. At higher tested speeds the share of roots which had not been completely sheared off was 3.0%.
4. When plucking carrots from an argillaceous soil of 19.1% relative humidity, the brushing conveyer (for cleaning roots of earth) did not work satisfactorily. Even at the most favourable of the tested speeds (1.9 $km \cdot h^{-1}$) there was 21% of earth in the gathered material.

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WPŁYW PARAMETRÓW ROBOCZYCH KOMBAJNU ALINA SUPERNOVA NA JAKOŚĆ ZBIORU KORZENI MARCHWI

Streszczenie. Celem badań było określenie wpływu prędkości roboczej kombajnu jednorzędowego Alina Supernova na jakość zbioru korzeni marchwi odmiany Volcano. Przeprowadzono je przy trzech prędkościach roboczych kombajnu, tj. 1,5, 1,8 i 3,1 $km \cdot h^{-1}$. Straty spowodowane nie wydobyciem korzeni marchwi z gleby

wyniosły przy badanych prędkościach odpowiednio: 2,4, 0,3 i 0,2%, zaś uszkodzenia korzeni - 2,3, 0,9 i 1,1%. Wśród uszkodzonych były korzenie pęknięte wzdłużnie i złamane. Korzenie z nie oberwaną nacią stanowiły przy badanych prędkościach około 3%. Udział zanieczyszczeń organicznych w zebranym materiale nie przekroczył 0,4%, stwierdzono natomiast bardzo wysoki udział zanieczyszczeń nieorganicznych od 22,9 do 29,4%.

Słowa kluczowe: marchew, zbiór kombajnowy, straty, uszkodzenia korzeni.