

DETERMINING THE LOSSES ON GROUND AT HARVESTING THE MEDICINAL PLANTS

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In the case of medicinal plants, the quality requirements imposed on the harvested material are strict. Among the researches conducted within INMA related to mechanical harvesting of chamomile inflorescences with different sizes of active organs, the paper summarizes the ones related to the rate of losses on soil. These were studied for the constructive variants of working organs, designated representatives on the basis of the harvesting degree, the main indicator of evaluation of a harvesting process, performed with a specialized equipment. The conclusions issued following the interpretation of the results is an important prerequisite for the optimization of the mechanized harvesting process of the Chamomile inflorescences, in order to achieve of efficient equipment.

Keywords: mechanized harvesting, chamomile inflorescences, the rate of losses on soil, multivariable functions

1. Introduction

Generally, medicinal plant cultivation offers the possibility to mechanize the agricultural works, which represents a guarantee of productivity and quality of vegetal material obtained [1]. Phytotherapeutical efficiency of medicinal and aromatic plants depends largely on the quality of vegetal material, obtained after a process of harvesting carried out differentially, depending on the species, the plant's useful body and on the season [2].

The chamomile (*Matricaria recutita* L.) is one of the best known and most used natural remedies both in the human traditional therapy and in the veterinary one, its beneficial properties being known since ancient times. At world level is cultivated on approx. 20,000 ha, the main producers being Argentina, Egypt, Italy, Hungary, Germany, Serbia, etc. [3]. In these countries it is very important the cultivation of some studied varieties, with a high content of volatile oil, together with other valuable bioactive compounds found in inflorescences (azulenes, flavonoids, coumarin etc.) [4]. The mechanized harvesting of the *chamomile inflorescences* is a key point in the production chain, because it has a major

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impact on the quantity and quality of vegetal material obtained [1,5]. Chamomile harvesting costs represent a large part of total costs, this being economically efficient when is done mechanically on surfaces of minimum 4 ha [6]. In many countries in Europe (including Romania) camomile cultivation is in a great decline. To relaunch this culture, in some countries, based on some investments or programs, were researched and realized selfpropelled combines of high productivity for the harvesting of *chamomile inflorescences* [5,7].

The chamomile reapers which equip the harvesting equipment can be of drum, or of conveyor type [1,8], the predominant harvesting organs being of comb type [3]. Due to the active bodies, the working process is a process of raking comprising the following stages: combs penetration in the layer of stalks; combs moving along the stalks; the combs exiting from the layer of stalks [9].

The paper presents the experimental results on the losses rate on soil and their interpretation by means of the multivariate functions. The results were obtained at the harvesting of chamomile inflorescences with a trailed machine, which was equipped with different types of active bodies comb type.

2. Material and method

The chamomile harvesting machine (fig.1) utilized was of traction type, with an offset position from tractor while working and fitted with mechanical transmission.

The gatherer moved along the rows of plants with the combs scrapers in action. These performed the bottom up combing of the plants, operation having the effect of detaching the inflorescences of strains. In the working process the combs performed a movement resulting from the overlapping of the rotational movement of the collecting conveyer belt over the translational movement given by the movement of the aggregate. Each point on the pulling bodies (characterized by a position vector against the center of rotation) described an elongated cycloidal trajectory. The action of the combs scrapers comprises the floral floors which are harvested according to the established working height.



Fig.1 Chamomile harvester

The experiments were conducted in a chamomile crop from the former SCPMA Fundulea, Calarasi County. The Table 1 presents the crop characteristics.

Table 1

Chamomile culture characteristics

Variety	Margaritar
Average number of chamomile plants [pcs/m ²]	326
Average number of weeds [pcs/m ²]	12
Average number of mature flowers [pcs/m ²]	1986
Average number of buttons non blossomed [pcs/m ²]	46
Average production of fresh inflorescences [kg/ha]	3204
Average mass of 100 inflorescences [g]	13.2
Average diameter of inflorescences [mm]	19.4
Minimum and maximum heights between which are found the flowers on plants [mm]	298...583

Several types of combs scrapers with straight teeth (fig. 2a) and with curved teeth (fig.2b) were executed and tried.

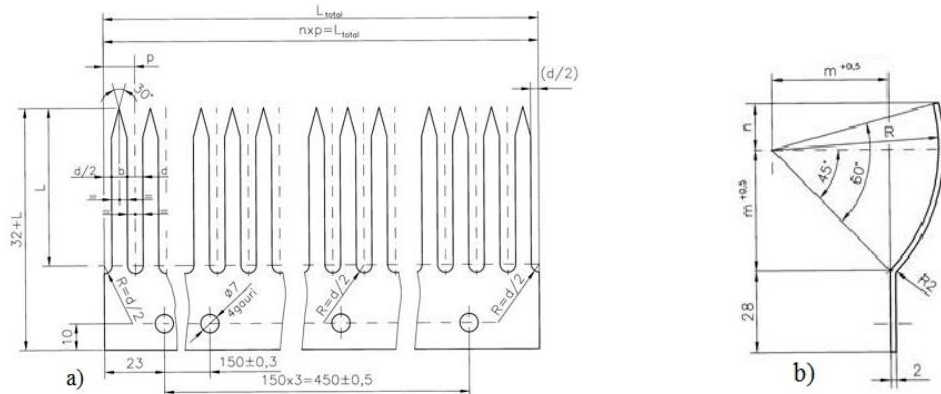


Fig. 2 The combs shape: a) with straight teeth; b) with curved teeth

For the curved teeth, it just shows the side view, in order to highlight the differences. At both types of combs the gap between teeth has the agreed shape of a rounded "U", the radius being equal to half of the distance between teeth ($d/2$) [3].

Notations used in Fig. 2 and Table 2, in which are shown the dimensional characteristics of the combs are shown, have the following meanings: d - the distance between two consecutive teeth; p - teeth pitch; L - teeth length; b - teeth width; R - curvature radius of the combs with curved teeth. Dimensions m and n can be expressed and calculated depending on the radius R .

In Table 2 are shown 12 typo dimensions of combs scrapers, for the identification of which the following symbols were used:

- a) combs with straight teeth - M1; N1; O1; S1; T1; V1;
- b) combs with curved teeth - M2; N2; O2; S2; T2; V2.

To be more comparable, the version with straight teeth, followed by the one with curved teeth are presented in pairs, for the common sizes. The distance d for the first 6 versions is 6 mm, for the others being 4 mm. The tooth width and length varies in the same way for the versions grouped by d .

Table 2

Dimensional characteristics of combs

Comb symbol	d [mm]	b [mm]	p [mm]	L [mm]	R [mm]	$m = \frac{\sqrt{2}}{2} R$ [mm]	n [mm]
M1	6	6	12	60	-	-	-
M2	6	6	12	60	60	42	16
N1	6	8	14	80	-	-	-
N2	6	8	14	80	80	57	21
O1	6	10	16	100	-	-	-
O2	6	10	16	100	100	71	26
S1	4	6	10	60	-	-	-
S2	4	6	10	60	60	42	16
T1	4	8	12	80	-	-	-
T2	4	8	12	80	80	57	21
V1	4	10	14	100	-	-	-
V2	4	10	14	100	100	71	26

Using interchangeable chain wheels, with different numbers of teeth, it was obtained the modification of the transmission ratio of the movement to gatherer and implicitly there were obtained different linear speeds ($v_b = 0.52$; 0.76 ; 1.08 ms^{-1}) for the band on which were mounted on all variants of active bodies (combs scrapers).

Any harvesting process is characterized by the degree of collection, which is the main indicator for assessing the working process. In this case it expresses percentually the ratio between the inflorescences detached from plants and the initial number of inflorescences from a crop area of 1m^2 . For each type of active organs there were performed five experimental determinations, for all the possible combinations relating to the working conditions. After analyzing the experimental results obtained for the collection rate, there were chosen the representative variants for the types of active bodies, these being: version V1 (for combs with straight teeth) and version T2 (for combs with curved teeth).

The losses of inflorescences on the ground represent the flowers detached from the stalks in the process of harvesting, which are not retained by gatherer. Due to a complex of factors difficult to control, these fall on the ground without having to be recovered. The losses rate represents the percentage ratio between the number of flowers fallen on the ground and the number of detached flowers from stalks per unit of harvested area.

After carrying out the experiments it was found that the values determined for the losses rate on soil of the inflorescences collected, depend on the values that we imposed for the working speed, the working height and peripheral speed of the combs. Thus the rate of losses on soil is a variable that depends on several independent variables simultaneously. This dependence could be expressed by means of an analytical expression, whose form should generally be determined as a multivariable function y type:

$$y = f(x_i, a_0, a_i, a_{ii}, a_{ij}) \quad (1)$$

Due to the complexity of solving this problem it is required to complete several steps: drawing up a suitable program of organizing of the experiences, determining the values of the constants, testing the significance of the variables, testing the adequacy function form [10].

This y function can be of type: polynomial regression function or polytropic regression function as follows [10,11,12]:

1. *Regression function of the polynomial form*, with three independent variables which has the form [10,12]:

$$y = a_0 + \sum_{i=1}^3 a_i \cdot x_i + \sum_{i=1}^3 a_{ii} \cdot x_i^2 + a_{12} x_1 x_2 + a_{13} x_1 x_3 + a_{23} x_2 x_3 \quad (2)$$

Where: x_1, x_2, x_3 are independent variables, y is a dependent variable and $a_0, a_i, a_{ii}, a_{12}, a_{13}$ si a_{23} are the constants whose values are to be determined.

2. *Regression function polytropic*, with three independent variables that has the form [10], [12]:

$$y = a_0 \cdot x_1^{a_1} \cdot x_2^{a_2} \cdot x_3^{a_3} \quad (3)$$

The structure of the experimental research program used to determine the function y is given by: the number $n_* = 14$ experiences carried out for the different values of the independent variables, necessary to determine the coefficients; the number $n_0 = 4$ of experiences carried out for identical values of the independent variables, necessary to determine the experimental error; the total number of experiments [13]:

$$n = n_* + n_0 = 14 \quad (4)$$

The main characteristics of the experimental program, defined in relation to the requirements of functions determination appropriate to the investigated processes are: *compatibility*, (defined in relation to the achievement of a unique solution of the coefficients), *orthogonality* (defined in relation with the realisation of some estimations of the coefficients, uncorrelated), *credibility* (defined in relation to carrying out of some conclusive values of the indicators of testing the significance of the coefficients and of the form function adequacy) [10,13].

For the multivariable regression functions (polynomial and polytropic), the following steps were performed:

a) *Coefficients calculation* - The determination of these constants is made with the method of the least squares, expressing the sum of deviations squares of the measured values compared to those computed with the modeling soft. Putting the condition that the sum should be minimal, a system of linear equations is obtained. Solving the system, the constants from the expression of the multivariate function are obtained [10,12,14,15]:

$$S_e = \sum_{i=n_*+1}^n \left(y_i - \sum_{j=1}^{m_1} \frac{y_i}{n_o} \right)^2, S_0 = nb_0^2, S_j = a_j^2 \sum_{i=1}^n X_{ij}^2 \quad j = 1, 2, 3, \dots, m_1 \quad (5)$$

b) *Testing the significance of the coefficients* - is done using Fisher test, by calculating the sum of experimental errors squares and the sums due to the coefficients.

The following ratios are calculated: $F_o = \frac{S_o(n_o - 1)}{S_e}, F_j = \frac{S_j(n_o - 1)}{S_e}, j = 1, 2, 3, m_1$ (6)

If $F_0 \geq F(1-\alpha, 1, n_o - 1), F_j \geq F(1-\alpha, 1, n_o - 1), F_{jj} \geq F(1-\alpha, 1, n_o - 1), F_{1j} \geq F(1-\alpha, 1, n_o - 1)$ și $F_{23} \geq F(1-\alpha, 1, n_o - 1)$ the coefficients a_0, a_j, a_{jj}, a_{1j} and respectively a_{23} are significant. If the condition is not met for one or more factors, they are equal to zero. The critical values $F(P=1-\alpha, k_1=1, k_2=n_o-1)$ are given for the significance level $\alpha = 0.95$ [10,11,16].

c) *Testing the function form adequacy* - is done, also, studying Fisher test to calculate:

$$F = \frac{(S - S_e)(n_o - 1)}{S_e(n - n_o - m_1)} < F(1-\alpha, n_* - m_1, n_o - 1) \quad (7)$$

where m_1 represents the number of function coefficients (without a_0). If this condition is met, then the function form is adequate [10,11,16].

The rate of harvested inflorescences lost on the ground, can be expressed using the multivariable regression functions. In this respect, the independent variables that influence the dependent variable are [17,18]: *The working speed*: $v_l = 0.5-1.22 \text{ km h}^{-1}$; *The height of harvest*: $H=0.3 - 0.45 \text{ m}$; *The combs peripheral speed*: $v_p = 0.52 - 1.08 \text{ ms}^{-1}$. The calculation algorithm shown above was used to carry out a program in the Turbo Pascal 7 programming language [19]. The experimental program of tests for determining the multivariable functions for calculating the rate of losses on ground of the inflorescences for the versions V1 and T2 is shown in Table 3.

Table 3

The experimental program of tests for determining the multivariable functions to calculate the losses on soil corresponding to V1 and T2

Crt. No.	v_l [km h ⁻¹]	H [m]	v_p [m s ⁻¹]	Losses on soil for V1 [%]	Losses on soil for T2 [%]
1	0.5	0.30	0.52	17.5	5,8
2	1.22	0.30	0.52	19.6	8,2
3	0.5	0.45	0.52	13.6	5,3
4	1.22	0.45	0.52	11	10,8

5	0.5	0.30	1.08	17.1	5,6
6	1.22	0.30	1.08	16.9	5,3
7	0.5	0.45	1.08	11.8	4,9
8	1.22	0.45	1.08	11.7	3,9
9	0.5	0.30	0.76	17	5,3
10	1.22	0.30	0.76	15.4	7,6
11	0.76	0.45	0.76	14.4	5,3
12	0.76	0.30	0.76	17.5	7,9
13	0.76	0.30	1.08	11.4	7
14	0.76	0.30	0.52	19.3	9,4
15	0.76	0.30	0.76	17.5	7,9
16	0.76	0.30	0.76	16	7,1
17	0.76	0.30	0.76	18	6,5
18	0.76	0.30	0.76	17	6,9

3. Results

The regression function of polynomial form P_{sl} with three independent variables v_b , H , v_p , expressing the losses on ground for V1 is of the form:

$$P_{sl} = a_1 + a_2 v_l + a_3 H + a_4 v_p + a_5 v_l^2 + a_6 H^2 + a_7 v_p^2 + a_8 v_l H + a_9 v_l v_p + a_{10} H v_p \quad (8)$$

Using a computer program developed in Turbo Pascal were calculated the regression coefficients for the function of polynomial form, expressing the losses on soil for the V1 combs version, by the method of the least squares. Fisher test was used to test the coefficients significance and the function adequacy.

Regression coefficients and coefficients of testing of the coefficients significance for the function of polynomial form corresponding to V1 are:

$$\begin{aligned} a_1 &= -0.763503, F_1 = 6417.467660 > F=8.25 \text{ results: } a_1 \text{ is significant;} \\ a_2 &= 0.00000, F_2 = 5.987685 < F=8.25 \text{ results: } a_2 \text{ is not significant;} \\ a_3 &= 154.649041, F_3 = 66.064084 > F=8.25, \text{ results: } a_3 \text{ is significant;} \\ a_4 &= -12.100387, F_4 = 15.233396 > F=8.25 \text{ results: } a_4 \text{ is significant;} \\ a_5 &= 2.115545, F_5 = 57.003245 > F=8.25 \text{ results: } a_5 \text{ is significant;} \\ a_6 &= -261.877069, F_6 = 571.108994 > F=8.25 \text{ results: } a_6 \text{ is significant;} \\ a_7 &= -3.980434, F_7 = 64.153649 > F=8.25 \text{ results: } a_7 \text{ is significant;} \\ a_8 &= -17.126107, F_8 = 8.797095 > F=8.25 \text{ results: } a_8 \text{ is significant;} \\ a_9 &= 0.00000, F_9 = 1.913586 < F=8.25 \text{ results: } a_9 \text{ is not significant;} \\ a_{10} &= 34.306827, F_{10} = 21.354733 > F=8.25 \text{ results: } a_{10} \text{ is significant;} \end{aligned}$$

The calculated regression coefficients are:

$$a_1 = 0.62118, a_2 = 0.00000, a_3 = 154.64904, a_4 = -10.26048, a_5 = 2.11554, a_6 = -261.87707, a_7 = -3.98043, a_8 = -17.12611, a_9 = 0.00000, a_{10} = 34.30683.$$

The coefficient of testing the form adequacy for the function is $F=4.504 < F_{\text{tab}} = 9.4$, so it follows that the function form is adequate. [16]

Polynomial function that allows the calculation of losses on the ground for the V1 combs version is:

$$P_{s1} = 0.62118 + 154.64904 H - 10.26048 v_p + 2.11554 v_l^2 - 261.87707 H^2 - 3.98043 v_p^2 - 17.12611 v_l H + 34.30683 H v_p \quad (9)$$

Next there were calculated the regression coefficients and the coefficients of testing the coefficients significance for the function of polytropic form corresponding to the losses on soil for V1:

$a_1 = 6.380547724$ $F_1 = 50592.229762 > F=8.25$ results: a_1 is significant;

$a_2 = -0.048975618$ $F_2 = 1.878456998 < F=8.25$ results: a_2 is not significant;

$a_3 = -0.744759146$ $F_3 = 89.753680159 > F=8.25$ results: a_3 is significant;

$a_4 = -0.210922389$ $F_4 = 23.391606194 < F=8.25$ results: a_4 is significant.

The recalculated coefficients are: $a_1 = 6.45427728$, $a_2 = 0$, $a_3 = -0.745874437$, $a_4 = -0.210893861$.

The coefficient of testing the function adequacy form is $F=4.770 < F_{\text{tab}} = 9.4$, so the function form is adequate [16]. Polytropic function that allows the calculation of losses on the ground for the V1 combs version is:

$$P_{s2} = 6.45427728 \cdot v_l^0 \cdot H^{-0.745874437} \cdot v_p^{-0.210893861} \quad (10)$$

Table 4 presents the deviations of the values for the losses on ground, calculated with the regression functions (9) si(10), compared to the experimental ones, for V1.

Table 4

Deviations of the soil losses rate calculated with the regression functions for V1

Crt. No.	Losses on ground [%]			Deviation [%]	
	P_{sexp}	$P_{s(9)}$	$P_{s(10)}$	$100(P_{\text{sexp}} - P_{s(9)})/P_{\text{sexp}}$	$100(P_{\text{sexp}} - P_{s(10)})/P_{\text{sexp}}$
1	17.5	19.105	18.186	-9.17	-3.921
2	19.6	18.025	18.186	8.034	7.213
3	13.6	14.232	13.440	-4.650	1.176
4	11	11.303	13.440	-2.758	-22.182
5	17.1	15.556	15.588	9.029	8.84
6	16.9	14.477	15.588	14.340	7.761
7	11.8	13.565	11.52	-14.961	2.371
8	11.7	10.636	11.52	9.09	1.537
9	17	17.89	16.787	-5.232	1.25
10	15.4	16.81	16.787	-9.157	-9.01
11	14.4	12.942	12.406	10.128	13.845
12	17.5	17.247	16.787	1.447	4.072
13	11.4	14.913	15.588	-30.817	-36.74
14	19.3	18.462	18.186	4.342	5.771
15	17.5	17.247	16.787	1.447	4.072
16	16	17.247	16.787	-7.792	-4.922
17	18	17.247	16.787	4.185	6.736
18	17	17.247	16.787	-1.451	1.25

For the V1 combs version, figure 3 shows the experimental values of the rate of losses on ground, compared to the theoretical ones, calculated using the polynomial and polytropic functions previously obtained, for each experiment.

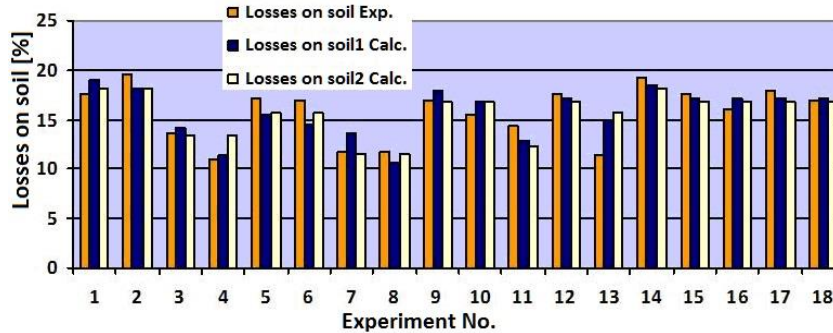


Fig. 3 Losses on ground for the V1 combs version

Using the same calculation program developed in Turbo Pascal and the methodology stated above, were calculated the coefficients of regression and the coefficients of testing the coefficients significance for the function of polynomial form corresponding to losses on soil for the T2 combs version, but the function form was not adequate.

Then, there were calculated the regression coefficients and the coefficients of testing the coefficients significance for the function of polytropic form corresponding to losses on soil for T2:

$a_1 = 3.530916808$ $F_1 = 9092.09151940 > F=8.25$ results: a_1 is significant;
 $a_2 = 0.2465642$, $F_2 = 18.152010439 > F=8.25$ results: a_2 is significant;
 $a_3 = -0.486373265$, $F_3 = 14.594299667 > F=8.25$ results: a_3 is significant;
 $a_4 = -0.508928921$, $F_4 = 51.922098693 > F=8.25$ results: a_4 is significant.
 Recalculated coefficients were: $a_1 = 3.5309168$, $a_2 = 0.2465642$, $a_3 = -0.4863733$, $a_4 = -0.5089289$

The coefficient of testing the function adequacy form is $F=6.214 < F_{\text{tab}} = 9.4$, so the function form is adequate [16]. The polytropic function that allows the calculation of losses on ground for the T2 combs version is:

$$P_s = 3.5309168 \cdot v_l^{0.2465642} \cdot H^{-0.4863733} \cdot v_p^{-0.5089289} \quad (11)$$

Table 5 presents the deviations of the values for the inflorescences lost on soil, calculated with the regression function (11), compared to the experimental ones, for T2.

Table 5

Deviations of the soil losses rate calculated with the regression functions for T2

Crt. No.	Losses on ground [%]		Deviation [%]
	P_{sexp}	$P_{s(11)}$	$100(P_{\text{sexp}} - P_{s(11)})/P_{\text{sexp}}$
1	5.8	7.456	-28.554
2	8.2	9.29	-13.296
3	5.3	6.122	-15.502

4	10.8	7.628	29.375
5	5.6	5.140	8.213
6	5.3	6.404	-20.839
7	4.9	4.22	13.876
8	3.9	5.258	-34.826
9	5.3	6.147	-15.974
10	7.6	7.659	-0.772
11	5.3	5.595	-5.572
12	7.9	6.815	13.733
13	7	5.699	18.585
14	9.4	8.267	12.053
15	7.9	6.815	13.733
16	7.1	6.815	4.013
17	6.5	6.815	-4.848
18	6.9	6.815	1.230

For the T2 combs version, figure 4 shows the experimental values of the rate of inflorescences lost on the ground, compared to the theoretical ones, calculated using the polytropic function previously obtained, for each experiment (Table 5).

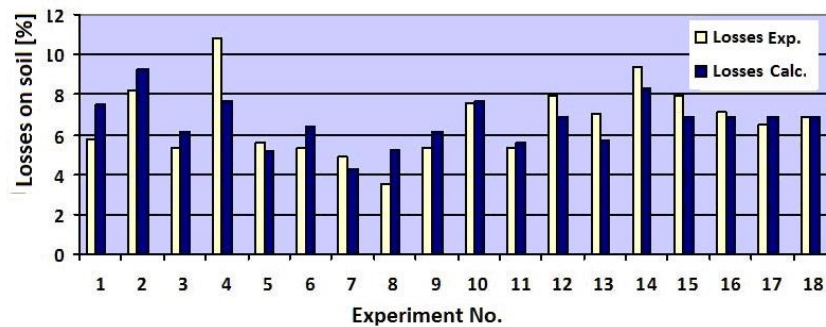


Fig. 4 The rate of the losses on ground for the T2 combs version

Usually, in a process of harvesting the inflorescences of chamomile, the harvesting height H (of working) is determined depending on the disposition height of the inflorescences on plant. At the first passage of the equipment through the field, a smaller working height is used, this being increased for the following crossings. For a working height which is maintained constant, the rate of the harvested inflorescences lost on ground can be determined using functions of two variables, dependent on the working speed ($v_l=x_1$) and by the peripheral speed of the combs ($v_p=x_2$), having the shape:

$$f(x_1, x_2) = a_0 + a_1x_1 + a_2x_2 + a_3x_1^2 + a_4x_1x_2 + a_5x_2^2 \quad (12)$$

Using the values recorded during the experiments from Table 6 and the MathCad software could be determined the constants of the two variables function of the form (12), with which can be studied the variation of the degree of harm of the harvested inflorescences at the working height $H = 0.3\text{m}$ for the variants V1 and T2 of the combs, as well as for the height $H = 0.45\text{m}$. [20]

Table 6

Experimental values of losses on soil for V1 and T2

Crt. No.	Working speed v_l [km h ⁻¹]	Combs peripheral speed v_p [m s ⁻¹]	Losses rate on soil [%] for V1 at H=0.3m	Losses rate on soil [%] for T2 at H=0.3m	Losses rate on soil [%] for V1 at H=0.45m	Losses rate on soil [%] for T2 at H=0.45m
1	0.5	0.52	17.5	8	13.6	5.3
2	0.5	0.76	17	5.8	11.4	4.9
3	0.5	1.08	17.1	5.3	11.8	4.9
4	0.76	0.52	19.3	5.6	14.2	5.1
5	0.76	0.76	17.5	9.4	14.4	5.3
6	0.76	1.08	11.4	7.9	12.7	4.7
7	1.04	0.52	19.2	7.0	15.1	6.9
8	1.04	0.76	17.1	13.0	14.4	6.2
9	1.04	1.08	17.3	9.4	13.6	8.3
10	1.22	0.52	19.6	7.8	11.0	10.8
11	1.22	0.76	15.4	8.2	11.4	7.7
12	1.22	1.08	16.9	7.6	11.7	3.9

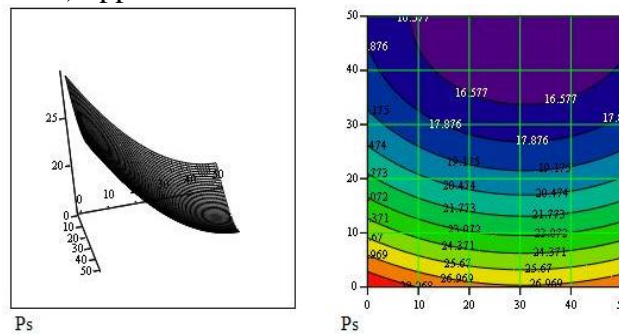
For the losses on soil corresponding to V1 at H = 0.300m, for a correlation coefficient R=0.67, the function (12) has the shape:

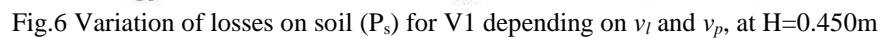
$$P_s(v_l, v_p) = 29.567 - 6.52v_l - 21.764v_p + 4.333v_l^2 + 0.009009v_lv_p + 9.998v_p^2 \quad (13)$$

For the losses on soil corresponding to V1 at H=0.450m, for a correlation coefficient R=0.879, the function (9.26) has the shape:

$$P_s(v_l, v_p) = 6.134 + 29.683v_l - 8.942 \times 10^{-3}v_p - 19.821v_l^2 + 4.868v_lv_p + 1.767v_p^2 \quad (14)$$

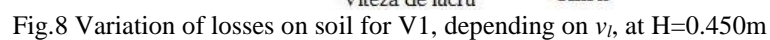
Figs. 5 and 6 show the plots representing the variation of losses on soil according to the working speed ($v_l=x_1$) and the peripheral speed of the combs ($v_p=x_2$), at a working height of H=0.300m and respectively of H=0.450m, using the functions given by the relations (13) and (14). On the axes corresponding to these speeds (x_1 and x_2) appears the number of intervals.

Fig.5 Variation of losses on soil (P_s) for V1 depending on v_l and v_p , at H=0.300m



Graph showing the dependence of the percentage of material loss (Ps) on the cutting speed (Viteza de lucru) in Km/h. The y-axis represents Ps [%] from 15 to 30. The x-axis represents Viteza de lucru Km/h from 0 to 1.5. Three curves are shown: $vp1$ (solid red line), $vp2$ (dashed black line), and $vp3$ (dotted black line). All curves show an initial decrease followed by an increase in material loss as cutting speed increases.

Analyzing Fig. 7, it results that for V1 at $H = 0.300\text{m}$, the losses on soil vary by a parabola, the minimum being at a working speed $v_l = 0.35\text{kmh}^{-1}$, for all peripheral speeds of the active bodies. The lowest values are recorded for the highest peripheral speed $v_{p3} = 1.08\text{ ms}^{-1}$.



Analyzing Fig. 8, it results that for V1 at $H=0.450\text{m}$, the losses on soil are ascending. For the peripheral speed $v_{p3}=1.08\text{ ms}^{-1}$, the values are slightly lower. For this height, the losses values are lower than for $H=0.300\text{m}$, at the same working speeds and the same peripheral speeds.

For the losses on soil of inflorescences corresponding to T2 at $H=0.300\text{m}$, for a correlation coefficient $R=0.909$, the function (12) has the form:

$$P_s(v_l, v_p) = -9.433 + 50.307 v_l - 6.252 v_p - 23.362 v_l^2 - 9.045 v_l v_p + 5.813 v_p^2 \quad (15)$$

For the losses on soil of inflorescences corresponding to T2 at $H=0.450\text{m}$, for a correlation coefficient $R=0.774$, the function (12) has the form:

$$P_s(v_l, v_p) = 2.162 + 6.169 v_l + 0.378 v_p + 3.854 v_l^2 - 11.32 v_l v_p - 4.232 v_p^2 \quad (16)$$

In Figs. 9 and 10, it is graphically represented the variation of losses on soil depending on the working speed ($v_l=x_1$) and of the peripheral speed of the combs ($v_p=x_2$), at a working height $H=0.300\text{m}$ and respectively $H=0.450\text{m}$, using the functions given by the relations (15) and (16). On the axes corresponding to these speeds (x_1 and x_2) appears the number of intervals.

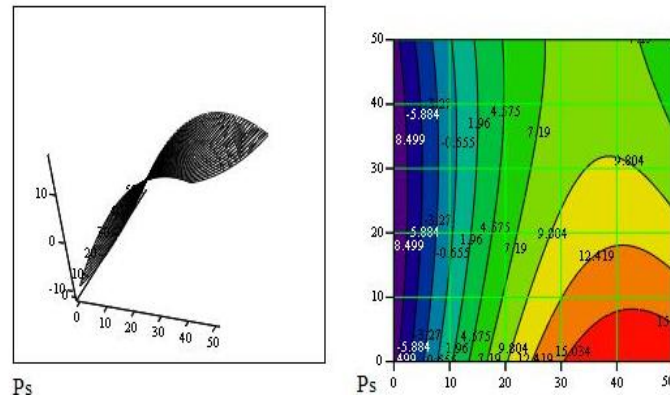


Fig. 9 Variation of losses on soil (P_s) for T2 depending on v_l and v_p , at $H=0.300\text{m}$

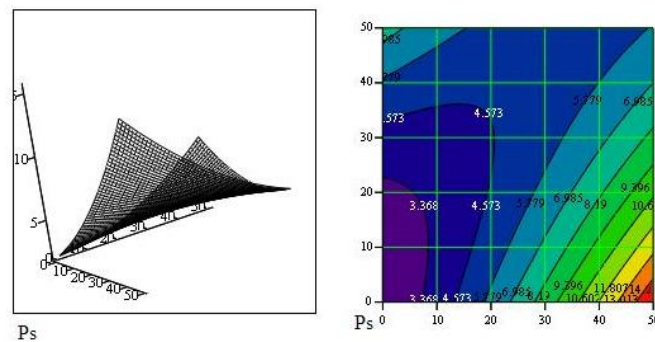


Fig. 10 Variation of losses on soil (P_s) for T2 depending on v_l and v_p , at $H=0.450\text{m}$

In the Fig. 11 and Fig. 12, for the T2 version of combs, corresponding to each heights ($H=0.300\text{m}$ and $H=0.450\text{m}$) was graphically represented the variation of the losses on the ground for each peripheral speed of combs ($v_{p1}=0.52\text{ ms}^{-1}$, $v_{p2}=0.76\text{ ms}^{-1}$, $v_{p3}=1.08\text{ ms}^{-1}$), depending on the working speed, (using the same relations 15 and 16).

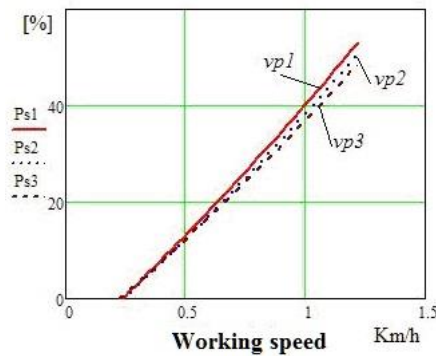


Fig.11 Variation of inflorescences losses on soil for T2, depending on v_l , at $H=0.300\text{m}$

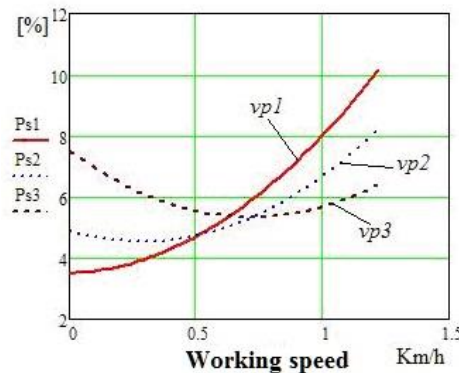


Fig.12 Variation of inflorescences losses on soil for T2, depending on v_l , at $H=0.450\text{m}$

Analyzing Fig. 11, it results that for T2 at the height of harvest $H=0.300\text{m}$, the losses on soil increase with the working speed. For the highest peripheral speed $v_{p3}=1.08\text{ ms}^{-1}$ are recorded slightly lower values.

Analyzing Fig. 12, it results that for T2 at $H=0.450\text{m}$, the losses on soil vary as follows:

- for the working speed $v_l \leq 0.55\text{kmh}^{-1}$ the losses are minimal for $v_{p1}=0.52\text{ ms}^{-1}$;
- for the working speed $0.55\text{kmh}^{-1} < v_l \leq 0.70\text{kmh}^{-1}$ the losses are minimal for $v_{p2}=0.76\text{ ms}^{-1}$;
- for the working speed $0.70\text{kmh}^{-1} < v_l \leq 1.22\text{kmh}^{-1}$ the losses are minimal for $v_{p3}=1.08\text{ ms}^{-1}$.

6. Conclusions

Analyzing comparatively the variation of losses on soil in case of using the V1 and T2 versions of combs scrapers, the following have resulted:

- from the point of view of the rate of the loss on the ground (which should record as lower values), is advantageous the highest peripheral speed of the active bodies ($v_p=1.08\text{ms}^{-1}$);

- for the same working conditions (harvesting height, working speed, peripheral speed of active bodies) the rate of the losses on the ground is smaller in the case of using the variant T2 of combs scrapers than in the case of variant V1;

- in the case of chamomile inflorescences harvesting at the working height $H=0.3\text{ m}$, the losses rate remains low for a low working speed (approx. $v_l=0.55\text{kmh}^{-1}$) and a high peripheral speed of the working bodies ($v_p=1.08\text{ ms}^{-1}$), for the variant T2 being recorded lower values of about. 12%;

- in the case of chamomile inflorescences harvested at the working height $H=0.45\text{ m}$, the losses rate has advantageous values (<6%) for the variant T2, for a working speed of $v_l=0.5\ldots0.7\text{ kmh}^{-1}$ and for the same high peripheral speed of working bodies ($v_p=1.08\text{ ms}^{-1}$);

The results obtained from this analysis of experimental data represents an important *prerequisite in order to achieve effective specialized equipment.*

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