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Comparison of Times during Manualand Mashineharvesting of Grape Wine Varieties in the Region of Vidin

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ABSTRACT: The article presents the results of the measurement, research and comparison of the times for harvesting grapes of wine varieties when the grapes are picked manually and with the use of a grape harvester. An additional theoretical study was made of the joint operation of a grape harvester and the two tractors with trailers with a load capacity of 1.1 in relation to the mass of grapes in the hopper of the grape harvester. The operational indicators of the participating machines (tractors with trailers with and without a grape harvester, as well as a grape harvester) were determined and their numerical values were compared. The obtained results were used to confirm the use of the existing variant using a grape harvester replacing manual labor.

KEYWORDS: Grape, technology, transport,grape harvester, exploitation indicators

I. INTRODUCTION

The cultivation of vines has long-standing traditions. In many regions, the massifs with winevineyards are at the to pinterms of number of hectares. This is confirmed by the annual reports from the year 2023 ontheactivity of the regional directorate "Agriculture" for Vidinand Plovdivregions [1, 2], namely for Vidinregion, thevineyards of wine grapevarieties are 1104.4 haw it han average yield of 2606 kg/ha, followed by Plums 117.9 haand for the Plovdivregion in the section "Permanent plantations" it is evident that the areas with "winevines" are 3551.9 ha, followedby "oilbearingrose" (1979.6 ha) andprunes (1725.5 ha) [3].

Harvesting of ripegrapes was done by hand in the past, but it is a laborious process that requires a significant amount of farm workers to be carried out in its appointed time. In recent years, grapeharvesters have entered the market, replacing manuallabor.

According to Kienzleetal. [4] and Marangoni Junior & da Costa Ferreira[5] even small farms need mechanization not only to maintain the feasibility of their activities despite the limited availability of labor, but also to increase their production capacity and efficiency.

Baldini & Intrieri [6] and Caprara & Pezzi [7] found that quality problems caused by mechanical harvestingare related to fruit damage, which is mainly revealed by mustrelease , which is often accentuated by delays between picking and processing, and in some cases by high temperatures.

Claryetal. [8], Chaler [9], Intrieri and Poni [10] and Caprara & Pezzi [11] have recorded other negative effects, namely: Stresses transmitted by product separation and during its capture and handling inside the machine, affect the outcome of the harvest interms of yield, productqualityandvineyardpreservation.

Despite the disadvantages of mechanical harvesting, it is increasingly used for large areas of vineyard. Many parameters remain completely unclear, one of which is the way a grape harvester moves in the vineyard and its interaction with the tractors with attached trailers serving it.

II. MATERIALS AND METHODS

The author Panayotov[12], in his book "Advanced technological complex of machines for the production of grapes for wine" defined 6

International Journal of Advances in Engineering and Management (IJAEM)
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technologies for harvesting grapes. Due to the fact that a wine cellar has been built to the massif for the processing of grapes, none of the mentioned technologies is fully implemented.

2.1. Hand picking the grapes.

When harvesting grapes manually, the technology is as follows:

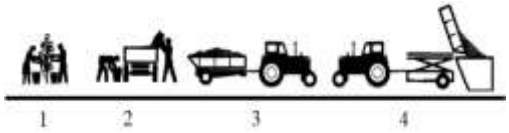

Figure 1. Technology with manual harvesting of grapes 1 – manual picking of grapes; 2 – manual pouring into the RVP-2 type trailer; 3-transportation of the trailer type RVP - 2 to the reception department of the wine cellar; 4 – unloading the trailer at the reception point

In manual harvesting, the pickers move through a row in pairs and pluck the grapes from two rows at the same time (Fig. 1). Full crates are placed in the middle of the aisle. After picking the last grape from the processed row, the pickers take a 15-minute break and move to other rows.

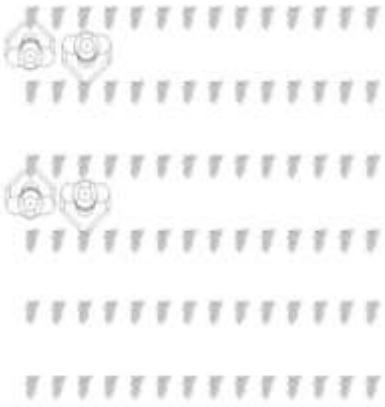

Figure 2. Movement of pickers in a vineyard [13]

The tractor with the trailer starts in the empty lane. Three loaders (one on the trailer and two on the side – one on the left and one on the right of the trailer) load the harvested grapes. The loaders moving in the side aisles with the full crates pick them up and pass them through the vines to the one on the tractor trailer.

He takes the crates and dumps them at one end of the trailer. He places the empty crates at the opposite end of the trailer. At the end of the lines, the empty crates are reloaded onto an empty trailer to take them to the next lines destined for processing.

With the organization of work created in this way, the pickers are of primary importance and are secured, and the other units in the regiment comply with them.

In addition to processing in the winery, grapes are harvested for sale. The quantity varies depending on the yields in the years. These grapes are placed in plastic tight crates.

According to Zahariev [12, 13], dense crates are not overfilled, but 80-86% of their volume is used so that they can be loaded on top of each other. At 80% of their volume, their usable volume is:

$q_1 = 0.8*q$ (1)

The average mass of grapes collected in one box is:

$m_{1k} = q_1*\gamma$ (2)

The gross mass of a full cartridge is:

$m_k = m_{0k} + m_{1k}$ (3)

The average number of vines to fill 1 cartridge is:

$n_k = m_{1k} / m_{loza}$ (4)

To fill 1 crate with an inter-row distance of 0.9 m, the required length:

$l_k = 0.9*n_k$ (5)

The following number of boxes are filled from 1 row, the last box being filled to about 65% of its volume:

$n_r = int(l_r/l_k)+1$ (6)

One row yields grapes with mass:

$m_r = (l_r / l_k)*m_{1k}$ (7)

The required number of empty boxes is:

$n_{0k} = int(1.15*n_r*n_{er})$, (8)

where:n_{er} is the number of concurrently operating pickers. 1.15 is an insurance factor with a larger number of cartridges to replace the damaged ones.

Quantity of loaded grapes in the trailer when passing through one row from n_{T_HAND}number of harvested rows, kg:

$Q = n_{T\_HAND} * m_r$ (9)

Time to harvest grapes from 1 row during manual picking Tr, min:

$T_r = n_L * T_{L1}$, (10)

where: n_L – number of vines in the row, pcs; T_{L1} – time to harvest grapes from one vine, min;

Number of days required to process the vineyard for manual picking are n_{days}, days:

$$n_{days} = \frac{\left(\frac{(T_r+T_{P101}).n_R}{n_B.\gamma_B}\right)}{\left(T_L-\frac{T_{P102}+T_{P2}+T_{P3}+T_{P4}}{\xi_R}\right)} \quad (11)$$

where: n_R – number of rows of the vineyard, pcs; n_B – number of pickers working in the vineyard during the day, pcs; γ_B– coefficient taking into account the time of presence and work of the pickers throughout the day; T_L – total time of presence of the pickers in the field (for example from 08:00 to 17:00), min; T_{P101} – rest time after

International Journal of Advances in Engineering and Management (IJAEM)
Volume 6, Issue 08 Aug. 2024, pp: 238-247 www.ijaem.net ISSN: 2395-5252

each processed row, min; T_{P102} – lunch break time, min; T_{P2} – preparatory time before the start of harvesting, min; T_{P3} – closing time after the end of harvesting, min; T_{P4} – time for unplanned downtime, min; ξ_R – generalized coefficient of use of time by pickers during the day.

2.2. Times for the tractor with the trailer.

According to Kehayov&Zyapkov [14] and Zahariev [15], for the calculation of operational indicators, timekeeping determines the necessary times for:

- execution of working moves T_1, min;

The time to travel the length of one row will be the sum of the movement time plus the total load time T_{T_HAND}, min.

$$T_{T\_HADN} = n_r.(T_{TK} + T_{SECURITY}) + \frac{L_{ROW}.60}{V.1000} \quad (12)$$

where: T_{TK} – the dwell time for loading and unloading the crates in the trailer, min; $T_{SECURITY}$ – the waiting time to grab the operator in the trailer by his handrail; L_{ROW} – row length, m; V- average speed between two full crates, km/h;

$$T_1 = \left(\frac{n_r}{n_{T\_HAND}}\right).T_{T\_HAND} + T_{Sklad} \quad (13)$$

where: n_{T_HAND} – number of serviced rows in one working move according to the scheme of movement in the interrow, pcs; n_r - total number of rows, pcs; T_{sklad}- time to travel the average distance from the end of the row to the unloading place, min;

Auxiliary time T2, min:

$$T_2 = T_{21} + T_{22} + T_{23} \quad (14)$$

- for maintenance T_{21}, min;
- for turns T_{22}, min;
- for idle runs T_{23}, min;

Time for preparation and bringing the tractor with the trailer from transport to working position and back T_3, min:

$$T_3 = T_{31} + T_{32} \quad (15)$$

- for technical maintenance of the vineyard T_{31}, min;
- to bring the machines into working position and vice versa T_{32}, min;

Troubleshooting time T_4, min:

$$T_4 = T_{41} + T_{42} \quad (16)$$

- to eliminate technological malfunctions T_{41}, min;
- to eliminate technical malfunctions T_{42}, min;
- organizational losses of time (stand by to wait) T_5, min.
- operating time T_{02}, min:

$$T_{02} = T_1 + T_{21} + T_{22} + T_{23} \quad (17)$$

- production time T_{04}, min:

$$T_{04} = T_{02} + T_{31} + T_{32} + T_{41} + T_{42} \quad (18)$$

- total working time T_8, min:

$$T_8 = T_{04} + T_5 \quad (19)$$

- operational time utilization factor K_{02}:

$$K_{02} = \frac{T_1}{T_{02}} \quad (20)$$

- coefficientto use production time K_{04}:

$$K_{04} = \frac{T_1}{T_{04}} \quad (21)$$

- coefficient of technological reliability K_{41}:

$$K_{41} = \frac{T_1}{T_1 + T_{41}} \quad (22)$$

- coefficient of technical reliability K_{42}:

$$K_{42} = \frac{T_1}{T_1 + T_{42}} \quad (23)$$

2.3. Harvesting the grapes with a grape harvester.

When harvesting grapes by machine, the technology is as follows:

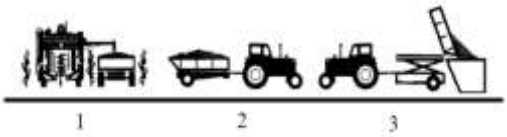

Figure 3: Machine grape harvesting technology

1 – mechanical harvesting of the grapes with a grape harvester and pouring into the RVP-2 type trailer; 2- transportation of the trailer type RVP-2 to the reception department of the wine cellar; 3 – unloading the trailer at the reception point

The harvester only processes one row at a time. At the end of the row, a tractor with a trailer is waiting for him, into which a grape harvester pours the contents of its hopper. Makes a turn and starts a new row.

Times are measured by timing:

T_{GK_1} - plucks the grapes from one row, min;

T_{22_1} - for positioning next to the tractor with the trailer, min;

T_{24_1} - for emptying the hopper and pouring the grapes into the trailer, min;

According to the methodology described above, the parameters for the grape harvester and the tractor with the trailer are calculated.

The remaining times and coefficients are determined according to the dependencies given above.

III. RESULTSANDANALYSIS

The object of the research is a plantation with vines of a wine variety, located in the land of the region. Vidin, with characteristics: area – S= 40 da; row spacing – b = 2.5 m; inter-row distance – b_1 = 0.9 m; average length of rows L_r = 199.6 m, number of rows n_r= 80 pcs.; average number of vines in a row – n_L= 221.8 pcs.; average amount of grapes harvested from one vine for the last year - m_{loza} = 2.6 kg. According to data from 2023, the average value of the volumetric weight of grapes is γ = 407.2 kg/ m3 [13, 15, 16].

International Journal of Advances in Engineering and Management (IJAEM)
Volume 6, Issue 08 Aug. 2024, pp: 238-247 www.ijaem.net ISSN: 2395-5252

In the considered vineyard, there is a base for temporary storage of the harvested grapes, located in the southeastern part.

The equipment available to the owner of the vineyard is two vineyard tractors with two dump trailers with a high lift platform. 10 rows are simultaneously picked by n_B = 10 pickers.

Using the dependencies developed in the MATERIAL AND METHOD section, the following were calculated:

Usable box volume at 80% filling: q_1 = 0.0464 m3;

The average mass of the harvested grapes in one cassette is m_{1k}=18.9 kg;

The gross mass of a full cartridge is m_k= 21.4 kg;

The average number of vines to fill 1 case is n_k = 7.27 pcs;

Length l_k= 6.54 m required to fill 1 crate;

The average length of the rows is L_r = 199.6 m;

The following number of cassettes are filled from 1 row: n_r= 30.52 pcs;

Grapes with mass m_r = 576.68 kg are obtained from 1 row;

The required number of empty cartridges is n_{0k} = 351 pcs;

Time to harvest grapes from 1 vine T_{L1} = 0.408 min;

Time to harvest grapes from 1 row T_r = 90.6 min;

Theoretical distribution of time during the working day:

- arrival at the vineyard at 8:00 a.m.;
- preparatory time before the start of harvesting T_{P2}= 15 min;
- harvesting the grapes from 1 row T_r = 90.6 min (from 8:15 to 9:46);
- rest time before starting a new row T_{P101} = 15 min;
- harvesting the grapes from 1 row T_r = 90.6 min (from 10:01 to 11:32);
- rest time before starting a new row T_{P101} = 15 min;
- harvesting the grapes from 1 row T_r= 90.6 min (from 11:47 to 13:17);
- lunch time, T_{P102} = 40 min;
- harvesting the grapes from 1 row T_r = 90.6 min (from 13:57 to 15:28);
- rest time before starting a new row T_{P101} = 15 min;
- harvesting the grapes from 1 row T_r= 90.6 min (from 15:45 to 17:14);
- closing time after the end of harvesting T_{P3} = 15 min;
- departed not from the vineyard 17:29 (29 min overtime).

With this distribution of time during the day, we will have processed 50 rows (5 times of 10 rows). With a total of 80 lines, 1.6 days are needed.

With the above theoretical distribution of time, no factors affecting the process of grape harvesting have been taken into account. In addition, the working day is more than 8 h, but due to the need to comply with agrotechnical deadlines and the campaign nature of certain operations, overtime is allowed with the express consent of the workers and payment of additional remuneration.

The number of days required to process the vineyard is n_{days} = 1.99 days taking into account the factors mentioned:

– coefficient taking into account the time of presence and work of the pickers throughout the day γ_B= 0.96;

– total time of presence of the pickers in the field (for example from 08:00 to 17:00) T_L = 540 min (9h);

– rest time after each processed row T_{P101} = 15 min;

– lunch break time T_{P102}= 40 min;

– preparatory time before the start of harvesting T_{P2} = 15 min;

– closing time after the end of harvesting T_{P3} = 15 min;

– time for unforeseen downtimes, T_{P4} = 20 min;

– generalized coefficient of time use by pickers during the day ξ_R =0.92.

The workflow in the vineyard for hand picking is shown in the following feature:

Figure 4. Manual harvesting of the grapes

Times for the tractor with the trailer when picking by hand.

The tractor covers the distance between two full crates (l_k = 6.54 m) with an average speed V= 1.92 km/h in time T_{lk} = 0.21 min and makes a stop of T_{TK} = 1.3 min to load and dump the grapes into the trailer. The tractor driver gives an audible signal that he is driving and waits $T_{SECURITY}$ = 0.15 min for the loader on the trailer to grab onto the railing.

With this movement scheme, the tractor with the trailer travels the length of one row with a stop to load the grapes for a time T_{one_row} = 51.46 min

International Journal of Advances in Engineering and Management (IJAEM)
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- number of serviced rows in one working move according to the movement scheme in the interrown$_{T_HAND}$ = 4 units (80/4 = 20 courses);
Quantity of loaded grapes from 4 rows: Q = 2306.72 kg
According to the manufacturer's data [17], the useful load of the trailer is 2260 kg. We have an overload of 46.72 kg, which is 2.07 %.
From which it follows that after the end of the row, the tractor with the trailer goes to the shed for dumping the trailer.
The average distance to the trailer dump shed is 104 m;
The average speed of the tractor with a full trailer is V_1= 3.2 km/h;
The average speed of movement of the tractor with a straight trailer is V_2 = 5.3 km/h;
From the measurements made, the following are determined:
- time to cover the average distance from the end of the row to the unloading place:
-- with full trailer T_{sklad1} = 1.95 min;
-- with empty trailer T_{sklad2} = 1.18 min;
- time to pour the trailer – T_{rem} = 2.8 min;
-- time to travel the length of one row with an empty trailer without stopping: $T_{rem\_trans\_1}$ = 2.26 min;
-- time to travel the length of one row with a full trailer without stopping: $T_{rem\_trans\_2}$ = 3.74 min.
The working times of pickers and tractors with trailers are schematically presented in the following figure 5.

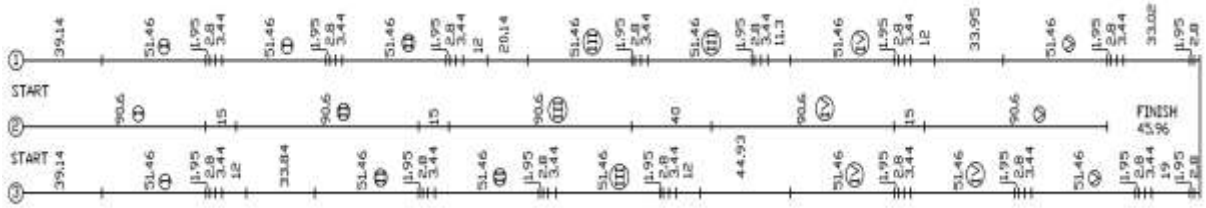

Figure 5. Schematic representation of the times in minutes when the two tractors work together with the trailers and the pickers. Line 1 and 3 – tractor with trailer; line 2 pickers; Times for line 1 and 3: 39.14 min, 20.14 min, 33.95 min, 33.84 min, 44.93 min, – stops; 12 min – unpacking of empty packaging; T_{one_row} = 51.46 min; T_{sklad1} = 1.95 min; T_{rem} = 2.8 min; T_{sklad2} + $T_{rem\_trans\_1}$ = 3.44 min; 19min and 33.02 – times from the last course. Times for line 2: T_r = 90.6 min; T_{P101} = 15 min; T_{P102} = 40 min

From the diagram in figure 5, it is clearly seen that the two tractors initially stand for 39.14 min and then go to the interrows to load the gathered beam. At the same time, the tractors and pickers will reach the end of the rows at the same time. After that, the pickers (line 2) take a break of 15 min, and the tractors with the full trailers go to the warehouse for unloading. The first tractor (line 1) returns to load the remaining amount of harvested grapes. The second tractor (line 3) loads and spreads empty cassettes in new rows for 12 min and stays for 33.84 min to have enough grapes picked. He leaves in time to collect the grapes.

The first tractor (line 1) after the second course for removing the picked grapes from the first pass of the pickers is immediately included in the removal of the newly picked grapes 14 min later than the first. Due to this delay, there is also a break for the driver, he makes a course to transport the grapes, delivers empty crates and stays until the start of the transportation of the newly harvested grapes. In this scheme, the tractors alternate and both drivers are given the opportunity to rest, but at different times.

Due to the need for 3 courses, and only two tractors with trailers available, at the end of the day, the two tractors haul away the remaining picked grapes from the last row. They finish work 45.96 min after the pickers.

According to the methodology, it is necessary to add other times for the tractor with the trailer. The calculated values are placed in Table I (column $T_{\_HAND1}$ and $T_{\_HAND2}$) for comparison with times when using a grape harvester.

Due to the fact that 10 rows are harvested at the same time and the number of rows served by one tractor with one trailer, it follows that two tractors with trailers are needed to transport the harvested grapes, which the owner has at his disposal.
Harvesting the grapes with a grape harvester:
The average speed at which a grape harvester processes the rows is V_3 = 3.1 km/h;
The following times were measured by timing:
- for processing one row is T_{GK_1} = 3.87 min;
- to perform 1 turns T_{22_1} = 1.9 min;
- for pouring the grapes from the hopper from the grape harvester T_{24_1} = 3 min.

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Figure 6. Mechanized grape harvesting

The harvester hopper is stored after each row in the tractor trailer. Due to the shuttle mode of movement of the grape harvester, we have unloading of the hopper at both ends of the rows.

Schematically, the joint operation of the two tractors with the trailers and the grape harvester are presented in the following figure 7. The two tractors are positioned at the two ends of the rows. After the grapes have ripened in the warehouse, they are returned to the original end of the row. Line 1 indicates the tractor located near the warehouse, and line 3 indicates the tractor located at the far end.

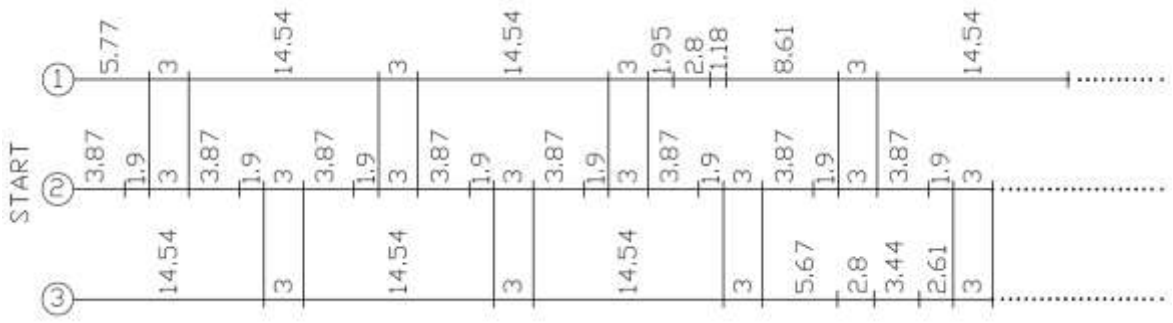

Figure 7: Schematic presentation of the times in minutes when the two tractors with the trailers and the grape harvester work together. line 1 and 3 – tractor with trailer; line 2 grape harvester.

Figure 7 shows that the first tractor with a trailer (line 1) remains 5.77 min until its first load, and the second (line 3) 14.54 min.

The trailer without overloading collects grapes from 3 rows. This means 3 harvester hopper pours. Therefore, they will have a dwell time of 2 * 14.54 min until the trailer is loaded.

At the times of the diagram in Fig.7 the other tenses are also added. The data are presented in Table 1.

Table 1. Times of the tractors with the trailers and the grape harvester

Times and coefficients	Firsttractorwith a standardtrailerfor a grapeharvester (line 1, Fig. 7.) T+R1_1	Secondtractorwith a standardtrailerfor a grapeharvester (line 3, Fig. 7.) T+R1_2	Grapeharvester (line 2, Fig.7 andFig. 8)	Firsttractorwith a smalltrailerat a grapeharvester (lines 1, Fig.8.) T+R2_1	Secondtractorwith a smalltrailerat a grapeharvester (lines 3, Fig.8.) T+R2_2	Firsttractorwith a standardtrailerformanual picking of grapes (line 1, Fig. 5.) T_HAND_1	Secondtractorwith a standardtrailerwhenpickingthegrapesmanually (line 3, Fig. 5.) T_HAND_2
Time to performworkmoves T_1,min	183.5	235.58	549.6	310	448.8	455.24	417.22
Maintenance time T_{21},min	5	5	18	5	5	5	5
Time for turns	39	35	152	42	48	16	16

T_{22},min							
Time for idle moves T_{23}	15.44	44.72	0	47.2	137.6	27.52	27.52
Auxiliary tenseT_2, min	59.44	84.72	170	94.2	190.6	48.52	48.52
Time for technical service of the machine in the vineyard T_{31},min	10	10	10	10	10	10	10
Time to bring the machine into working position and back T_{32},min	0	0	8	0	0	0	0
Time to preparean dbringthe machinef romtrans port to workposi tionandba ckT_3,min	10	10	18	10	10	10	10
Time to troublesh ootT_4,mi n	25	25	25	25	25	25	25
Time to troublesh oot technolog y T_{41},min	10	10	10	10	10	10	10
Time to fix technical faults T_{42},min	15	15	15	15	15	15	15
Organizat ional waste of time T_5,min	495.74	426.51	15	341.56	111.32	93.22	117.91
Operatin g time T_{02},min	242.94	320.30	719.6	404.2	639.4	503.76	465.74

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Production time T_{04},min	277.94	355.30	762.6	439.2	674.4	538.76	500.74
Total operating time T_8,min	773.68	781.81	777.6	780.76	785.72	631.98	618.65
Coefficient for operating time utilization K_{02},min	0.755	0.735	0.763	0.767	0.702	0.904	0.896
Coefficient for utilization of production time K_{04},min	0.660	0.663	0.721	0.706	0.666	0.845	0.833
Coefficient of technological reliability K_{41},min	0.948	0.959	0.982	0.969	0.978	0.979	0.977
Coefficient of technical reliability K_{42}, min	0.924	0.940	0.973	0.954	0.968	0.968	0.965

From the results for the operational indicators, it is evident that the technical and operational reliability coefficients are close to the desired values. The remaining performance indicators are unsatisfactory. This is due to the fact that the rows are short, the performance of the harvester is poor and it processes the row in 3.87 min while it takes 3 min to unload its hopper.

Tractors have long stays for loading trailers and relatively short runs. The performance of tractor with trailer 2 (line 3, Fig. 7.) is better than the other tractor precisely because of the longer distance traveled and less downtime.

Opportunities to improve these indicators are found in reducing the times for technical maintenance, for the elimination of technological malfunctions and organizational time losses.

An additional theoretical study of the joint operation of a grape harvester and tractors with trailers with a load capacity of 1.1 times the quantity of grapes harvested from one row was made. Schematically, the times are presented in Fig. 8.

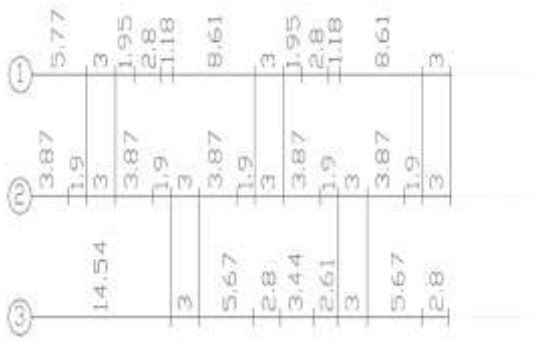

Figure 8. Schematic presentation of the times in minutes when the two tractors with the trailers and the grape harvester work together.line 1 and 3 – tractor with trailer; line 2 grape harvester

It can be seen from Figure 8 that with this arrangement both tractors arrive at the loading location earlier than the arrival of the harvester.

The first tractor waits 5.77 min before its first load of grapes. Followed by: 3 min grape overload; 1.95 min transport to the warehouse; 2.8 min pouring the grapes into the warehouse; 1.18 min

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transport to the place of the next load; 8.61 min stay. This cycle is repeated 20 times.

Tractor 3 is waiting 14.54 min before its first load of grapes. Followed by: 3 min grape overload; 5.67 min transport to the warehouse; 2.8 min pouring the grapes into the warehouse; 3.44 min transport to the place of the next load; 2.61 min stay. This cycle is repeated 20 times.

The times are averaged, but with both tractors having idle time to offset the averages, there is no harvester downtime to wait for an empty trailer.

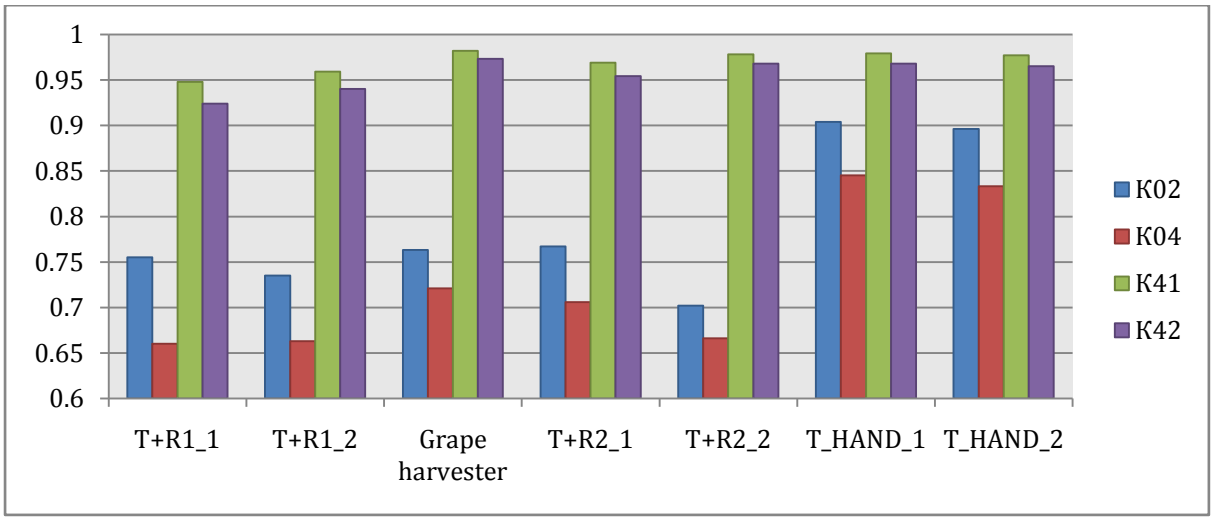

Figure 9. Comparison of the 4 coefficients for the harvester and the tractors with different trailers and ways of picking the grapes

In the new scheme with smaller trailers, an increase in all 4 observed coefficients is found, as can be seen from the graph in Fig. 9.

As a disadvantage, we can say the increased mileage of the tractors, which will lead to more spent fuel, greater pollution of the atmosphere and, of course, greater costs for the owner.

IV. CONCLUSIONS

Based on the above, the following conclusions can be formulated:

1. The times for harvesting the grapes for manual and machine plucking are determined.
2. A new scheme of the joint operation of a grape harvester and tractors with attached trailers with a load capacity of 1.1 times the quantity of grapes harvested from one row is proposed. As an advantage, it was found that trailer downtime was drastically reduced, but the cost to the owner and driver workload increased.
3. The operating indicators of the three variants were calculated and a comparison was made between them.
4. A theoretical distribution of time during the working day for manual picking of grapes was made.
5. Of all the options developed in the article, the mechanical picking of the grapes from a grape harvester and their transportation by the currently existing tractors with attached trailers is preferable.

REFERENCES

[1]. https://www.mzh.government.bg/odz-vidin/Libraries/%D0%94%D0%BE%D0%BA%D0%BB%D0%B0%D0%B4%D0%B8/doklad_god__2023_Vidin.sflb.ashx, 2024/07/04;

[2]. https://www.mzh.government.bg/odz-plovdiv/Libraries/%d0%94%d0%be%d0%ba%d0%bb%d0%b0%d0%b4%d0%b8/%d0%be%d1%82%d1%87%d0%b5%d1%82_%d0%b7%d0%b0_%d0%bf%d1%8a%d1%80%d0%b2%d0%be%d1%82%d0%be_%d1%82%d1%80%d0%b8%d0%bc%d0%b5%d1%81%d0%b5%d1%87%d0%b8%d0%b5_2024_%d0%b3.sflb.ashx, 2024/06/03;

[3]. Zahariev, I. Energy potential of cut off branches from a plum garden during annual crown pruning, collection of reports from the scientific conference "Knowledge, Science, Technologies, Innovations" 2024, pp:763-781, ISSN 2815-3472 (Print), ISSN 2815-3480 (CD), 2024;

[4]. Kienzle, J., Ashburner, J.E., Sims, B.G. Mechanization for rural development: A

review of patterns and progress, v.20. Rome: FAO, p.364,2013;

[5]. Marangoni Junior, A. Da Costa Ferreira, M. Influence of working pressure and spray nozzle on the distribution of spray liquid in manual backpack sprayers, Arquivos do InstitutoBiológico, 86, e0442018, 2019;

[6]. Baldini, E.,Intrieri, C. Viticolturameccanizzata: sceltadellemacchine, adeguamentodeivigneti, valutazionicheaphe, organizzazione del lavoro, CollanaMeccanizzazioneagricola, Ed. Edagricole, Bologna, pp. 137, 2004;

[7]. Caprara, C.,Pezzi, F. Measuring the stresses transmitted during mechanical grape harvesting, Biosystems Engineering, Volume 110, Issue 2, 2011, pp: 97-105, ISSN 1537-5110, https://doi.org/10.1016/j.biosystemseng.2011.07.003, 2011;

[8]. Clary, C.D., Steinhauer, R.E., Frisinger, J.E.,Peffer, T.E. Evaluation of machine-vs. hand-harvested Chardonnay, American Journal of Enology and Viticulture, 1990, Vol. 41, No. 2, pp: 176-181 ref. 31, 1990;

[9]. Chaler, G. Récoltemécanique de la vigne: comportement des nouveaux dispositifs de récolteProgrèsAgricole et Viticole, 1991;

[10]. Intrieri C.,Poni, S. Integrated Evolution of Trellis Training Systems and Machines to Improve Grape Quality and Vintage Quality of Mechanized Italian Vineyards, American Journal of Enology and Viticulture, https://doi.org/10.5344/ajev. 1995.46.1.116, 1995;

[11]. Caprara, C.,Pezzi, F. Measuring the stresses transmitted during mechanical grape harvesting, Biosystems Engineering, Volume 110, Issue 2, 2011, pp. 97-105, ISSN 1537-5110, https://doi.org/10.1016/j.biosystemseng.2011.07.003, 2011;

[12]. Panayotov J. Advanced technological complex of machines for the production of grapes for wine, ZEMIZDAT - Sofia, pp: 54-65, 1988;

[13]. Zahariev, I. Determining the time for harvesting grapes from small areas in the Karlovska rose valley, IOSR Journal of Engineering (IOSRJEN), www.iosrjen.org, ISSN (e): 2250-3021, ISSN (p): 2278 -8719, Vol. 14, Issue 1, January 2024, Series -I, pp: 24-31, Figure 3b, 2024;

[14]. Kehayov, D.,Zyapkov, D. Basic tillage of sloping terrain - performance indicators. NT AU-Plovdiv, item 1, book 2, pp: 265-268, 2005;

[15]. Zahariev, I. Determination the volume of transport operations when harvesting wine grapes from small areas, IOSR Journal of Engineering (IOSRJEN), www.iosrjen.org, ISSN (e): 2250-3021, ISSN (p): 2278 -8719, Vol. 13, Issue 12, December 2023, Series -I, pp: 67-74, 2023;

[16]. https://eurocode.bg/index.php?title=%D0%9E%D0%B1%D0%B5%D0%BC%D0%BD%D0%B8_%D1%82%D0%B5%D0%B3%D0%BB%D0%B0_%D0%BD%D0%B0_%D0%BC%D0%B0%D1%82%D0%B5%D1%80%D0%B8%D0%B0%D0%BB%D0%B8_%D0%B8_%D0%BF%D1%80%D0%BE%D0%B4%D1%83%D0%BA%D1%82%D0%B8_%D0%B7%D0%B0_%D1%81%D1%82%D1%80%D0%BE%D0%B8%D1%82%D0%B5%D0%BB%D0%BD%D0%B8_%D0%BA%D0%BE%D0%BD%D1%81%D1%82%D1%80%D1%83%D0%BA%D1%86%D0%B8%D0%B8_%D0%BF%D0%BE_%D0%9D%D0%B0%D1%80%D0%B5%D0%B4%D0%B1%D0%B0_%E2%84%96_3, 2023/06/19;

[17]. https://madaraagro.com/bg/product/252/lozarsko-remarke-loznitza/, 2024/06/17;