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TECHNICAL AND TECHNOLOGICAL PARAMETERS OF THE PROTECTION ZONE PROCESSINGIN PERENNIAL PLANTATIONS

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Abstract:*Maintaining modern intensive plantations requires the latest practical and theoretical knowledge, the application of which achieves top-quality production results. In recent years, more and more attention has been paid to both energy efficiency and environmental aspects as the ultimate goal of the sustainability of each production. The sustainability of a process can limit reaching the maximum of said process. In the technologies of soil maintenance in perennial plantations in recent years, it becomes imperative that the chemical treatment of the soil, immediately adjacent to the plant and within the row, be replaced by mechanical processing. This need is primarily aimed at minimizing the use of pesticides in order to respond to the environmental requirements. Regular land cultivation is a technically complex problem. The given area is made up of up to 25% of the total land area of the plantation. The paper presents the results of testing a rotary harrows with a deflection, which in one pass achieves the processing of a part of the inter-row surface and half of the protective zone. The results of the research show that the optimal speed of movement of the aggregate carried out in the plantation of the orchard is 1,56 m/s, and in the plantation of the vineyard 1,23 m/s. Productivity of aggregates in the orchard 0,24 ha/h, in the vineyard 0,19 ha/h. Fuel consumption in the vineyard 7,2 l/ha, and in the orchard 6,8 l/ha. Productivity of the aggregate is largely conditioned by the technical solution of the aggregate and the technology of plantation cultivation*.

Key words: *rotary shredder, soil cultivation, perennial plantation, aggregate productivity*

1. INTRODUCTION

High-quality processing of perennial crops also implies the rational engagement of human labor and mechanized means. The modernization and development of agricultural techniques, especially information and communication technologies, have significantly improved the technological processes of processing [10]. The application of modern fruit growing technologies is, above all, related to the implementation of new techniques and mechanization in the production process, regardless of the fruit type [12]. Procedures and measures of soil cultivation in plantations, in addition to climatic and soil conditions, are also conditioned to a considerable extent by cultivation technology [15]. Modern fruit and vineyard plantations are characterized by the so-called dense planting, it greatly affects processing procedures.

The lifespan of the plantations, the size of the yield as well as the quality of the fruits, are largely determined by the technology of tillage [3]. Maintenance of soil in perennial plantations during its exploitation is a technically complex job that requires the engagement of a large amount of energy [4]. In conditions of dry fruit growing, where there is no infrastructure and availability of water resources for irrigation, mechanical soil cultivation is a mandatory agrotechnical measure [17]. This processing is carried out both in the space between the rows and in the protective zone. Processing of the protective zone is a far more complex technological procedure and involves the use of far more complex machines and devices [14]. In addition to processing the surface of half of the protective belt, a larger surface is often processed, so that the processed surfaces overlap. Overlapping processing avoids finding an unprocessed and weedy surface due to poor machine guidance.

The mechanization of this process is realized by a machine-tractor aggregate of the appropriate energy potential [11]. Attached machine in a aggregate with a tractor consisting of a tractor equipped with a attached machine that has the ability to move the working elements when encountering a plant and return to the intermediate space with its own processing time. The use of appropriate tillage enables the reduction of costs and ecological preservation of the soil [5]. High-quality mechanical soil cultivation, in addition to improving the physical properties of the soil, destroying weed vegetation, ensures sufficient accumulation and rational use of moisture [2].

Mechanical cultivation in perennial plants loosens the soil, achieves areation, increases volume, increases absorption of moisture, so that optimal conditions for the development of the root system of perennial plants are provided in the zone of the root system of perennial plants. For those conditions of fruit growing, it is necessary to perform high-quality basic and supplementary equipment in order to sufficiently accumulate and rationally consume moisture in the soil [1], [6] . The working depth of the part of the machine that processes the protective zone is directly dependent on the depth of the roots of the planted plants. The working elements of the machine that process the inter-row space at a greater depth can be basic or supplementary.

With a quality choice of technological procedures and adequate mechanization, it is possible to achieve greater economic and energy efficiency while preserving the ecological environment and soil [8]. The transition from conventional to new technological procedures in primary agricultural production should be handled, with the obligatory presence of expertise and research work [9] . The use of modern technologies in soil cultivation should create prerequisites for achieving sustainable agricultural production, which is largely made up of fruit-growing and viticulture production. The integration of aggregates for the simultaneous cultivation of regular and inter-regular plantings contributes to the reduction of soil compaction [7]. The obtained results in concrete production conditions indicate the possibility of saving energy and increasing the productivity of aggregates in soil works.

2. MATERIAL AND METHODS

According to the set goal, the aggregate consisting of the tractor »McCormick x2.40« and the rotary harrow with deflection »Rinieri EL brand 140« was tested. The measurement was carried out in real conditions of fruit production at »OD Radmilovac-Table I« in a peach orchard with the following parameters:

- speed of movement (obtained as the quotient of the path covered on a pathway of a certain length m and the time for which the tractor covers that path),
- slippage of drive wheels based on the actual and theoretical speed of movement of the aggregate
- hourly fuel consumption (obtained by volumetric method - measuring cylinder)
- specific fuel consumption (calculated method)
- volumetric mass of soil (of Cilindri Kopecki)
- fuel consumption per unit area (obtained as a quotient of hourly consumption and productivity of the given aggregate),
- torque on the tractor's PTO shaft. Control of TD2 transmitter measurements was performed with a Tektronix 2230 oscilloscope.
- analysis of the soil structure of cultivated land (done using the *Savinova* method)
- Presence of sedge vegetation after processing (visual)
- productivity of aggregates (based on chronography)

Table 1. *Technical characteristics of the tested aggregate*

Technical characteristics of the tractor	**McCormick x2.40**	**Tech. characteristics of the rotary harrow with deflection**	**Rinieri EL brand 140**
Engine power [kW]	40	Number of working bodies	2
Number of rotations at max. of power [min-1]	2800	Working grip/operation [cm]	65
Mmax./nMmax [Nm/ min-1]	160/1400	Deflection of the working assembly [cm]	50
Specific fuel consumption [g/kWh]	225	Processing depth [cm]	10
Energy supply in comparison with construction mass [kW/t]	24.24	Deflection speed of the working assembly [m/s]	0.75
Specific mass without ballast [kg/kW]	41.25	Transmission type	Hydrostatic
Specific mass with ballast [kg/kW]	44.25	Method of aggregation	Carried
Mass without ballast [kg/]	1650	Mass [kg]	320

Fig. 1 Tractor “McCormick x2.40”

Fig. 2 Rotary harrow “Rinieri EL brand 140”

Fig. 3 Formed aggregate

Fig. 4 Tested aggregate in progress

List of symbols:

Eha – tech. energy consumption [kWh/ha]
Fv - traction force [kN]
kt – spec. ground resistance [N/cm2]
Mmax – max. [Nm]
nMmax – rotation speed at Mmax [min-1]
Pv – traction power [kW]
q – spec. ef. tractor fuel consumption [g/kWh]
Qe – hourly consumption of mechanical work [Nm]
Q – hourly fuel consumption [l/h]
Qha – fuel consumption per unit area [l/ha]
v – movement speed [km/h]
Wh – performance [ha/h]
φ - adhesion [-]
λ - sliding [%]
η – coefficient of beneficial effect [-]

2.1. Test conditions

The dominating type of soil, on "Table I" in Radmilovac, is the arable land [13]. From the Display in Table 2, it can be seen that the processing conditions were partly difficult, considering that the processing process was carried out in a dry period. The analysis of the data in Table 2 shows that the soil moisture was significantly reduced and that the soil belongs to the heavier category based on volumetric mass.

Table 2. *Soil moisture and volumetric mass*

Serial number	Measurement place	% moisture	Volumetric mass *(d/cm^3)*
1.	Area	14,41	1.374
2.	Depth 5 cm	15,36	1.483
3.	Depth 10 cm	15,15	1.426

2.2. Energy parameters of aggregates

The implementation of agrotechnical measures during the maintenance of perennial crops, such as processing that engages a significant amount of mechanical work, which directly affects the economy, is measured with energy parameters. The rational consumption of energy is achieved first of all by good design of the tractor-machine aggregate as well as the conditions defined by the technology of growing plants, which achieves the necessary adaptability of plants for machine processing. The lack of adaptation of plants is projected on the appearance of more frequent downtimes as a great limitation of technological speeds and in some cases the impossibility of using processing machines.

The results obtained from the field tests of the tractor-machine aggregate are shown in Tables 3 and 4. The engagement of the power of the tractor engine depends to the greatest extent on the type of soil, the quality of the previous process and the number of rotations of the tractor PTO shaft.

Table 3. *Energy parameters of aggregate operation in supplementary processing of orchards*

S. number	**M** *(Nm)*	**n** *(o/min)*	**Pv** *(kW)*	**v** *(km/h)*	**Fv** *(kN)*	**Qha** *(l/ha)*	**Wh** *(ha/h)*	**Eha** *(kWh/ha)*	**Qe** *(MJ/h)*
1.	92	495	5.68	1.22	1.44	8,21	0.19	29.89	20.44
2.	86	501	5.72	1.38	1.48	7.35	0.20	28.60	20.58
3.	85	500	5.27	1.49	1.35	7.11	0.21	25.09	19.58
4.	87	503	5.33	1.56	1.38	6.8	0,24	22.20	19.18
5.	91	420	5.07	1.22	1.12	7.38	0.21	24.14	18.25
6.	100	390	6.12	1.09	1.54	8.95	0.20	30.60	22.03

The obtained data show that the optimal speed of movement of aggregates was carried out in the orchard plantation in variant 4 and was 1.56 m/s. At the same time, the torque had a value of 85 Nm, and the number of rotations was 502 rpm. In the vineyard, the optimal speed was in variant 2 and was 1.23 m/s, with torque. Aggregate productivity in the orchard was 0.24 ha/h, in the vineyard 0.19 ha/h. Fuel consumption in the vineyard was 7.2 l/ha, and in the orchard 6.8 l/ha.

Table 4. *Energy parameters of aggregate operation in supplementary cultivation of vineyards*

S. number	M (Nm)	n (o/min)	Pv (kW)	v (km/h)	Fv (kN)	Qha (l/ha)	Wh (ha/h)	Eha (kWh/ha)	Qe (kJ/h)
1.	87	501	5.96	1.13	1.48	9.61	0.14	42.57	21.45
2.	83	502	6.02	1,23	1.52	7.20	0,19	31.68	21.67
3.	82	500	5.53	1.17	1.41	9.32	0.15	36.86	19.91
4.	85	498	5.81	1.23	1.24	8.62	0.18	32.27	20.91
5.	93	490	5.32	0.96	1.15	9.36	0.16	33.25	19.15
6.	97	485	6.43	0.93	1.58	10.32	0.19	33.84	23.14

Aggregate productivity is largely determined by the technical solution of the aggregate and the technology of planting. The low torque values are the result of more intensive preprocessing in both cases, which led to a relatively low engagement of driving energy. In addition, the relatively low speed of movement of aggregates is a condition of lower productivity of aggregates in the processing of both plantations. Higher aggregate productivity in the orchard was achieved due to higher movement speed due to greater distance between plants in the row. Lower technological speed in the cultivation of vineyards was due to the insufficient distance between the vines. Observations made during the experiment lead to the conclusion that there is also a certain inertness of the hydraulic system, which, after detecting plants as an obstacle, carries out the drift-deflection of the working elements.

2.3. Processing quality

One of the basic indicators of the quality of aggregate work during processing is the achieved content of individual structural soil aggregates. By analyzing the obtained values in table 5, it can be concluded that the processing quality is satisfactory. At the same time, it can be stated that there are significantly present and significantly fine aggregates of around 5 and less than 5 mm, which can be explained by the fact that during processing the soil was with reduced moisture.

Table 5. *Performance quality indicators of the tested aggregate*

Aggregate dimensions (mm)	Measurement I		Measurement II	
	Mass (d)	Participation of individual fractions in the sample (%)	Mass (d)	Participation of individual fractions in the sample (%)
>50	-	-	-	-
25-50	170	3.41	180	3.30
19-25	560	11.22	200	3.67
16-19	440	8.82	270	4.95
9,5-16	510	10.22	480	8.81
5-9,5	1730	34.67	820	15.06
1-5	750	15.03	2600	47.71
>1	830	16.63	900	16.51
Total amount	4990	100	5450	100

Another important quality parameter is the intensity of the destroyed weed vegetation, which was mostly represented by narrow-leaved weeds with shallow roots, which facilitated the processing process. The fact that tillage with rotary harrows is accompanied by worse destruction and covering of weed vegetation in the tested tillage achieved satisfactory results, which was also contributed to by the orderly tillage that preceded the planting maintenance procedures.

3. CONCLUSIONS

Carrying out the process of mechanical processing in the protection zone of perennial plantations represents a great technological advance in the management of modern intensive plantations. This procedure greatly reduces the participation of human labor, which increases productivity and significantly reduces the costs of maintaining plantations.

The high-quality application of machines for processing the protective belt needs to be sufficiently adapted to the plantings, which primarily refers to the layout that defines the distance between rows and between rows. In addition, proper training of the operator of the aggregate is required.

Tests of the roto harrow in the given conditions showed that the layout of the grape vines due to dense planting did not allow higher technological speeds, which resulted in a relatively lower output than designed.

Further research should more fully cover the testing of the hydraulic system, which would determine the required force detected by the feeler when encountering the plant, as well as the speed of operation of the hydraulic system, which moves the working element during the tour of the plant and returns it to the intermediate space. The obtained results of the parameters in practical conditions would give the possibility to reduce the inertness of the system, which was manifested during the testing of the machine, through technical improvements.

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