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Determination of Soil Moisturization Dynamics Four Factor Experience

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Abstraction: This article presents a method for using a full factorial experiment to determine soil moisture dynamics, which provides research data to ensure the validity of an experiment based on four factors. We have studied four factors affecting the dynamics of the soil moisture perimeter. Those, tillage depth, dropper flow rate, irrigation duration and bulk density of the soil. Changing any of these values will change the perimeter of water absorption and soil moisture.

Keywords: A complete factorial experiment (CFE), calculation of soil moisture perimeter, soil moisture, dropper flow, watering duration, tillage depth, bulk soil mass, intensive garden,

A complete factorial experiment (CFE) is an experiment in which all possible repetitive combinations of n independently controlled factors are performed **,** each of which changes at two levels. In this case, the influence of the process under study on the response function takes into account their interaction, and not all factors taken into account in the experiment.

Based on the above (in the square $Re = Re_{gr}$), we can write:

$\mathbf{h/b = f(q, \rho, h_K, t)}$ (1.1)

where: **q** is the flow rate of dripping water, l / s; **ρ -** soil density, kg/m^3 ; $\mathbf{h_K}$ - processing depth, m; **t is** the operating time of the dropper, hours.

In addition, methodological experiments make it possible to determine that the interdependence of these characteristics is not integral. The planning and implementation of a full-factor experiment is carried out with their responses, and not with specific characteristics, if necessary, taking into account the continuity of the model and bringing it into the desired form.

The design should select symmetrical experimental points relative to the zero level or center of the experiment and separated from it by another intermediate value. The choice of the amount of change is determined by two conditions:

It must ensure that the factor level is not less than the detected error (otherwise the conditions do not differ) and that its maximum value ensures that all values obtained in the experiment fall within its definition. Proceeding from this, on the basis of preliminary experiments on a mathematical model, an interval of variation (interval) determined by the specific properties of soil moisture and the similarity of this phenomenon was obtained.

To get a linear model defined by the equation, it is enough to change two levels of factors - the maximum and minimum. In this case, experiments are defined by the following general formula:

N = PK (1.2)

Where: **P** is the number of levels of variability; **K** is the number of factors involved in the experiment, so the number of factors studied as usual is $N = 2^4 = 16$. In this case, all possibilities of

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combining the level of factors are realized, which is a characteristic feature of this model. an experiment with a full coefficient (multiplier).

To simplify the recording of the experimental conditions and processing, the data on the factors were selected in such a way that the high level was +1, -1, and the base level corresponded to zero. For factors with a continuous region observed under our conditions, using these experiments, we can do the following:

$$X_J = \frac{x_J - x_{JO}}{\Delta x_J} \qquad (1.3)$$

Where: **J-** serial number; $\mathbf{X_J}$ - coded value of the coefficient; x_J - natural value of the factor; x_{JO} - natural value of the base level; Δx_J - factor variation interval. The factors at all levels shown in Table 1 represent the design matrix, in which the rows correspond to the various experiments and the columns correspond to the factor values.

Table 1 Condition for carrying out a four-factor experiment

Option No.	Natural value				Code value				hour	b	Y	
	X4 = q	X1 = p	X2 = h	X3 = t	x_1	x_2	x_3	x_4				
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*
1	8	1.52	0.3	20	+1	+1	+1	+1	1.13	1.22	28.9	25,7
2	8	1.52	0.3	10	+1	+1	+1	-1	0.86	1.08	28.4	23.2
3	8	1.52	0.15	20	+1	+1	-1	+1	1.10	1.21	22.3	20.6
4	8	1.52	0.15	10	+1	+1	-1	-1	0.83	1.05	20.2	17.6
5	8	1.22	0.3	20	+1	-1	+1	+1	1.27	0.76	34,7	31.2
6	8	1.22	0.3	10	+1	-1	+1	-1	1.06	0.64	30.1	29.7
7	8	1.22	0.15	20	+1	-1	-1	+1	1.12	0.77	29.7	26.8
8	8	1.22	0.15	10	+1	-1	-1	-1	1.05	0.66	28.3	25,7
9	2	1.52	0.3	20	-1	+1	+1	+1	1.05	0.98	28.7	26.4
10	2	1.52	0.3	10	-1	+1	+1	-1	0.83	0.88	27.5	25.6
11	2	1.52	0.15	20	-1	+1	-1	+1	0.98	0.96	26.2	25.3
12	2	1.52	0.15	10	-1	+1	-1	-1	0.81	0.86	25,7	23.8
13	2	1.22	0.3	20	-1	-1	+1	+1	1.13	0.77	29.4	26.1
14	2	1.22	0.3	10	-1	-1	+1	-1	0.96	0.62	32.8	28.7
15	2	1.22	0.15	20	-1	-1	-1	+1	1.09	0.71	28.1	25.3
16	2	1.22	0.15	10	-1	-1	-1	-1	0.93	0.61	298	27.1

Building an experimental design following the above scenarios will allow you to get a model with some functions that will later be used in calculations. This includes:

symmetry property.

$$\sum_{I=1}^{N} X_{JI} = 0 \qquad (1.4)$$

Here: **J** - factor number, **I -** experiment number;

normalization mode:

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$$\sum_{I=1}^{N} X_{JI}^{2} = N \qquad (1.5)$$

orthogonal attribute of the planning matrix:

$$\sum_{I=1}^{N} X_{JI} X_{UI} = 0 \qquad (1.6)$$

Where: **J ≠U,J,U = 1,2,3, ... K.**

When determining the soil moisture perimeter, a linear mathematical model was adopted, in which the natural logarithms of the initial soil absorption properties of water were taken as the previously determined coefficients X_1, X_2, X_3, X_4. The general form of expressions can be determined by the formulas:

$$Y=B_0+B_1X_1+B_2X_2+B_3X_3+B_4X_4+B_{12}X_1X_2+B_{13}X_1X_3+B_{14}X_1X_4+B_{23}X_2X_3+B_{24}X_2X_4+B_{34}X_3X_4+B_{123}X_1X_2X_3+B_{124}X_1X_2X_4+B_{134}X_1X_3X_4+B_{234}X_2X_3X_4+B_{1234}X_1X_2X_3X_4 \qquad (1.7)$$

To calculate the values of the **BJ** coefficients, a full factorial experiment was carried out, during which a combination of all factors was performed.

Table 2. Full planning factor for full factorial experience

No.	X_0	X_1	X_2	X_3	X_4	X_1X_2	X_1X_3	X_1X_4	X_2X_3	X_2X_4	X_3X_4	$X_1X_2X_3$	$X_1X_2X_4$	$X_1X_3X_4$	$X_2X_3X_4$	$X_1X_2X_3X_4$
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
2	1	1	1	1	-1	1	1	-1	1	-1	-1	1	-1	-1	-1	-1
3	1	1	1	-1	1	1	-1	1	-1	1	-1	-1	1	-1	-1	-1
4	1	1	1	-1	-1	1	-1	-1	-1	-1	1	-1	-1	1	1	1
5	1	1	-1	1	1	-1	1	1	-1	-1	1	-1	-1	1	-1	-1
6	1	1	-1	1	-1	-1	1	-1	-1	1	-1	-1	1	-1	1	1
7	1	1	-1	-1	1	-1	-1	1	1	-1	-1	1	-1	-1	1	1
8	1	1	-1	-1	-1	-1	-1	-1	1	1	1	1	1	1	-1	-1
9	1	-1	1	1	1	-1	-1	-1	1	1	1	-1	-1	-1	1	-1
10	1	-1	1	1	-1	-1	-1	1	1	-1	-1	-1	1	1	-1	1
11	1	-1	1	-1	1	-1	1	-1	-1	1	-1	1	-1	1	-1	1
12	1	-1	1	-1	-1	-1	1	1	-1	-1	1	1	1	-1	1	-1
13	1	-1	-1	1	1	1	-1	-1	-1	-1	1	1	1	-1	-1	1
14	1	-1	-1	1	-1	1	-1	1	-1	1	-1	1	-1	1	1	-1
15	1	-1	-1	-1	1	1	1	-1	1	-1	-1	-1	1	1	1	-1
16	1	-1	-1	-1	-1	1	1	1	1	1	1	-1	-1	-1	-1	1

The experiment must ensure that the influence of the random parameters of the process under study on the response function is minimized. To minimize the impact of the experiment on the results, the following requirements must be met:

- conducting several parallel experiments under the same conditions provided in the corresponding row of the planning matrix (experiment number);

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- it is necessary to classify the parameters of an uncontrolled process, i.e. ensure their mutual compensation.

To satisfy the first requirement, at least two parallel experiments must be carried out, and their number must be increased to ensure high reliability of the results. In our case, the repeatability of the experiments was n = 4.

In this case, the results of n parallel experiments for each row of the planning matrix were averaged, and when analyzing the experimental results, the response function and the average value corresponding to the experimental conditions were calculated using the following formula:

$$\bar{Y} = \frac{\sum_{i=1}^{n} Y_i}{n} \qquad (1.8)$$

To minimize the influence of external variables, not included in the design, but affecting the experiment, the experimental design was evaluated in a random way, that is, the levels of the variables and the sequence of experiments were chosen at random in accordance with some unregulated rules. All these experiments made it possible to more or less distribute the influence of external factors on conditions.

Uncertainty of the response surface can also be related to the degree of influence of one factor on another. In this case, an interaction effect occurs. Table 3 shows the measured and average values of the logarithms of the resistance coefficient of the combined perimeter of the experiment:

Y = lnξ.

The arithmetic mean variables in each row of the matrix are determined by the following formula:

$$S_I^2 = \frac{\sum_{I=1}^{m} \left[\bar{Y}_1 - Y_1\right]^2}{m-1} \qquad (1.9)$$

Because even one big error can skew the test results, it is important to control the reproducibility of the test results. The homogeneity of variances is checked using the Cochrane test. Application of dependencies to (5) and (6) is limited to observance of experiments S_I^2 in case of homogeneity of differences in the exact factorial experiment.

h = f (q, ρ, h $_K$, t) for the variant

C= 0.0071224 / 0.026618 = 0.268 (1.10)

b = f (q, ρ, h $_K$, t) for the variant

$$G_{\max} = \frac{S_{I\,\max}^2}{\sum_{i=1}^{N} S_{I\,i}^2} = 0.0052336 / 0.022722 = 0.230 \ (1.10a)$$

For a typical combined region, where the largest coefficient of change is the sum of the differences of all experiments with the critical Cochrane number as a function of the number of degrees of freedom (m = 3 and k = 16-1 = 15 G_{KR} = 0.373), G_{MAX} <Gcn. On the homogeneity of dispersions.

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When processing a full factor experiment, the number of effects that can be obtained from the columns of factor products using the rules for multiplying the columns is calculated. When calculating the coefficients corresponding to the interaction, the same dependencies are applied to any single variable.

It should be borne in mind that the measures taken (watering time, cultivation depth, watering time, etc.) do not affect the main characteristics of the planning matrix for studying the dynamics of soil moisture. In connection with the above, a review of the equation of the corresponding adopted model of this experiment

The processing of experimental data is often carried out using the best squares method, which gives the following formula for calculating the coefficients of the polynomial (4), taking into account the orthogonality of the graph.

$$B_J = \frac{\sum_{I=1}^{N} (\bar{Y})_I X_{IJ}}{N} \qquad (1.11)$$

You are here: **(Y)$_I$** - **I** -tajribadagi mean deviation, **I am** testing the combined number (variant), the normal test zone can range from 1 to 16.

After calculating the coefficients, their importance is assessed for determining the parameters of the impact of various factors and the degree of impact (response function). In this case, using the t-test (Student's test), the hypothesis about the insignificance of the considered coefficient is tested, i.e., about the value of $\mathbf{b_i = 0}$ *(zero hypothesis test). The parameter value is determined by the following formula:*

$$t_i = \frac{b_i}{\sqrt{S^2_{ОШ}}} \qquad (1.11a)$$

S_{osh}^2 - *When* planning orthogonal experiments, variations in the errors in determining each of the coefficients are equal to each other.

$$t_i = \frac{b_i}{\sqrt{S^2_{ОШ}}} \qquad (4.1.11b)$$

S_{vosp}^2 is the reproducibility distribution resulting from the overall variability of S_J^2 for each experiment .

$$S^2_{восп} = \frac{\sum_{I=1}^{N} S_I^2}{N} \qquad (1.12)$$

The calculated value of the **t-** criterion is compared in the form of a table with n specified levels of reliability and compliance. The reliability of simple engineering calculations is limited to 95% or 99%. The number of experiments and their repetition m determines the number of degrees of freedom N.

$n = N(m-1)$ (1.12a)

The **t-** criterion value gives 2.68 for 16 experiments with 48 measurements in four iterations with 99% confidence.

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Similarly, as mentioned above, the coefficients of the combination of factors were calculated.

For independent variables, the coefficients indicate the degree of influence of factors. The greater the number of coefficients, the greater the impact on this factor. In some cases, the measures resulting from the influence of the independent variable on the model do not go beyond the natural variability of experimental data resulting from measurement errors.

The results of calculating $t_J \geq t_{cn}$ can be simplified in the original mathematical model, since the significance of factors and interactions in the experimental area under consideration does not exceed measurement errors. Using the properties of symmetry, normalization, dictation of the planning matrix, we get the encoded values to create a complete factorial design of the experiment that allows us to use the remaining facts.

For the option **h = f (q, ρ, h $_K$, t)** :

$$Y = 0.038X_1 - 0.065X_2 + 0.022X_3 + 0.096X_4 + 0.026X_2X_4$$

For option **b = f (q, ρ, h $_K$, t)** :

$$Z = -0.334+0.110X_1+0.274X_2+0.026X_3+0.076X_4+0.077X_1X_2-0.043X_1X_4+0.064X_2X_4+0.033X_1X_2X_4$$

Then we performed decoding according to the formula (4) $x_J = \Delta x_J X_J + x_{JO}$.

$$1.003q\ h = ^{0.0548} \rho^{0.6825\ln(t) - 2,4} h_k^{0.0635} t^{0.0662} \quad (1.12b)$$

$$b = 3.056\ q^A \rho^B h_k^{0.003} t^{-0.261} \quad (1.12v)$$

where: A = 4.1384 *ln* (ρ) + 0.386 *ln (t) - 1.129 - 1.25 ln* (ρ) *ln (t)*

B = 1.7328 ln *(t)* - 7.3295

We check the correspondence of the obtained equation. We calculate the magnitude of the errors $\Delta\xi = \xi_{CP} - \xi_P$ *and calculate the values, the results of which are shown in Table 6. We also calculate the compatibility differential*

$$S_{a\partial}^2 = \frac{\sum_{I=1}^{m}\left[\overline{Y}_1 - Y_{расч}\right]^2}{N-(k+1)} = \frac{\sum_{I=1}^{m}\Delta Y^2}{N-(k+1)} \quad (1.13)$$

Compliance testing using Fisher's test **F** reproductive variation of the corresponding $\mathbf{F_{KR}}$ can be carried out by comparing the number of tests.

$$F = \frac{S_{a\partial}^2}{S_{восп}^2} \leq F_{KP} \quad (1.14)$$

For the option **h = f (q, ρ, h $_K$, t)** :

$S_{ad}^2 = 0.0111$; $S_{rep}^2 = 0.003686$; $F = 3.01$;

For option **b = f (q, ρ, h $_K$, t)** :

$S_{ad}^2 = 0.0372$; $S_{rep}^2 = 0.00671$; $F = 5.54$;

$\nu_1 = \mathbf{16}$, $\nu_2 = \mathbf{64}$, when the value of the criterion **F** is 95%, $\mathbf{F_{KR} = 8.74}$. A critical comparison of the calculated number shows that in the range of variation of these factors, this phenomenon is

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consistent with the formulas of the approved mathematical model (1.9), which can be recommended for determining the coefficient of interaction of aggregate factors.

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