

Analysis of the Operation of a Disc Harrow in a Plum Garden

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ABSTRACT: The article presents the results of a study of the operation of a disc harrow in a plum orchard. The results of the measurements made according to the same scheme and location of the measurement points and areas are compared. The degrees of weed destruction after the first $\delta_I = 68.44\%$ and the second passage of the machine $\delta_{II} = 92.91\%$, the deviation from the set working depth $\Delta a = 0.44$ cm were determined. The obtained results of the measurements were used to prepare recommendations for the use of the disc harrow in other orchards as well

KEYWORDS: Disc harrow, destruction of weeds, orchard, plum garden

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I. INTRODUCTION

The cultivation of fruit trees is an important branch of agriculture in the Republic of Bulgaria.

As a type of fruit, the plum is in second place after the apple in terms of established orchards and production. [1, 2].

According to a published report on the website of the Regional Directorate of Agriculture - Plovdiv of the Ministry of Agriculture and Food of the Republic of Bulgaria [3], in the section "Permanent plantations" it is evident that the fruiting areas with plums are 1725.5 ha [4], which is on the first place compared to other fruit trees.

There are favorable conditions for the development of plum growing in the hilly-mountainous regions with an altitude of up to 600 m, which helps the plants to enter the harvest more quickly and enables higher yields [5, 6].

In the soil, vital processes of accumulation and transformation of substances take place, and when the roots are in contact with the soil solution and its solid part, processes of assimilation and exchange of substances take place, processes that are the basis of the mineral nutrition of plants [7, 8].

One of the main measures is tillage or maintaining the row spacing in the plantation, as this measure has a decisive influence on the growth and productivity of the cultivated fruit trees [2, 9]

Tirovska&Dancheva [10] prove that better quality is achieved when working with disc harrows compared to cultivators.

Despite the research done by various authors, some indicators of work have not yet been fully established.

II. MATERIAL AND METHODS

According to the method described by the authors Kosev&Zahariev [11] in the article "Method for Unambiguously determining the location of an observed area of 1 m² in fruit plantation", the spatial orientation of the fruit plantation is determined using a compass. The intra-row and inter-row distance between individual trees is measured and 5 locations are randomly determined.

Using 3 three-meter tape measures, 1 five-meter tape measure, a 90° angle measuring tool and a polyethylene rope with a diameter of $\varnothing 4$ and a length of 10 m, the observed area is fenced off (Fig. 1).

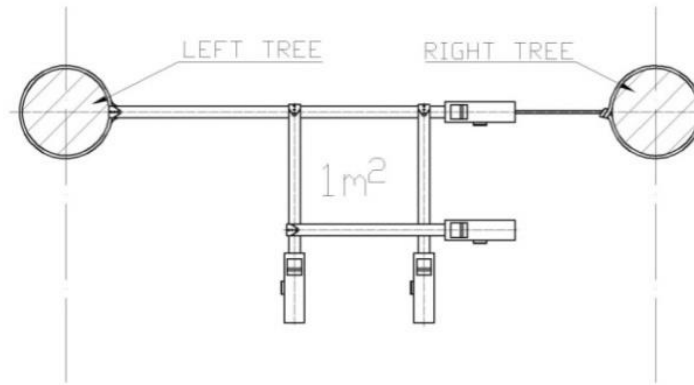


Figure 1: Layout of the measuring devices [11]

The two trees (left and right) are marked with paper tape, on which the serial number of the observed area is written.

Care must be taken not to trample the weeds in the area of the observed area when stretching the tapes and the rope.

The weeds in the fenced area are counted and their number recorded.

Disassemble the structure defining the location of the observed area (retract the tapes of the tapes and untie the rope).

The above action is repeated 5 times.

The tractor with the disc harrow passes for the first time.

For the marked trees, the construction is assembled from tapes and rope. Count the remaining weeds unaffected by the working organs of the machine with the possibility of recovery. Their number is recorded. The processing depth is measured in 5 points (in the 4 corners of the formed square and in the center of its described circle). The center of its described circle which is located at the intersection of the diagonals of the square and is established with the help of two pieces of rope passed through the two diagonals.

After the measurement, the structure is disassembled.

The remaining four observed areas are traversed, the remaining weeds unaffected by the working organs of the machine with the possibility of recovery are counted and recorded. The depth of work is considered.

The tractor with the disc harrow passes for the second time.

Reassemble the construction of rollers and rope at the marked trees and count the remaining unaffected weeds with the possibility of recovery after the second pass of the tractor with the disc harrow. Their number is recorded. The processing depth is not measured a second time.

The results are processed statistically.

An average value is calculated, \bar{X} :

$$\bar{X} = \frac{\sum_{i=1}^n X_i}{n} \quad (1)$$

where: n – number of measurements, pcs; X_i – value of the i th measurement;

Dispersion:

$$\sigma^2 = \frac{1}{n-1} \sum_{i=1}^n (X_i - \bar{X})^2 \quad (2)$$

Root Mean Square Deviation:

$$\sigma = \sqrt{\sigma^2} \quad (3)$$

Coefficient of variation:

$$\nu = \frac{\sigma}{\bar{X}} \cdot 100 \quad (4)$$

Dependencies are defined:

$$\left| \frac{X_{max} - \bar{X}}{\sigma} \right| \geq U, \quad \left| \frac{X_{min} - \bar{X}}{\sigma} \right| \geq U \quad (5)$$

where: U – criterion (standardized value); X_{max} and X_{min} – maximum and minimum values in the order of n measured values [4].

The U criterion for rejecting gross measurement errors is selected from the reference literature. It has a value of $U=1.869$ at confidence probability $\gamma=0.95$ ($\alpha=0.05$) and number of measurements $n=5$ [12].

When the inequalities (5) are met, the min and max values are excluded and the check is repeated until we have a non-fulfilment.

After determination, gross errors are excluded and only those values that fall within the range of permissible values are worked on.

III. RESULTS AND DISCUSSIONS

The research was conducted in the spring of 2024 in a permanent plantation with prunes in the Rakovski municipality, Plovdiv region, and the processing of the obtained results - in the Department of Agricultural Mechanization of the Agricultural University - Plovdiv.

The permanent plantation has the following characteristics:

Area – 12.67 da - with a regular rectangular shape 70 x 181 m;

Row spacing – 5.00 m;

Intra-row distance – 4.00 m;

Width of turning strips – 3 m;

Number of rows - 13 pieces

Average number of trees in a row - 45;

Soilmoisture – 22.5 %;

Soil type - solonchetic soils [13].

The machines used are a YTO MF504 tractor with a mounted disc harrow V-shaped 1BQX-1.9 with 20 toothed discs (Fig. 2). The disc harrow was equipped on the front and rear rows with cut (toothed) discs. The angle of attack of the front row was 16° and the rear - 25° . Working speed - up to 9km/h=No additional weights were added to the frame of the machine.



Figure2: Passing a tractor with a disc harrow
(photo credit: Kosev&Zahariev)

Destruction of weeds

The experimental weed control results obtained are tabulated in Table (1) and illustrated in figure 3 and figure 4.

In the observed areas of 1 m^2 , the number of weeds before and after the first and second passes of the disc harrow were counted. When counting the weeds after passing the machine, only those unaffected by the working organs of the machine with the possibility of recovery were counted.

Table I. Destruction of weeds

	Observed area	Weeds before treatment, pcs./m ²	Weeds after the first pass, pcs./m ²	Weeds after second pass, pcs./m ²	Killing weeds after first pass δ_I , %	Killing weeds after second pass δ_{II} , %
Disc harrow	N1	53	19	4	64.15	92.45
	N2	47	15	4	68.09	91.49
	N3	66	18	3	72.73	95.46
	N4	73	21	5	71.23	93.15
	N5	50	17	4	66.00	92.00
Average value \bar{X}		57.8	18.0	4.0	68.44	92.91

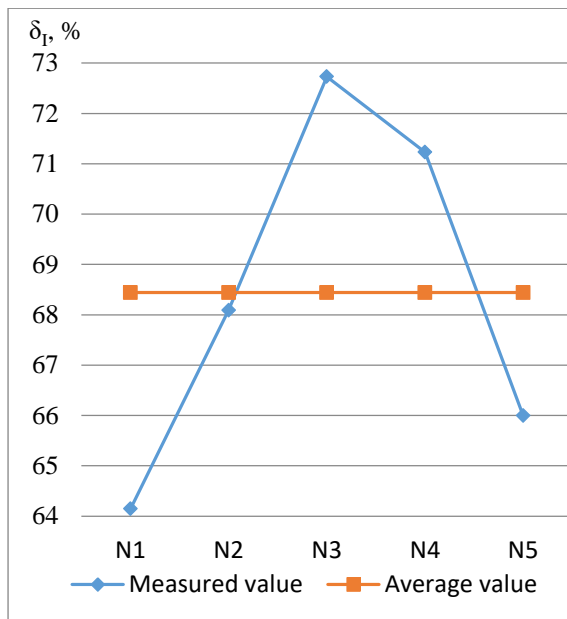


Figure 3: Weed destruction after the first pass compared to the initial number

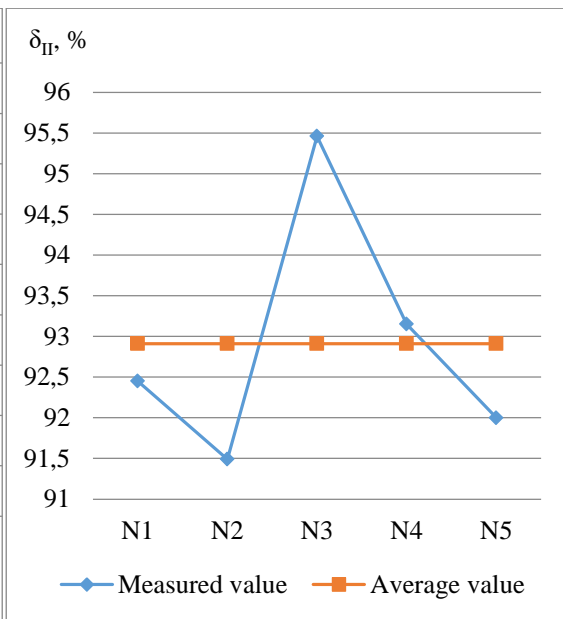


Figure 4: Weed destruction after the second pass compared to the initial number

The obtained experimental results for the destruction of weeds after the first and second passes of the machine ($\delta_I = 68.44\%$ and $\delta_{II} = 92.91\%$ - average values) shown in figure 3 and figure 4 are higher than the literature data for monitoring the operation of V- and X-shaped disc harrows by the authors Panchev, Manolov and Nankov [14], who found 66.8% destruction in the first pass and 92.3% after the second pass.

It follows that the obtained research results are better by 1.64% after the first pass and by 0.61% after the second pass compared to the literature data.

Table II. Results of the statistical processing of the experimental data

	Weed count		
	Before processing	After a first pass	After a second pass
Average value \bar{X} , pcs	57.8	18.0	4
Dispersion σ^2	124.7	5	0.5
Root Mean Square Deviation σ	11.17	2.24	0.71
Coefficient of variation v , %	19.32	12.42	17.68
X_{max}	73	21	5
$\frac{ X_{max} - \bar{X} }{\sigma}$	1.36	1.34	1.41
X_{min}	47	15	3
$\frac{ X_{min} - \bar{X} }{\sigma}$	0.97	1.34	1.41
Criterion U	1.869	1.869	1.869

The results in Table (2) show that all 6 numbers (1.36; 1.34; 1.41 0.97; 1.34 and 1.41) are smaller than the criterion $U=1.869$, that is, it is not fulfilled inequality (5) - no gross errors.

The distribution of the number of remaining weeds unaffected by the working organs of the machine with the possibility of recovery after the second pass is illustrated in Figure 5.

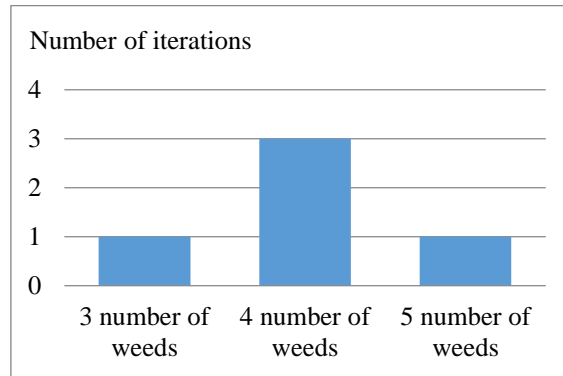


Figure 5: The distribution of the number of remaining weeds unaffected by the working organs of the machine with the possibility of recovery after the second pass

Figure 5 shows a normal distribution, which is logical and is a consequence of the tractor passing twice with the disc harrow equipped with toothed discs.

Maintaining the set working depth

The obtained experimental results are placed in Table (3):

Table III. Deviation from the set working depth

Monitored Area	N1	N2	N3	N4	N5
Processing depth a, cm	10	10,7	10,5	10	11
Average value \bar{X} ,cm	10,44				
Deviation Δa , cm	0,44				
Dispersion σ^2	0.193				
Root Mean Square Deviation σ	0.439				
Coefficient of variation v, %	4.21				
X_{max}	11				
$\frac{ X_{max} - \bar{X} }{\sigma}$	1.275				
X_{min}	10				
$\frac{ X_{min} - \bar{X} }{\sigma}$	1.002				
Criterion U	1.869				

The values of the parameters listed in Table (3) show that it fulfills inequality (5), which means that there are no gross errors.

The results of the parameter maintaining the set working depth of the serrated discs show the stability of the working process. Only in one case was a larger deviation than the set one recorded. For sample No. 5 it is 1 cm (+10%), which deviation is within the permissible 10-15%.

This shows that even without additional weights, the working organs are well deepened. From here it can be concluded that the mode of operation (speed) and angles of attack are selected within optimal limits.

The data are presented graphically in Figure 6.

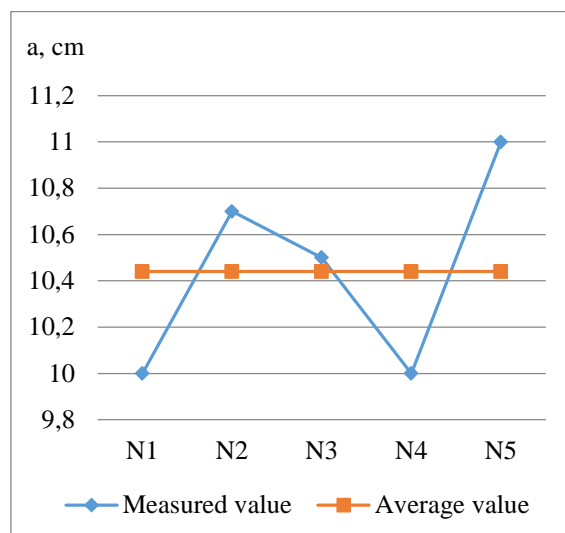


Figure 6: Working depth, cm

The results of the research confirm what was previously expected, namely that when working with a disc harrow with toothed discs, a ridged bottom is obtained where the cutouts of the discs hit. On the other hand, weed vegetation is being cut.

The obtained data for the two monitored indicators meet the agrotechnical requirements for this type of processing. This gives reason to recommend the disc harrow for use in processing the inter-rows of all orchards.

IV. CONCLUSIONS AND RECOMMENDATIONS

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

1. The disc harrow meets the agrotechnical requirements for surface tillage in plum orchards. With a large number of weeds, it is appropriate to pass the tractor twice with the disc harrow. Adding the disadvantage of disc harrows - the compaction of the soil layer under the cultivated one, it is necessary to alternate treatments with a disc harrow and a cultivator equipped with loosening working organs.

2. In the absence of rhizome weeds, it is appropriate to use a disc harrow to process the inter-rows in the orchards.

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