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INNOVATIVE MECHANIZATION TECHNOLOGY FOR VINE PLANTATION MAINTENANCE

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Abstract: The importance of soil mechanization technologies in vineyards results from the following advantages: protection and sustainable use of the soil, reduction of the impact of pesticides on the environment, and provision of renewable energy sources. In this paper, it is present an innovative mechanization technology for the maintenance of vineyards that includes carried out in optimal conditions respecting the requirements imposed by agrotechnics: the work of loosening the soil, breaking the crust, and destroying the weeds by turn and between the vines (which until now could not be mechanized) to keep the soil loose, permeable to air and water, without crust, destroying the weeds, and burying fertilizers and herbicides; application of spray treatments with the reduction of specific consumption of pesticides, fuel, labor and especially the reduction of environmental pollution; and recovering biomass, a by–product from wine–growing holdings resulting from land cuttings (during the vegetative dormancy period) to capitalize on renewable energy.
Keywords: mechanization technologies, vines, maintenance of vineyards

1. INTRODUCTION

The grapevine, which is mainly cultivated in traditionally consecrated areas, had and still has an important place in the Romanian economy [6]. The vine plantations represented a factor of progress for the peoples and civilizations of antiquity that took care of this business and it could not be seen outside of contemporary problems, such as environmental protection, climate change, and pollution due to industrial development, which influences everything today domains [1].

To avoid the serious ecological imbalances of an increasingly less stable living environment, it is necessary to rethink and harmonize the technologies of vine culture to the current requirements that offer solutions regarding environmental protection and combating climate change [3]. In recent years, the academic world and even the personnel involved in wine production have shown intense concerns, approaching different technological sequences through the lens of quantifying their impact on the environment [2].

Due to the specifics of the vine culture, the maintenance of plantations, one of the technological sequences addressed at the international level with orientations and new development possibilities in perspective, acquires special importance because:

≡ constantly ensures the favorable aerohydric and trophic regime in the layer explored by the roots of the vines, through repeated weeding so that the soil remains loose, permeable to air and water, without crust;

≡ provides active substance according to the vegetative phase of the vine plantation by applying phytosanitary protection treatments according to a well–established plan and only when necessary;

≡ capitalizes on biomass as a by–product in the technological process of the vine plantation, from dry cutting + ripening + stems and cords palisade + circulation of the cords to obtain renewable energy.

Global trends are to adapt vine cultivation technologies to the ecological system, by maximizing soil fertility, especially to improve soil structure, biological activity, and its water retention capacity, in order to conserve it[5].

2. METHOD AND MATERIAL

The research materials and methods consist in the use of the reading sheets of the research phases from the project "Innovative mechanism technology for the maintenance of vine plantations" carried out within the ADER 2019–2022 program, contract no. ADER 25.1.3 / 26.09.2019, [7–10].

3. RESULTS AND DISCUSSION

In this paper, the innovative mechanization technology for the maintenance of grapevine plantations is presented, which involves the execution of the following operations (Figure 1):

≡ works that are carried out on the soil with a weeding equipment in a row and between vine stumps in order to loosen, small, level the soil and mechanically fight weeds. In this way the soil is kept loose, without crust, permeable to air and water.

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≡ works carried out with a vine baling machine for the recovery of biomass, a by–product from wine farms resulting from dry cutting (during the vegetative rest period), with a view to capitalizing on obtaining renewable energy.

Figure 1. Innovative mechanization technology for the maintenance of vine plantations

The experimental research presented in the work sought, on the one hand, to verify the truth of the hypotheses and theories that were the basis of the studies related to the researched processes, and on the other hand, allows low the investigation of some phenomena for which no results with practical applicability can be obtained theoretically, due to their complexity or insufficient knowledge of some laws that determine the evolution of the researched phenomenon.

The experimental researches carried out with the innovative mechanization technology for the maintenance of vine plantations were as follows:

A. DETERMINING THE FUNCTIONAL PARAMETERS OF THE WEEDING EQUIPMENT IN ROWS AND BETWEEN VINE TRANKS

— The operation of the hydraulic system to actuate the withdrawal from the row and the return from the row of the weeding blade knife between the vine trunks.

Weeding equipment in the rows and between the trunks of vines is intended for the mechanized execution of the work of mobilizing the soil between the vine stumps simultaneously with the execution of the cultivation work on the interval between the rows, in plantations with the management of the vines on the stem, vertically, with tutors at each trunk.

The process of tilling the soil between the hubs consists of the translational movement of the knife–type active organ with a long side wing, lifting a strip of soil and shredding it simultaneously with cutting the roots of weeds.

During the movement of the active organ on the row of hubs, the feeler rod touches the hubs at a height of 10–15 cm above the ground and through the lever system transmits the command to withdraw the active organ to the hydraulic distributor.

The withdrawal is made progressively depending on the race of palpation. After passing the hub, the feeler rod returns to its initial position under the action of a spring, also commanding the return of the active organ to the row of hubs. In this way, by withdrawing and returning the active organ, the area between the stumps is processed on the vine row with the exception of an area around the stumps and trellis pillar. The main technical characteristics of the technical equipment are presented in table 1.

Table 1. The main technical characteristics of the row and between vine hoeing equipment

Nr. ctr.	Characteristics	The value
1	Tractor required, hp	45
2	Equipment type	worn
3	The number of weeding knives per row of vines, pcs.	6
4	Type of weeding organs on the vine row	dart knife
5	The number of weeding knives between vine stumps, pcs.	2
6	Type of organs for sifting between the vines	blade knife
7	Sowing depth, mm	100–120
8	Roll type	adjustable
9	Working width of the roller, mm	1020–1300
10	Outer diameter of the roller, mm	335
11	Transport light, mm	250
12	Working travel speed, km/h:	2–6

The folding mechanism of the active organ in the form of a side knife with a long side wing consists of palpation, a hydraulic distributor, and a double–acting cylinder. The palpation consists of the feeler rod, rod support, vertical shaft, connecting rod and return spring. The double–effect force cylinder is hinged mounted on a parallelogram mechanism integral with the supporting support of the active organ. The follow–up hydraulic distributor is fixed integrally with the support of the parallelogram mechanism of the hydraulic cylinder, and the actuation is carried out by means of a lever by the palpation rod. The pressure hoses ensure the connection of the components of the hydraulic installation.

— The working width of the equipment for the positions of the blade–type side knife for weeding between the vine trunks:
 ≡ extended
 ≡ retired

To perform the measurements, the frame was positioned so that the protection zone between the active organ in the retracted position and the axis of the vine row was at least 150 mm. The active organ in the extended position was made when the hydraulic distributor of the hydraulic cylinder is in the neutral position: in which the drawer allows the free circulation of the oil in the hydraulic circuit of the tractor, the pressure being reduced (10–20 bar) being determined only by the resistances hydraulics of the component parts. The active organ in the retracted position was realized when the distributor drawer, by actuating the feeler rod, moved from the neutral position by approx. 10–13 mm. The actuation force was 3 daN at the rear end of the feeler rod. The results of the determinations, for the rows of vines planted at a distance of 2000 mm, are presented in table 2.

Table 2. The results obtained during the experimental researches for the determination of the functional parameters

Characteristic	Determined value, mm	
	Extended	Withdrawn
Working width for blade side knife positions	2590	1700

B. DETERMINATION OF THE FUNCTIONAL PARAMETERS UNDER OPERATING CONDITIONS OF THE SPRAYING MACHINE IN VINE PLANTATIONS

The spraying machine is intended for spraying with the recovery of the working substance in vine plantations planted at a distance between rows of 2–2.2 meters. The liquid that does not adhere to the leaf surface is transferred back to the reservoir and reused for work in order to obtain a significant saving of active substance and reduce environmental pollution compared to the conventional application of treatments in vine plantations. The technological process of the operation of the machine is carried out in the following order: from the shaft of the power take–off of the tractor, by means of the cardan shaft, the shaft of the M135s Imovilli pump is driven in rotation. The liquid in the polyethylene tank is absorbed by the pump through the suction filter and sent to the flow and pressure regulator. From the flow and pressure regulator, the working liquid is sent to the ramps with nozzles mounted on the central panels and the stg/dr panels and from here to the plants. The dispersed working fluid passes through the foliage of the plants. A part of the drops is deposited on the leaves, and the rest, drips on the panels and reaches the accumulation tanks located in the lower part of the panels. Here it is filtered and transported through the solution recovery system with venturi injectors to the liquid tank for reuse. The machine is fed through the filling mouth of the tank, in which the filling filter is fixed. The liquid level in the tank is visualized on the level indicator located on the outside of the tank. Emptying the liquid from the tank is done through the 3–way tap located at the bottom of it. The main technical characteristics of the spraying machine are shown in table 3.

Table 3. The main technical characteristics of the spraying machine in vine plantations

Nr. ctr.	Characteristics	The value
1	Tractor required, hp	45
2	The type of car	carried
3	The number of rows of vines sprayed per pass	2
4	Working height, mm	2300–2600
5	Pump type	with 4 membranes
6	Maximum flow rate, l/min	107
7	Maximum pressure, bar	50
8	Maximum speed, rpm	550
9	Total number of spray bodies	24
10	The type of spray bodies	double jet
11	Working travel speed, km/h	4.2–7.5

— Sprinkler system operation

The working method for determining the volume of liquid consumed:

≡ the tank of the spraying machine was filled with clean water, to the nominal capacity, the water level in the tank was read and noted on the level indicator;
≡ the linear route along the row of vines was traveled with the spraying machine in operation and the solution recovery system turned off;
≡ the water level in the solution tank was read on the level indicator and the volume of water consumed was calculated by the difference;
≡ the tank was filled with clean water, up to the first marked level, and the linear route was followed again with the spraying machine in operation and the solution recovery system on;
≡ the volume of water consumed was calculated by the difference.

The tests were carried out for the 2 working modes of the spraying machine, respectively with and without recovery of the solution, at 3 working speeds (4.2 km/h; 6.04 km/h and 7.5 km/h) , at 4 working pressures (5 bar, 10 bar, 15 bar and 20 bar) and 2 nozzle sizes (ϕ 0.8 and ϕ 1.2 mm).

To determine the work speed, the time it takes for the sprayer to travel the length of a row of vines with the solution tank half full was timed. 5 repetitions were performed and the average timed time was calculated. The working speed was calculated with formula (1):

$$v = 3{,}6\ \frac{d}{t}\ (\text{km/h}) \tag{1}$$

where: d is the distance traveled in meters and t is the time in seconds.

The solution norms were determined according to the flow through the nozzles, the number of nozzles, the distance between the rows and the speed of movement.

The degree of recovery of G_r solution was calculated with formula (2):

$$G_r = 100 - \frac{N_{cr}}{Nfr} 100\ (\%) \tag{3}$$

where: N_{cr} – the norm obtained in the working mode with solution recovery, N_{fr} – the norm obtained in the working mode without solution recovery.

The results obtained are presented in table 4.

Table 4. The results obtained during the experimental researches for the determination of the functional parameters

Nozzle size		ϕ 0,8 mm				ϕ 1,2 mm			
Working pressure (bar)		5	10	15	20	5	10	15	20
Flow rate on 24 nozzles (l/min)		16,8	23,5	25,9	30,2	28,8	38,8	51,8	62,6
Working speed (km/h)	Working mode	Solution norms (l/ha)							
4,2	without recovering the solution	588	823	907	1057	1008	1358	1813	2191
	with solution recovery	377	469	472	634	675	801	979	1380
Amount of solution recovery (%)		36	43	48	40	33	41	46	37
6,04	without recovering the solution	407	569	627	732	697	939	1254	1515
	with solution recovery	277	341	345	454	502	601	727	940
Amount of solution recovery (%)		32	40	45	38	28	36	42	38
7,5	without recovering the solution	330	461	508	592	565	761	1015	1227
	with solution recovery	251	323	310	397	435	556	690	859
Amount of solution recovery (%)		24	30	39	33	23	27	32	30

From Table 3 it can be seen that the highest degree of solution recovery (48%) was obtained for the working speed of 4.2 km/h, the working pressure of 15 bar and the nozzles with ϕ 0.8 mm. For the same nozzle size, the next lowest solution recovery value was 45%, which was obtained for a working speed of 6.04 km/h and a working pressure of 15 bar.

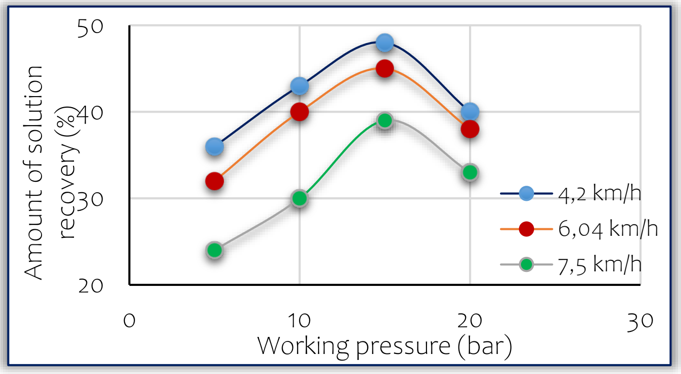


Figure 2. The graph of the variation of the degree of recovery of the solution according to the pressure and the working speed, for the nozzles with ϕ 0.8 mm

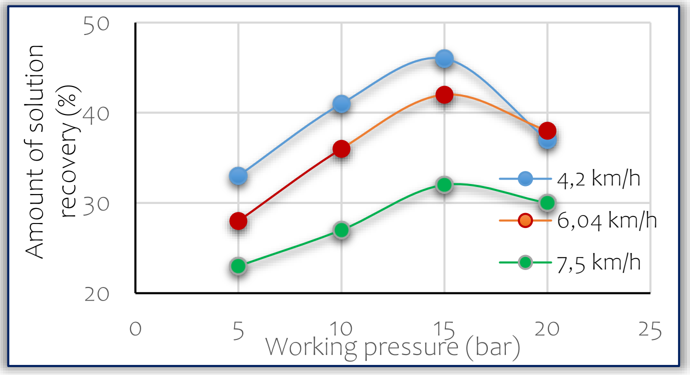


Figure 3. Graph of the variation of the degree of recovery of the solution according to the pressure and the working speed, for nozzles with ϕ1.2 mm

Analyzing the graphs in figures 2 and 3, it is observed that the degree of recovery of the solution increases with the increase of the working pressure up to the value of 15 bar and has a tendency to decrease when the working pressure increases above this value. This is due to the fact that by increasing the pressure, the solution droplets are smaller and smaller, so the chances of reaching the recovery panels decrease more and more, being subject to evaporation and drift phenomena. The tendency to decrease the degree of recovery of the solution is also observed when the working speed increases. If we also take into account the working capacity of the tractor–sprayer aggregate, which increases with the increase of the working speed, we can conclude that a satisfactory degree of solution recovery is obtained for the working speed of 6.04 km/h and the pressure working pressure of 15 bar, for both nozzle sizes.

Figure 4 shows some aspects during the verification of the operation of the sprinkler system.

C. DETERMINATION OF THE FUNCTIONAL PARAMETERS OF THE VINE SHOOTS BALING MACHINE

— Operation of the bale loading system

The vine shoots baling machine is intended for the recovery of biomass, as a by–product resulting from dry cutting, in order to use it to obtain renewable energy.

Figure 4. Aspects during the verification of the operation of the sprinkler system

Thanks to the combination of drums and chains, the machine can collect other products: corn stalks, silage material. The work process is carried out through the following phases:

- ≡ it is coupled to the tractor's drawbar, secured with the coupling bolt and the related safety and the front of the machine is raised as much as it is possible to position the support leg in the transport position;
- ≡ the hydraulic and automation installations are connected to the related installations of the tractor, the aggregate is moved to the workplace and positioned at the end of the row of vines;
- ≡ lower the machine to the ground so that its feeding prongs come into light contact with the ground;
- ≡ the tractor's power take–off is engaged, the automation system is turned on, the tractor's gearbox is engaged in a suitable gear for moving to work, at which point the baling process begins;
- ≡ as soon as the bale has formed, at a preset pressure, the bale release process is automatically triggered by the automation installation which is equipped with an inductive motion sensor, opening the release shutter by a hydraulic cylinder;
- ≡ after releasing the bale, the release shutter closes automatically, resuming the bale forming process.

The time elapsed between the opening and closing phase of the mobile shutter can be adjusted from the automation system. Bale pressure can be adjusted by means of two traction springs, mounted in front of the machine. The distance of the feed tines from the ground can be adjusted both by moving the tractor's drawbar up and down and by acting on the right–right tie rods, existing on the running wheels of the machine. It should be mentioned that the work process is continuous, in the sense that the operator does not have to stop the tractor from moving when the formed bale is released. The best quality of the work (gathering and baling as large a percentage of the cut cords as possible) is obtained when the cut cords are placed towards the middle of the row in an area of width less than or equal to the width covered by the lifting tines and feed drum. Also, the quality of the formed bale is superior if it remains compact after release to the ground. The main technical characteristics are presented in table 5.

Table 5. The main technical characteristics of the vine shoots baling machine

Nr. ctr.	Technical specifications	The value
1	Tractor required, hp	45
2	The type of car	trailed
3	Working travel speed, km/h	3–5
4	the speed at the power take–off	
5	The speed of the working bodies, rpm – gatherer – feeder – pressing rollers	 150 175 180–200
6	Bale size, mm – the width – the diameter	 700–800 400±20
7	Working travel speed, km/h	3–5

The vine shoots cut and left along the furrows are gathered and directed to the compression chamber by the feed drum. In the compression chamber the product is pressed in the form of cylindrical bales. The "soft center" bale compaction allows air to pass through evenly and therefore natural drying is guaranteed, preventing mold and fermentation. The bales, after the natural drying process, can be cut, compressed into pallets or burned whole in boilers to generate heat.

— Operation of the bale unloading system

To check the system, the formation of the bale was simulated at a preset pressure by activating the inductive motion sensor, which simulated the automatic triggering of the bale release process, by the automation installation, by opening the release shutter by the double–action hydraulic cylinder. 15 repetitions were performed. The average opening–closing time of the mobile shutter was 1.15 seconds. Figure 5 shows some aspects during the verification of the operation of the bale unloading system.

— The speed of the power take–off

The splined shaft of the power take–off is located behind the tractor, and its direction of rotation is clockwise, seen from the back of the tractor. The speed achieved by the New Holland TCE 50 tractor is constant at 540 rpm, (regardless of the tractor's travel speed).

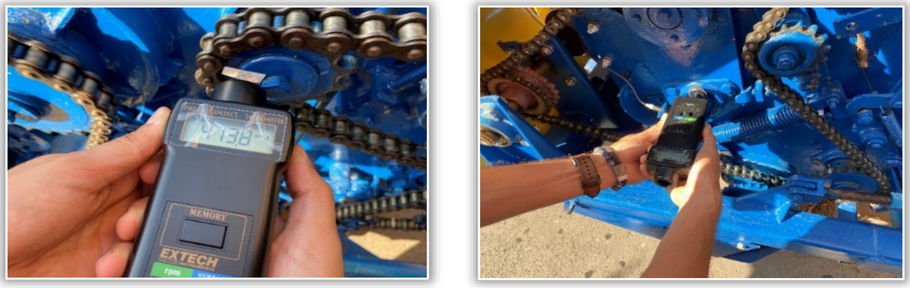
Figure 5. Aspects during checking the operation of the bale unloading system

— The revolutions of the working bodies: gatherer, feeder, pressing rollers

To determine the revolutions of the working organs of the vine baling machine, an electronic tachometer was used, which was used to measure with contact or without contact (at a distance) the revolutions of the gatherer, feeder and press rollers. Table 6 shows the results of speed measurements for the collector, feeder and press rolls. Figure 6 shows some aspects during the measurements of the revolutions of the working organs of the vine baling machine.

Table 6. The results obtained during the experimental researches for the determination of the functional parameters

Characteristic	Determined values	Corresponding / Not Corresponding with execution documentation
Speed at the adder, rpm	150	Corresponding
Feeder speed, rpm	175	Corresponding
Speed of the pressing rollers, rpm	180	Corresponding



a) b)

Figure 6. Aspects during the measurement of the revolutions of the working organs of the vine shoots baling machine: a) with contact; b) without contact

4. CONCLUSIONS

The research results allow useful recommendations for the direct beneficiaries, which are the wine research stations SCDVV Bujoru, SCDVV Murfatlar, the INCDBH Ştefăneşti Argeş institute, but also the other wine research stations in the country that can benefit from the scientific services obtained as a result of the research project.

At the same time, the indirect beneficiaries who are the owners of wine plantations, educational and research institutions, companies producing agricultural machinery, local or central administration units (Environmental Protection Agencies, Ministry of Environment, Water and Forests, Ministry of Agriculture and of Rural Development, local councils).

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