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CONSIDERATIONS ON THE QUALITY OF SOIL DEEP LOOSENING WORKS USING MATHEMATICAL STATISTICS

CONSIDERAȚII ASUPRA CALITĂȚII LUCRĂRILOR DE AFÂNARE ADÂNCĂ A SOLULUI UTILIZÂND ANALIZA STATISTICĂ

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Abstract. *The field surveys were conducted within the North-East development region on moderately inclined terrain. The primary data were obtained from the vertical sections of the ground made perpendicular to the forward direction of the soil tiller. The width of the cross-sections was 2 m and the depth of 1.2 m. The primary data obtained from the measurements of the vertical sections made were subsequently processed mathematically. In order to further verify the significance of the differences occurring within a plot, the use of mathematical methods for analyzing the area, volume and shape of the tiled surface has been attempted, which will allow the researcher a larger number of checks under optimal conditions using the mathematical statistical apparatus.*
Key words: deep soil loosening works, soil, statistical analysis

Rezumat. *Cercetările de teren au fost realizate în cadrul regiunii de dezvoltare Nord-Est pe un teren moderat înclinat. Datele primare au fost obținute din secțiunile verticale de sol realizate perpendicular pe direcția de înaintare a maşinii de afânat solul. Lățimea secțiunilor transversale a fost de 2 m, iar adâncimea de 1,2 m. Datele primare obținute în urma măsurătorilor secțiunilor verticale realizate au fost ulterior prelucrate matematic. În vederea verificării suplimentare a semnificației deosebirilor care apar în cadrul unei parcele s-a încercat utilizarea unor metode matematice de analiză a ariei, volumului şi formei suprafeței afânate ce va permite cercetătorului un număr mărit de verificări în condiții optime folosind aparatul statistic matematic.*
Cuvinte cheie: afânare adâncă, sol, analiză statistică

INTRODUCTION

An important work for setting up vine and tree plantations within horticultural farms is the deepening of the soil to a depth of 50-60 cm. This work can be performed by trenching work or deep loosening without mixing the soil from different horizons. The deep loosening work results in the formation of cracks and irregular cracks in the soil, the modification of the structural aggregates by lateral and surface displacement (Nițu, 1988).

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During the execution of the deepening loosening work, the present water content must be within 60 - 90% of the active humidity range. If this interval is exceeded, deep loosening is not recommended (Oprea, 1979).

The validation of the quality of the deep loosening works can be achieved through the cross sections made perpendicular to the direction of execution of the loosening works.

In this paper we will try to further validate the quality of the loosening work using methods specific to mathematical statistics: the interpolation of the measured points, the means and the dispersions will be compared using the Student test and the Fisher test, respectively.

This paper is in continuation of the study started in 2015 to highlight the effect of the deep loosening works on some morphological and physical properties of the soil (Filipov, 2015).

MATERIAL AND METHOD

The cross-sections of the soil were made perpendicular to the tractor's driving direction with the soil tiller. The width of the cross-sections was 2.5 m and the depth was 1.2 m. The criterion considered in determining the dimensions of the cross-section was to capture the modification of the morphological characteristics of the soil and to assess the quality of the deep soil loosening work based on the instructions in the official methodology for carrying out pedological studies (Florea *et al*. 1987). The delimitation of the tiled surface within the vertical section made through the soil was achieved after the soil was refreshed with the knife and an initial assessment of the morphological indicators of the soil (Colibas, 2000). The study of soil resources was carried out in the tree plantation, cleared out in order to re-establish a new vineyard plantation. In the area taken into consideration, deep loosening work was carried out.
Statistical analysis was performed taking into account a standard working model for MAS-60 and soil profiles that were performed in the field. The sampling points were analyzed by means of statistical functions from the MS Excel 2016 program.
The surface and area model of the standard of the loosening equipment was used as a control (fig. 1) MAS 60.

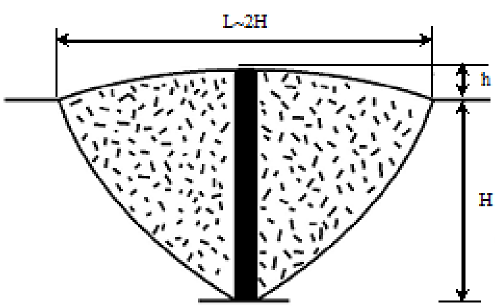

Fig. 1 The shape of the reference cross-section resulting from the work with the soil tiller (MAS-60) - Working width of the machine (L) Working depth of the machine (H); the height between the maximum elevation of the loose soil surface and the elevation of the soil surface that has not been modified (h)

RESULTS AND DISCUSSIONS

We will use the values of the nodes measured on the model (see table 1) in order to determine the coefficients of the interpolation polynomial.

Table 1

Standard profile

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
x	0	10	20	30	40	50	60	70	80	90	100
y measured	0	-17	-28	-37	-45	-50	-45	-37	-28	-17	0
y* calculated	0.441	-16.406	-29.508	-38.867	-44.482	-46.354	-44.482	-38.867	-29.508	-16.405	0.441

The found polynomial helps us approximate the standard form of loosening:

$$L(x) = 0.018718\, x^2 - 1.871795\, x + 0.440559 \qquad (1)$$

The mathematical calculation indicates that this function is a very good approximation of the chosen model because the coefficient of determination is $R^2 = 0{,}991$. Next we will use this polynomial to see how large the variations in other soil profiles are, compared to the chosen model (fig. 2).

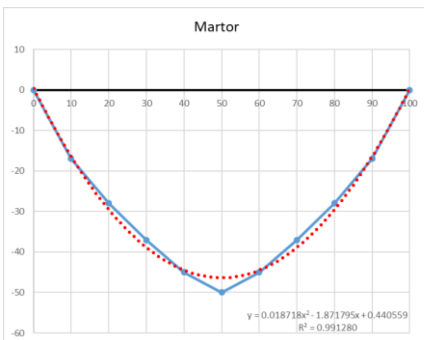

Fig. 2 Interpolation function with degree 2 polynomial Standard profile (Control)

Soil profile 1 (fig. 3)

Fig. 3 The loose soil surface in the first section

Table 2

Soil profile 1 (fig. 4)

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
x	3	25	39	42	50	57	62	67	69	79	86	95	100	101
y measured	-18	-21	-24	-43	-50	-52	-50	-41	-28	-20	-15	-13	-5	0
y calculated	-5.01	-34.66	-44.09	-45.16	-46.35	-45.44	-43.66	-40.94	-39.60	-30.61	-22.10	-8.45	0.44	2.33

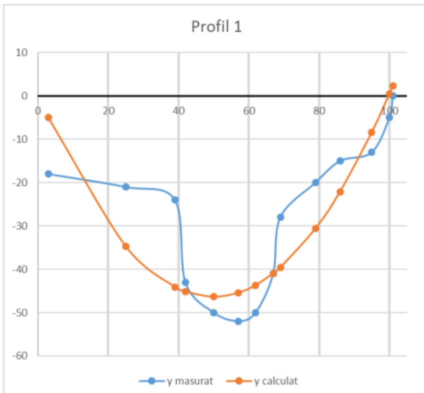

Fig. 4 Soil profile 1 – interpolation nodes measured vs. calculated

We gathered in the tables the measured data together with the data calculated using the interpolation polynomial (1): thus for profile 1 in table 2 and for profile 2 in table 3. The results were compared using the Fischer and Student statistical tests and we graphically represented the evolution of the points. This style of work allows a researcher to be able to use the resulting polynomial as a model for different sections obtained from different specific equipment for deep soil loosening works.

Soil profile 2 (fig. 5)

Fig. 5 The loose soil surface within the second cross-section

Table 3

Soil profile 2 (fig. 6)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
x	2	13	18	25	38	50	52	54	58	64	68	83	95	101
y measured	-3	-3	-6	-18	-28	-25	-37	-48	-53	-51	-40	-35	-25	0
y calculated	-3.23	-20.73	-27.19	-34.66	-43.66	-46.35	-46.28	-46.05	-45.16	-42.69	-40.29	-25.97	-8.45	2.33

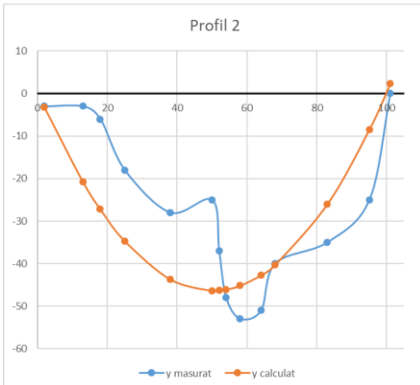

Fig. 6 Soil profile 2 – interpolation nodes measured vs. calculated

An analysis with the Ficher test is desired if the variance of the two selections is equal (Stoleriu, 2010).

The first data were chosen by sampling from the model (y - measured), and the second set of data was calculated using the interpolation polynomial obtained from the standard profile (y - calculated).

The data was assembled into a table: alternative σ_1^2 şi alternative σ_2^2.

The null hypothesis: $H_0 : \sigma_1^2 = \sigma_2^2$

Alternative hypothesis: $H_1 : \sigma_1^2 \neq \sigma_2^2$

Testing stages:

1. A level of risk is chosen $\alpha = 0.05$ equivalent to a level of significance $1-\alpha$ and 11 measurements are performed.
2. A selection from each population is chosen $x_1, x_2, \ldots, x_{11}$ and $y_1, y_2, \ldots, y_{11}$.
3. A confidence interval is built for σ_1^2 / σ_2^2 for the level of significance $1-\alpha$ (Chiruță, 2019).

If the value *1* is found in the confidence interval then we accept the hypothesis H_0 (the variances are equal) if we do not reject the hypothesis H_0 (the variances are different). Similarly, using the Student test, data from the two sets were analyzed, to verify that they have equal averages. The results are presented in the following table (tab. 4):

Table 4

P values

	Fisher Test (Pv)	Student Test (Pv)
Profile 1	0.4001	0.4032
Profile 2	0.3970	0.2776

CONCLUSIONS

1. For profile 1, following the evaluation with the help of the statistical tests, we observed that the measured data have a different distribution from the data calculated with the help of the interpolation polynomial (the null hypothesis is not accepted) but they have equal averages (the null hypothesis is accepted).

2. For profile 2, the measured data have a distribution equal to the data calculated using the interpolation polynomial (the null hypothesis is accepted) and the equal averages (the null hypothesis is accepted).

3. Following the statistical analysis it was found that although the profiles are different in form (the variance determined by points is different) on average they are significantly equal to the proposed standard. Therefore, the loosening performed and analyzed for the two profiles obeys the imposed standard.

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