

Soil Descriptive Parameters and Properties – Interdependence Relationships and Variation Models

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Abstract. The study aimed to evaluate the soil descriptor parameters in the case of agricultural land in the pasture category, non-irrigated system, and to evaluate the variation of soil agrophysical properties in relation to textural components. The study area was located within the ATU Ciacova, Timis County, Romania. The soils identified in the study plot were of the type Eutricambosol weakly gleyed, weakly sodicized, and Eutricambosol gleyic, moderately gleyed. The following parameters were considered for the soil characterization: Coarse sand (CS, %), Fine sand (FS, %), Dust (Dst, %), Colloidal clay (CC, %), Physical clay (PC, %), Specific density (SD, g/cm³), Apparent density (SD, g/cm³), Total porosity (TP, %), Aeration porosity (AP, %), Compaction degree (CD, %), Hygroscopicity coefficient (HygC, %), Withering coefficient (WC, %), Field capacity (FC, %), Total capacity (TC, %), Usefull water capacity (UWC, %), and Hydraulic conductivity (HydC, mm/h). The data series showed normal distribution. High variability was recorded for CS and HydC, moderate variability for AP and CD, and low variability for the other parameters and indices. The variable interdependence in intensity and direction of action was recorded between the soil descriptor parameters considered. Parameters HygC, WC, FC, which express the hydrophysical properties of the soil, presented, according to Ordinary Least Squares Regression (OLSR), positive distribution, with Slope $a = 0.2425$, $r^2 = 0.8854$ in the case of HygC, respectively with Slope $a = 0.3635$, $r^2 = 0.8861$ in the case of WC. Under the same analysis conditions, the UWC parameter values presented a negative distribution, with Slope $a = -0.2895$, $r^2 = 0.8113$. Polynomial models described the variation of the HygC, WC, FC and UWC parameters in relation to the soil textural components, in conditions of statistical safety.

Keywords: PCA, soil hydrophysical properties, soil parameters, regression analysis, trend model

INTRODUCTION

Soil is the result of the pedogenesis process, through which the “solid-phase lithomatrix” (parent material) was transformed into the “pedomatrix” (soil mantle, soil body), under the influence of pedogenesis factors (Targulian and Krasilnikov, 2007). The pedogenesis process, in relation to local specifics, has led to the formation of different soil types, each soil type (soil body) being the result of a certain combination of specific pedogenetic processes (Targulian and Krasilnikov, 2007; Lin, 2011; Hu et al., 2021).

Depending on the specifics of the pedogenesis process, horizons with specific physical, chemical and biological properties have been differentiated on the soil profile (Li et al., 2021; Luo et al., 2024).

Soil texture represents basic input parameters for models describing and studying the Earth system (Liu et al., 2022; Reddy and Gopinath, 2025).

Physical soil parameters are important for crop productivity, ecosystem sustainability and environmental quality (Reynolds et al., 2002; He et al., 2023). Crop plants have different requirements for physical soil parameters (Oliver et al., 2013).

The hydrophysical properties of soils vary in relation to the parent materials, relief conditions, climate and vegetation cover that contributed to the formation of the soil (Gökbülak and Özcan, 2008). Land use also influences the hydrophysical properties of the soil (Alhassan and Askira, 2021). The variation of the hydrophysical properties of the soil was evaluated, in the medium and long term, under the conditions of integrated agricultural systems “crops - animals” (Dhaliwal and Kumar, 2021).

The soil water regime is closely dependent on soil texture elements, and the sensitivity of ecosystems to moisture is shaped by soil texture (Wankmüller et al., 2024). Soil texture influences the nutrient regime in the soil and its availability to plants (Ye et al., 2024).

Soil hydrophysical properties influence soil-water dynamics, soil nutrient cycling, soil health, and have been considered “critical determinants” of agricultural ecosystem sustainability and ecosystem resilience (Mítrová et al., 2025; Vidana Gamage et al., 2025).

Climate is one of the main factors in the pedogenesis process, and climate change influences soil functionality (Filho et al., 2025). Soil functionality can be affected by climate change directly (thermal regime, rainfall regime, soil water regime) and indirectly (irrigation, crop structure and rotation, soil works), with an impact on the sustainability of crops, farms and farmers (Hamidov et al., 2018). The impact of climate change,

agricultural practices and cropland management was assessed in relation to soil integrity as a multifunctional system (Sünnemann et al., 2023). Soil dynamics, the "soil - plants - atmosphere" relationship, climate stress and plant response, direct and feedback phenomena have been studied in relation to climate change (Oishy et al., 2025). The performance of agricultural and horticultural ecosystems was analyzed, by considering some approach strategies, and the use of genotypes with a high level of adaptation and tolerance to climate change, including by reconsidering local germplasm where possible (Dobrei et al., 2015; Raza et al., 2019; Chandio et al., 2025; Ricart et al., 2025).

Different models have been found to describe the variation of soil properties in relation to climate change and anthropogenic activities (Filippi et al., 2016; Mesfin et al., 2021; Schlutow et al., 2021). The hydrophysical properties of the soil were analyzed through modeling in relation to different soil parameters under the influence of climate change (Polláková et al., 2021; Bovi et al., 2022; Bargués-Tobella et al., 2024; Ishola et al., 2025).

The purpose of this study was to determine the interdependence between the descriptive indices of the soil profile and to describe through mathematical models the variation of hydrophysical indices in relation to soil textural parameters, under the conditions of an agricultural land in the pasture category.

MATERIAL AND METHODS

The soil profiles analyzed in this study were located in the ATU Ciacova area, Timis County, Romania, on an agricultural area in the pasture category, according to Figure 1, generated based on ESRI (2025). At a large scale, the study area is located in the Western Plain of Romania, in the eastern compartment of the Pannonian Depression. At a small scale, the area is located in the Timis Plain, with good hydrological vascularization, given by the Timis and Bega rivers and their tributaries.

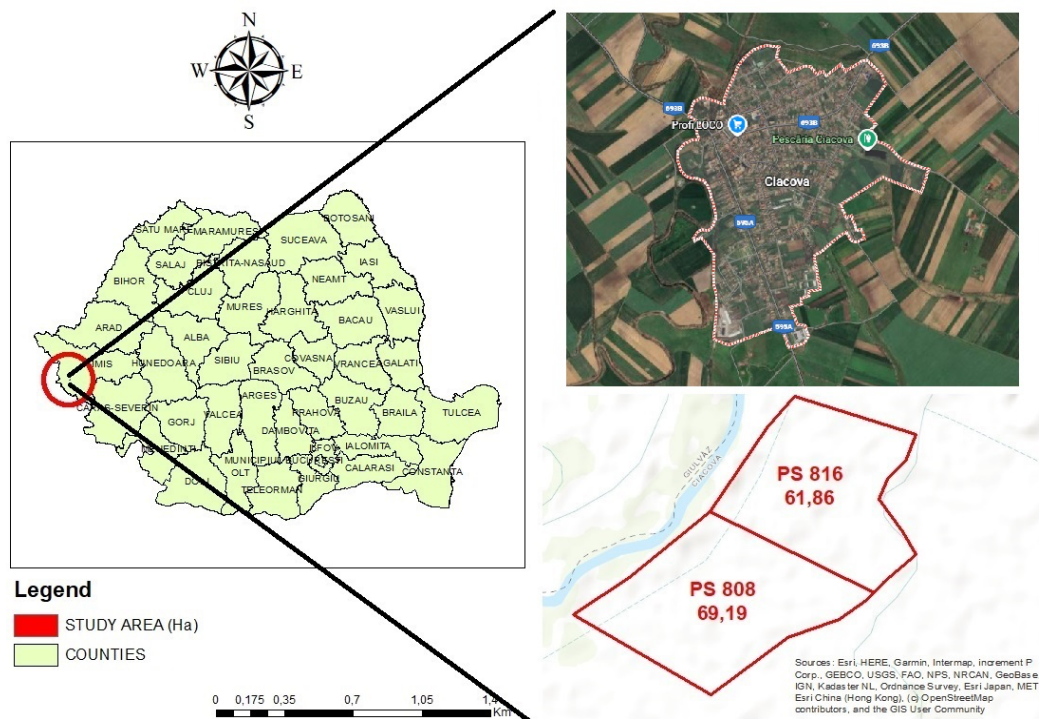


Figure 1. Study location, ATU Ciacova, Timis County, Romania

The overall relief is a flat expanse, and the microrelief presents high spatial variability, with alternation of positive and negative relief shapes at a small scale. With a water table at depth that influenced pedogenetic processes, the groundwater, through variations over time, led to a high diversity of soils over time.

Three soil profiles were considered in the study area (Bertici et al., 2022, 2024, 2025). The agricultural land was in the pasture category. Fertilization with pig slurry was applied annually (first decade of April), at a dose of 80 m³/ha/year.

The soils identified in the study area were of the sodicized Eutricambosol, weakly gleyed, weakly sodicized, and gleyic Eutricambosol, moderately gleyed types. In relation to the purpose of the study, the following soil profile characterization parameters were considered: Coarse sand (CS, %), Fine sand (FS, %),

Dust (Dst, %), Colloidal clay (CC, %), Physical clay (PC, %), Specific density (SD, g/cm³), Apparent density (SD, g/cm³), Total porosity (TP, %), Aeration porosity (AP, %), Compaction degree (CD, %), Hygroscopicity coefficient (HygC, %), Withering coefficient (WC, %), Field capacity (FC, %), Total capacity (TC, %), Usefull water capacity (UWC, %), and Hydraulic conductivity (HydC, mm/h).

The study analyzed the interdependence between soil characterization parameters and the variation of parameters that define the soil water regime, in relation to parameters that define soil texture. Correlation analysis (Pearson's r) was used to find out the interdependence between the indices considered for soil characterization. Quadratic regression analysis was used to evaluate the variation of HygC, WC, FC, and UWC indices in relation to CS, FS, Dst, CC, and PC in different combinations.

The flow chart, Figure 2, was used to conduct the analysis. PAST software (Hammer et al., 2001), JASP software (2022) and Mathematica software (2024) were used for statistical data analysis and graph generation.

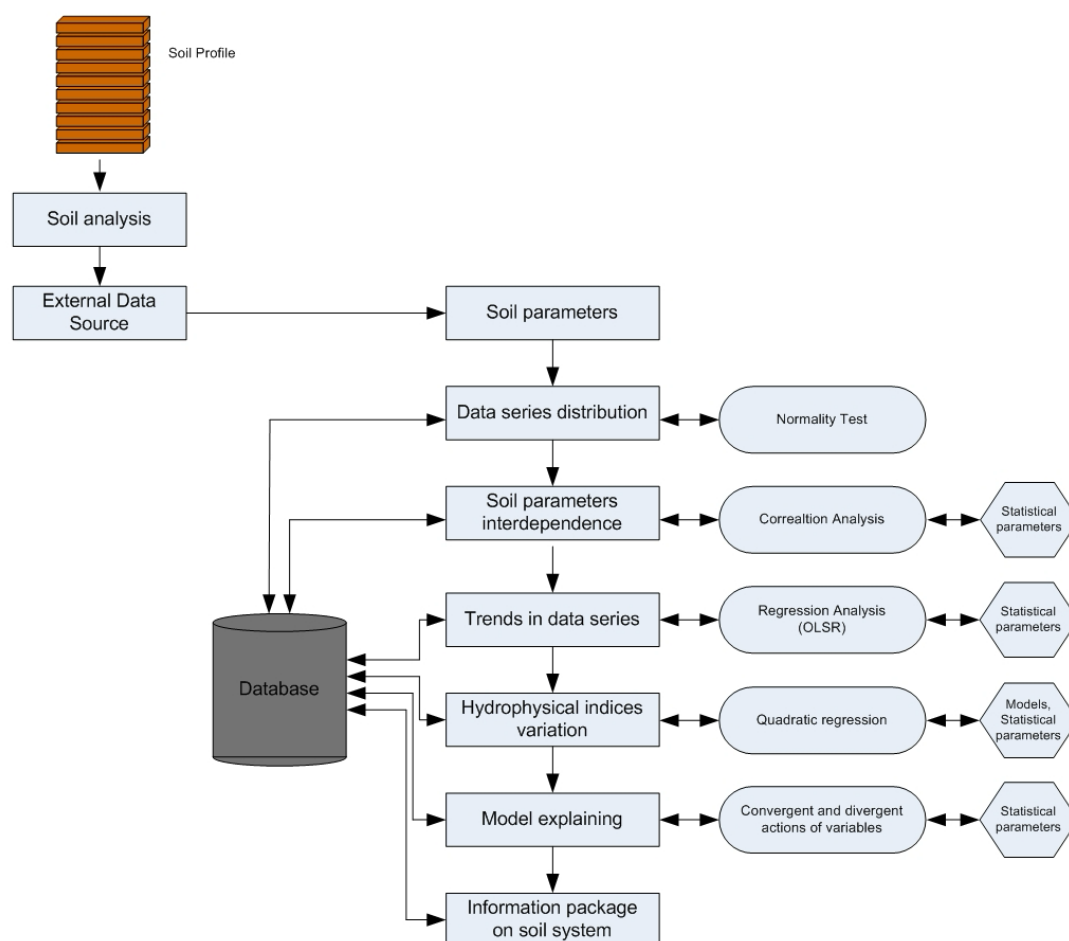


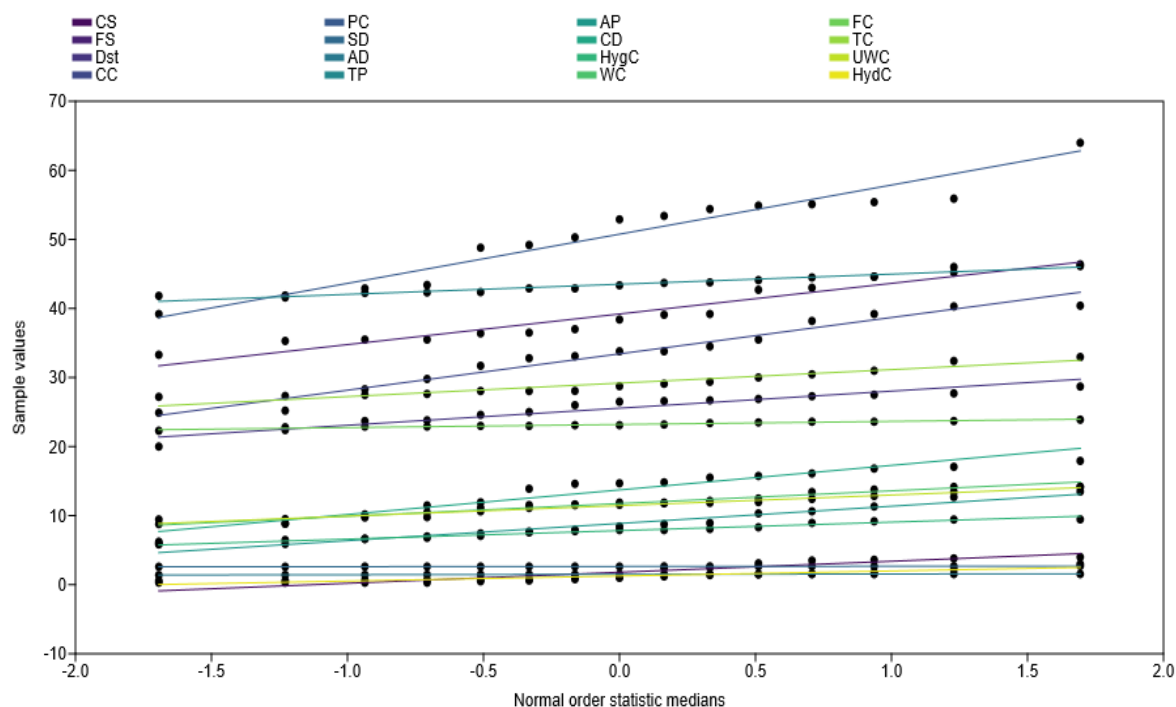
Figure 2. Study flow chart

RESULTS AND DISCUSSIONS

Descriptive statistical analysis of the index values on the soil profile led to the results in Table 1. According to the coefficient of variation (CV) values, low variability was recorded in the case of fine sand parameters ($CV_{FS} = 10.60$), dust ($CV_{Dst} = 9.07$), colloidal clay ($CV_{CC} = 14.76$), physical clay ($CV_{PC} = 13.15$), Specific density ($CV_{SD} = 1.10$), aparent density ($CV_{AD} = 3.07$), total porosity ($CV_{TP} = 3.15$), hygroscopicity coefficient ($CV_{HC} = 14.71$), withering coefficient ($CV_{WC} = 14.69$), field capacity ($CV_{FC} = 1.80$), total capacity ($CV_{TC} = 6.28$), usefull water capacity ($CV_{UWC} = 12.55$), and soil pH ($CV_{pH} = 7.58$). Moderate variability was recorded for the parameters aeration porosity ($CV_{AP} = 26.36$), and compaction degree ($CV_{CD} = 24.29$), and high variability was recorded for the parameters coarse sand ($CV_{CS} = 83.04$) and hydraulic conductivity ($CV_{HC} = 54.17$). The data series showed normal distribution, Figure 3.

Table 1. Descriptive statistics for soil profile values, pasture category, ATU Ciacova

Parameter	Soil profile parameters																
	CS	FS	Dst	CC	PC	SD	AD	TP	AP	CD	HygC	WC	FC	TC	UWC	HydC	pH
N	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15
Min	0.30	33.30	20.00	24.90	39.20	2.60	1.40	41.83	5.98	6.22	5.84	8.77	22.30	27.20	9.45	0.60	6.42
Max	4.00	46.40	28.70	40.40	64.00	2.70	1.54	46.15	13.49	17.93	9.46	14.19	23.90	32.97	14.14	3.00	8.21
Sum	27.00	588.10	383.40	501.50	761.40	39.65	22.40	652.69	133.06	205.83	117.53	176.31	348.00	437.84	171.76	18.90	107.74
Mean	1.80	39.21	25.56	33.43	50.76	2.64	1.49	43.51	8.87	13.72	7.84	11.75	23.20	29.19	11.45	1.26	7.18
Std. error	0.39	1.07	0.60	1.27	1.72	0.01	0.01	0.35	0.60	0.86	0.30	0.45	0.11	0.47	0.37	0.18	0.14
Variance	2.23	17.26	5.37	24.36	44.57	0.00	0.00	1.88	5.47	11.11	1.33	2.98	0.17	3.36	2.07	0.47	0.30
Stand. dev	1.49	4.16	2.32	4.94	6.68	0.03	0.05	1.37	2.34	3.33	1.15	1.73	0.42	1.83	1.44	0.68	0.54
Median	1.00	38.40	26.50	33.80	52.90	2.63	1.51	43.35	8.44	14.69	7.92	11.88	23.10	28.75	11.57	1.10	7.28
25 prentil	0.30	35.50	23.80	29.80	43.40	2.63	1.46	42.32	6.79	11.47	6.99	10.48	22.90	27.62	9.78	0.70	6.68
75 prentil	3.50	43.00	27.30	38.20	55.10	2.67	1.53	44.49	10.63	16.11	8.95	13.42	23.60	30.47	12.42	1.60	7.43
Skewness	0.33	0.48	-1.04	-0.27	-0.12	0.37	-0.85	0.70	0.71	-0.95	-0.27	-0.27	-0.27	0.91	0.15	1.32	0.13
Kurtosis	-1.83	-1.14	0.90	-0.62	-0.20	-0.45	-0.47	-0.32	-0.54	0.26	-0.62	-0.62	0.08	-0.15	-0.69	1.69	-0.71
Geom. mean	1.14	39.01	25.46	33.08	50.34	2.64	1.49	43.49	8.60	13.25	7.75	11.63	23.20	29.14	11.37	1.12	7.16
Coeff. var	83.04	10.60	9.07	14.76	13.15	1.10	3.07	3.15	26.36	24.29	14.71	14.69	1.80	6.28	12.55	54.17	7.58

**Figure 3.** Probability plot for data series

The level of interdependence between parameters determined at the soil profile was evaluated by correlation analysis (Pearson's r), with the results presented in Figure 4. Positive and negative correlations of different levels of intensity were recorded. In particular, the correlations between hydrophytic indices and other soil profile parameters were analyzed. The HygC index showed a very strong, positive correlation with CC ($r = 1.000^{***}$), with WC ($r = 1.000^{***}$) and a negative correlation with UWC ($r = -0.982^{***}$). HygC showed a strong, negative correlation with FS ($r = -0.895^{***}$) and with HydC ($r = -0.852^{***}$). The WC index showed a very strong positive correlation with CC ($r = 1.000^{***}$) and with HygC ($r = 1.000^{***}$), and a very strong negative correlation with UWC ($r = -0.982^{***}$). The FC index showed a moderate positive correlation with CC ($r = 0.759^{**}$), with HygC ($r = 0.758^{**}$), with WC ($r = 0.759^{**}$) and a moderate negative correlation with FS ($r = -0.758^{**}$). The TC index showed a very strong positive correlation with TP ($r = 0.986^{***}$) and with AP ($r = 0.965^{***}$), and a very strong negative correlation with AD ($r = -0.986^{***}$) and with CD ($r = -0.936^{***}$).

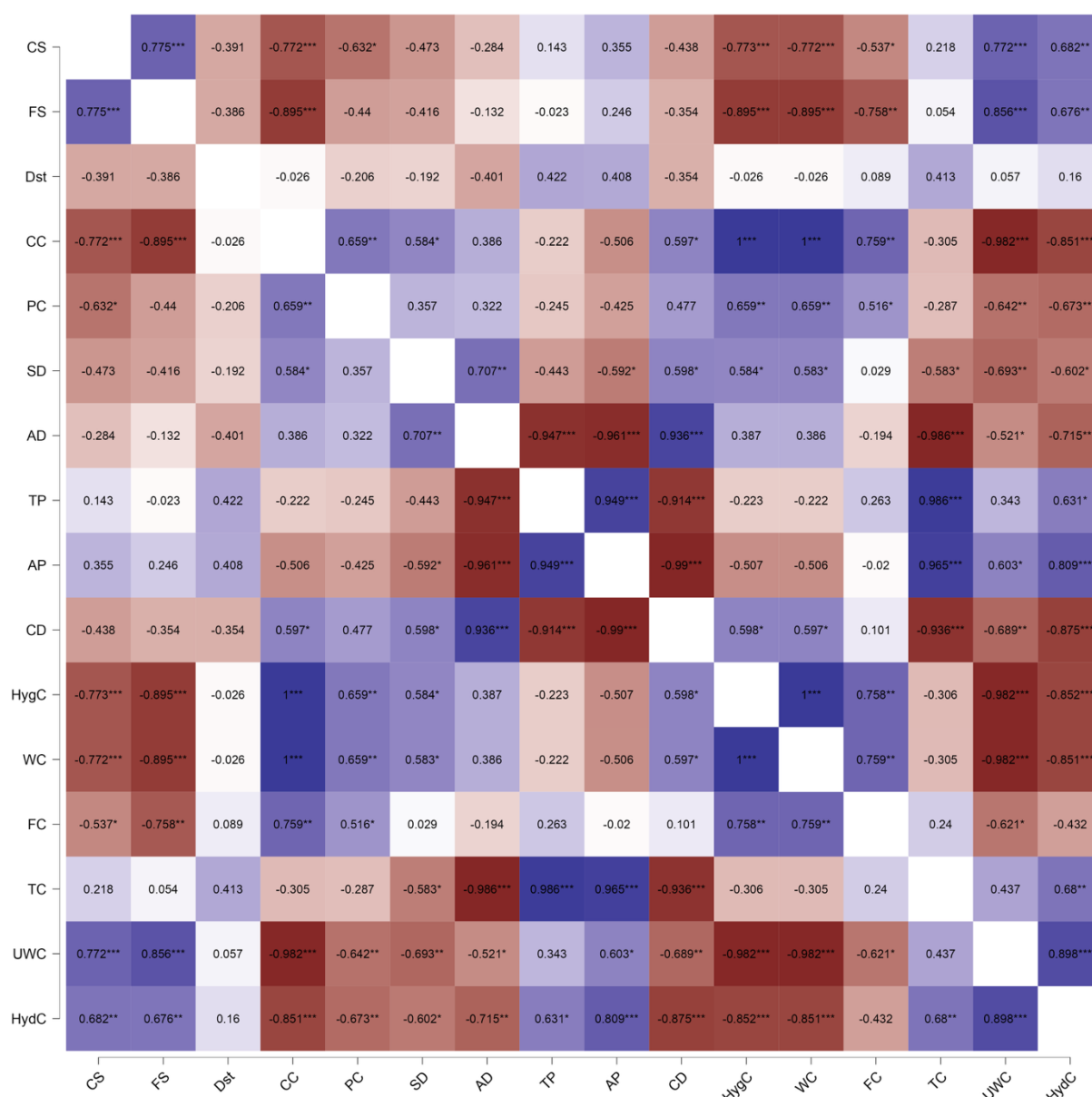


Figure 4. Correlation matrix between soil indices and parameters

The UWC index showed a very strong negative correlation with CC ($r = -0.982^{***}$), with HygC ($r = -0.982^{***}$) and with WC ($r = -0.982^{***}$). The UWC index showed a strong positive correlation with FS ($r = 0.856^{***}$), and with HydC ($r = 0.898^{***}$), and a moderate positive correlation with UWC and CS ($r = 0.772^{***}$). The HydC index showed a strong positive correlation with UWC ($r = 0.898^{***}$) and a strong

negative correlation with CC ($r = -0.851^{***}$), with CD ($r = -0.875^{***}$), with HygC ($r = -0.852^{***}$) and with WC ($r = -0.851^{***}$). Other correlations, positive or negative, of lower intensity were also recorded between the considered indices.

In the context of climate change, soil water regime has become a limiting factor for most crops in non-irrigated systems. This has motivated us to pay greater attention to hydrophysical indices.

The data series for parameters describing the soil water regime (HygC, WC, FC, and UWC) were analyzed by linear regression, and the Ordinary Least Squares Regression (OLSR) results are presented in Table 2. Statistical divergence was recorded for each index, according to Table 2. The distribution of the data series for the considered indices, with the 95% confidence interval, is presented in Figure 5.

Table 2. The values of the statistical parameters related to OLSR

Soil Indices	Statistical parameters	Valori ale parametrilro statistici		
HygC	Slope a	0.2425	Std. error a	0.0242
	t	10.0220	p (slope)	1.75E-07
	Intercept b	5.8953	Std. error b	0.2200
	Slope a	(0.201, 0.29876)		
	Intercept b	(5.4128, 6.1669)		
	r	0.9410		
	r ²	0.8854		
	t	10.0220		
	p (uncorr.)	1.75E-07		
	Permutation p	0.0001		
WC	Slope a	0.3635	Std. error a	0.0362
	t	10.0550	p (slope)	1.69E-07
	Intercept b	8.8460	Std. error b	0.3287
	Slope a	(0.30094, 0.44572)		
	Intercept b	(8.107, 9.2552)		
	r	0.9413		
	r ²	0.8861		
	t	10.0550		
	p (uncorr.)	1.69E-07		
	Permutation p	0.0001		
FC	Slope a	0.0743	Std. error a	0.0157
	t	4.7378	p (slope)	0.0004
	Intercept b	22.6060	Std. error b	0.1426
	Slope a	(0.042399, 0.10065)		
	Intercept b	(22.32, 22.908)		
	r	0.7958		
	r ²	0.6333		
	t	4.7378		
	p (uncorr.)	0.0004		
	Permutation p	0.0004		
UWC	Slope a	-0.2895	Std. error a	0.0387
	t	7.4772	p (slope)	4.65E-06
	Intercept b	13.7660	Std. error b	0.3520
	Slope a	(-0.36756, -0.22982)		
	Intercept b	(13.39, 14.381)		
	r	-0.9008		
	r ²	0.8113		
	t	-7.4772		
	p (uncorr.)	4.65E-06		
	Permutation p	0.0001		

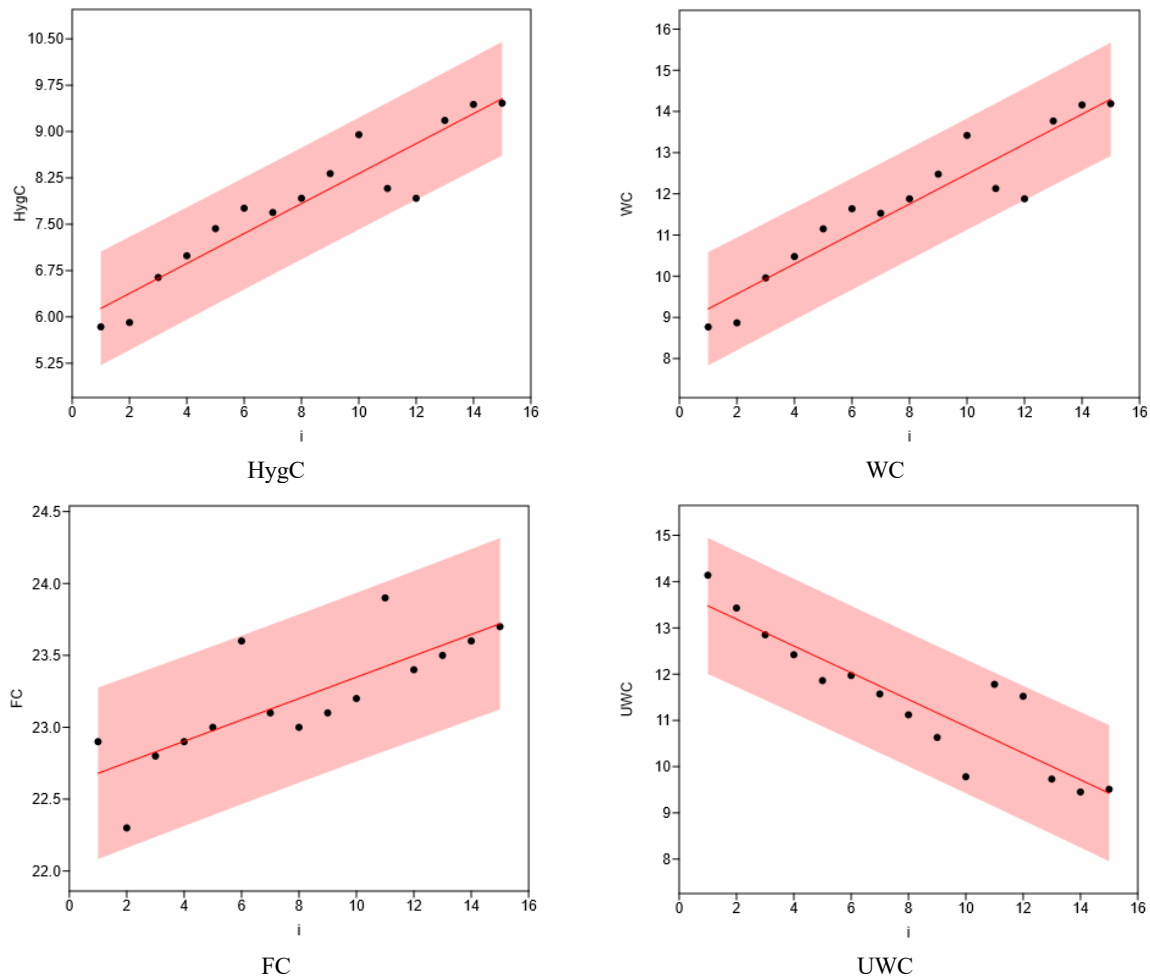


Figure 5. Distribution of value series for considered parameters, as a result of OLSR

An ascending distribution was observed for the data series for the HygC, WC, FC indices, and a descending distribution of the data series was observed for the UWC index, following the Ordinary Least Squares Regression (OLSR) analysis. A similar distribution pattern was recorded for the HygC and WC indices, with Slope $a = 0.2425$, $r^2 = 0.8854$ in the case of HygC, respectively with Slope $a = 0.3635$, $r^2 = 0.8861$, in the case of WC, with $p = 0.0001$ in all cases. In the case of the FC index, Slope $a = 0.0743$, $r^2 = 0.6333$ ($p = 0.0004$) was recorded. In the case of the UWC index, Slope $a = -0.2895$, $r^2 = 0.8113$ ($p = 0.0001$) was recorded.

Based on the level of interdependence identified between soil profile indices, regression analysis was applied to find patterns of variation of the main hydrophysical indices in relation to other soil profile indices. The variation of Hygroscopicity coefficient (HygC) in relation to physical indices (CS, FS, Dst, CC and PC) in different combinations was described by equation (2), in conditions of statistical safety, according to the data in Table 3.

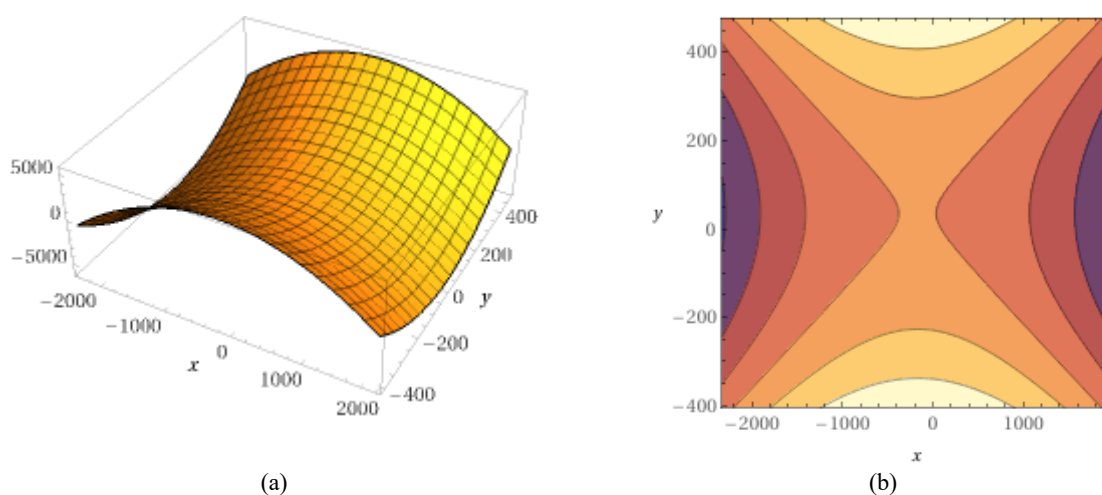
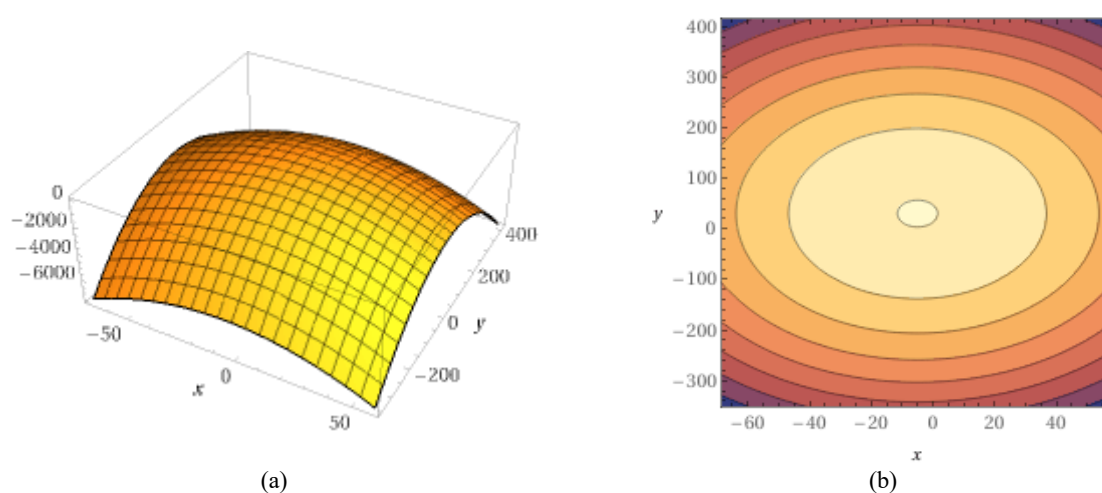
$$\text{HygC} = ax^2 + by^2 + cx + dy + exy + f \quad (1)$$

where: HygC - Hygroscopicity coefficient; x , y – the variables of equation (1), according to Table 3; a , b , c , d , e , f – the coefficients of equation (1), according to Table 3

The results recorded based on equation (1), Table 3, presented statistical safety at the $p = 0.0051$ level in the case of variables $x = \text{CS}$, $y = \text{PC}$, and at the $p < 0.001$ level in the other cases. Based on the values of the coefficients of equation (1), divergent action was observed in the case of three combinations of variables ($x = \text{CS}$, $y = \text{CC}$; $x = \text{FS}$, $y = \text{Dst}$; $x = \text{FS}$, $y = \text{PC}$), with graphic sample in Figure 4, and convergent action in the case of the other combinations of variables, with graphic sample in Figure 5, and Figure 6.

Table 3. The values related to equation (1) in the description of the HygC variation

Indice	Variables	Coefficients values of equation (1)						Statistical parameters		
		a	b	c	d	e	f	R ²	F	p
HygC	x = CS; y = FS	-0.5853405	-0.0362066	-6.1739658	2.3089481	0.2071331	-27.7703208	0.891	14.6623	<0.001
	x = CS; y = Dst	-0.3541882	-0.0408395	0.3807071	1.8138501	0.0119545	-10.9749838	0.881	13.3760	<0.001
	x = CS; y = CC	0.0029286	-8.957E-06	-0.0210357	0.2339679	0.0003200	0.0279322	0.999	1670167.26	<0.001
	x = CS; y = PC	-0.2982416	-0.0094480	2.8935612	1.1410600	-0.0357290	-25.9143115	0.805	7.4123	0.0051
	x = FS; y = Dst	-0.0013414	0.0282770	-0.4824560	-2.0803939	0.0116830	51.7265835	0.977	75.2045	<0.001
	x = FS; y = CC	-0.0003338	-0.0002544	0.0440040	0.2710405	-0.0005077	-1.4862894	0.999	648841.71	<0.001
	x = FS; y = PC	-0.0305603	0.0205412	2.3183420	-1.8045042	-0.0064128	14.9149976	0.902	16.6219	<0.001
	x = Dst; y = CC	-5.889E-05	-4.222E-05	0.0025818	0.2360867	8.6317E-06	-0.0442777	0.999	454131.87	<0.001
	x = Dst; y = FC	-0.0371599	-0.0159934	1.5211944	1.6779217	0.0023984	-52.9853407	0.906	17.3014	<0.001
	x = CC; y = FC	-0.0001291	-9.085E-06	0.2358906	-0.0028969	0.0001226	0.0562854	0.999	512635.75	<0.001

**Figure 4.** HygC variation in relation to FS (x axis) and Dst (y axis); (a) 3D model, (b) model isoquant**Figure 5.** HygC variation in relation to CS (x axis) and FS (y axis); (a) 3D model, (b) isoquant model

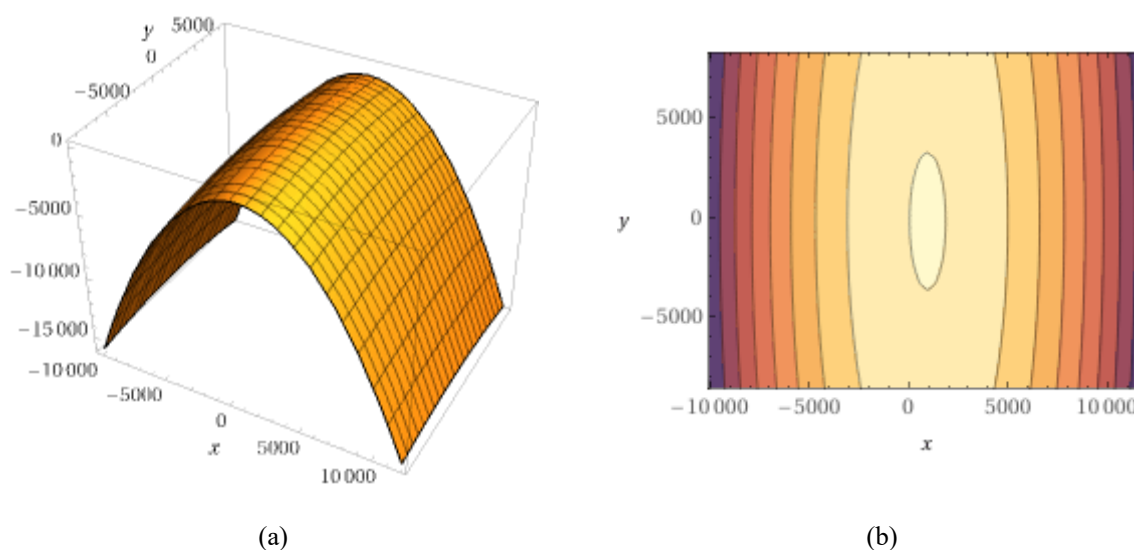


Figure 6. HygC variation in relation to CC (x axis) and PC (y axis); (a) 3D model, (b) isoquant model

The variation of Withering coefficient (WC) in relation to physical indices (CS, FS, Dst, CC and PC) in different combinations was described by equation (2), under conditions of statistical safety, according to the data in Table 4.

$$WC = ax^2 + by^2 + cx + dy + exy + f \quad (2)$$

where: WC - Withering coefficient; x, y – the variables of equation (2), according to Table 4; a, b, c, d, e, f – the coefficients of equation (2), according to Table 4.

The results recorded based on equation (2), Table 4, presented statistical safety at the $p = 0.0051$ level in the case of variables $x = CS$, $y = PC$, and at the $p < 0.001$ level in the other cases. Based on the values of the coefficients of equation (2), divergent action was observed in the case of three combinations of variables ($x = FS$, $y = Dst$; $x = FS$, $y = PC$; and $x = CC$, $y = PC$), with graphic sample in Figure 7. In the case of the other combinations of variables, convergent action was recorded, with graphic sample in Figure 8, and Figure 9.

Table 4. The values related to equation (3) in the description of the WC variation

Indice	Variables	Coefficients values of equation (2)						Statistical parameters		
		a	b	c	d	e	f	R ²	F	p
WC	x = CS; y = FS	-0.8792025	-0.0541705	-9.2430966	3.4533336	0.3103840	-41.4776565	0.891	14.7134	<0.001
	x = CS; y = Dst	-0.5318059	-0.0606920	0.5470880	2.6913204	0.0190436	-16.0859174	0.881	13.3811	<0.001
	x = CS; y = CC	0.0007695	0.0000233	-0.0098148	0.3481179	0.0002252	0.0898732	1.000	848784.47	<0.001
	x = CS; y = PC	-0.4497127	-0.0141109	4.3439395	1.7046931	-0.0535020	-38.6823110	0.805	7.4130	0.0051
	x = FS; y = Dst	-0.0018500	0.0427357	-0.7415590	-3.1445299	0.0177374	78.2284247	0.977	76.4661	<0.001
	x = FS; y = CC	0.0003098	0.0002773	-0.0451207	0.3071461	0.0006039	1.6754814	1.000	1087806.72	<0.001
	x = FS; y = PC	-0.0455152	0.0307281	3.4459323	-2.7038422	-0.0094887	22.9192380	0.902	16.6457	<0.001
	x = Dst; y = CC	0.0001764	3.7695E-06	-0.0066243	0.3511765	-0.0000608	0.1137587	1.000	987754.78	<0.001
	x = Dst; y = FC	-0.0558995	-0.0239879	2.3050871	2.5233527	0.0033182	-79.9400319	0.905	17.1973	<0.001
	x = CC; y = FC	7.9004E-05	-0.0000146	0.3475335	0.0038102	-0.0000646	0.0003536	1.000	976433.16	<0.001

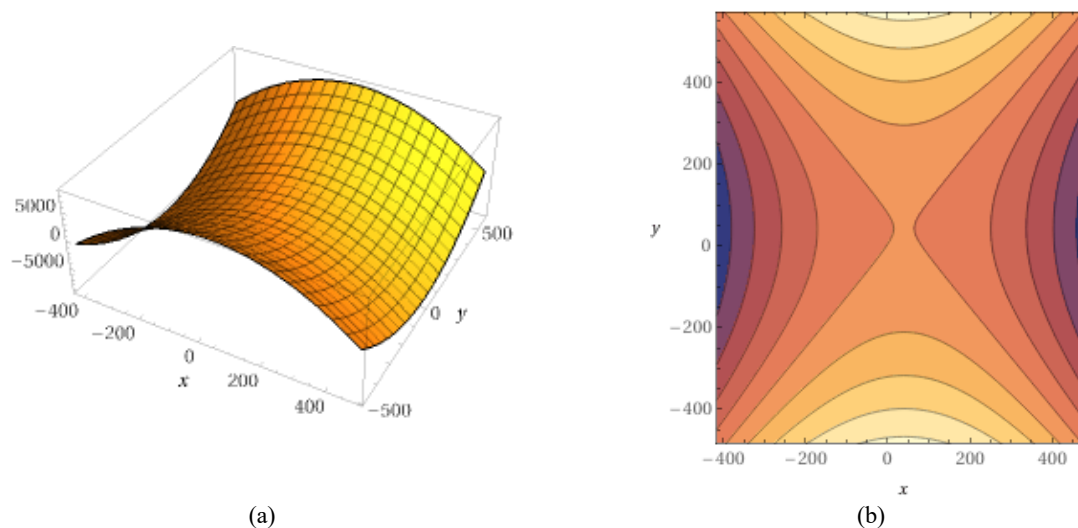


Figure 7. WC variation in relation to FS (x axis) and PC (y axis); (a) 3D model, (b) isoquant model

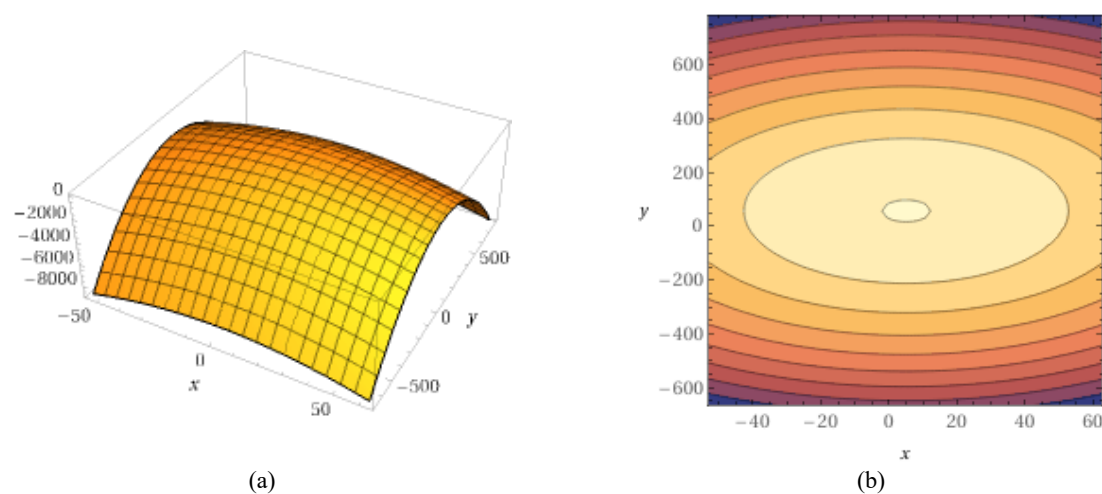


Figure 8. WC variation in relation to CS (x axis) and PC (y axis); (a) – 3D model, (b) isoquant model

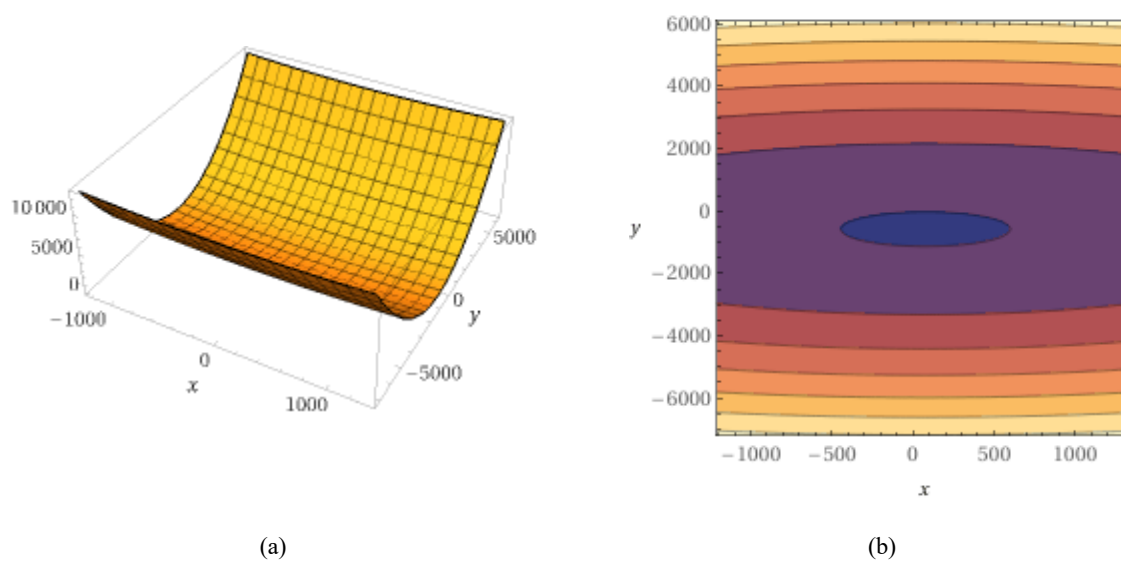


Figure 9. WC variation in relation to FS (x axis) and CC (y axis); (a) 3D model, (b) isoquant model

The variation of field capacity (FC) in relation to physical indices (CS, FS, Dst, CC and PC) in different combinations was described by equation (3), under statistical safety condition, according to the data in Table 5.

$$FC = ax^2 + by^2 + cx + dy + exy + f \quad (3)$$

where: FC – field capacity; x, y – the variables of equation (3), according to Table 5; a, b, c, d, e, f – the coefficients of equation (3), according to Table 5

Table 5. The values related to equation (3) in the description of the FC variation

Indice	Variables	Coefficients values of equation (3)						Statistical parameters		
		a	b	c	d	e	f	R ²	F	p
FC	x = CS; y = FS	-0.1628186	-0.0060421	0.8935603	0.4466240	-0.0066630	14.8332429	0.775	6.2168	0.0091
	x = CS; y = Dst	-0.2004540	0.0021656	-0.4637768	-0.1924992	0.0437861	26.6376837	0.737	5.0508	0.0175
	x = CS; y = CC	0.0802293	0.0195165	-4.3864754	-1.4658272	0.1265792	50.4722981	0.781	6.4272	0.0082
	x = CS; y = PC	-0.2041035	-0.0062854	2.5430240	0.7684285	-0.0311850	-0.1739869	0.856	10.6725	0.0014
	x = FS; y = Dst	-0.0061553	0.0137749	0.1503962	-1.1411511	0.0101653	36.8121304	0.710	4.4100	0.0262
	x = FS; y = CC	0.0223979	0.0270081	-3.7359649	-4.0403658	0.0566478	165.8806344	0.731	4.8860	0.0194
	x = FS; y = PC	-0.0151750	0.0071160	0.9462885	-0.8222928	0.0021373	28.5497022	0.677	3.7798	0.0402
	x = Dst; y = CC	-0.0059301	-0.0066545	1.0126520	1.0350734	-0.0213597	-7.5486409	0.721	4.6536	0.0224
	x = Dst; y = FC	-0.0208010	-0.0065964	1.4894525	0.9322078	-0.0093324	-19.1447210	0.726	4.7660	0.0209
	x = CC; y = FC	0.0171573	-0.0038159	-0.1807257	1.0117305	-0.0189795	0.9034325	0.735	4.9969	0.0181

The results recorded based on equation (3), Table 5, presented statistical safety at the $p < 0.05\%$ level in seven cases, and at the $p < 0.01$ level in three cases. Based on the equation (3) coefficients, divergent action was observed in the case of four variables combinations, with graphic sample in Figure 10. In the case of the other combinations of variables, convergent action was recorded, with graphic sample in Figure 11 and Figure 12.

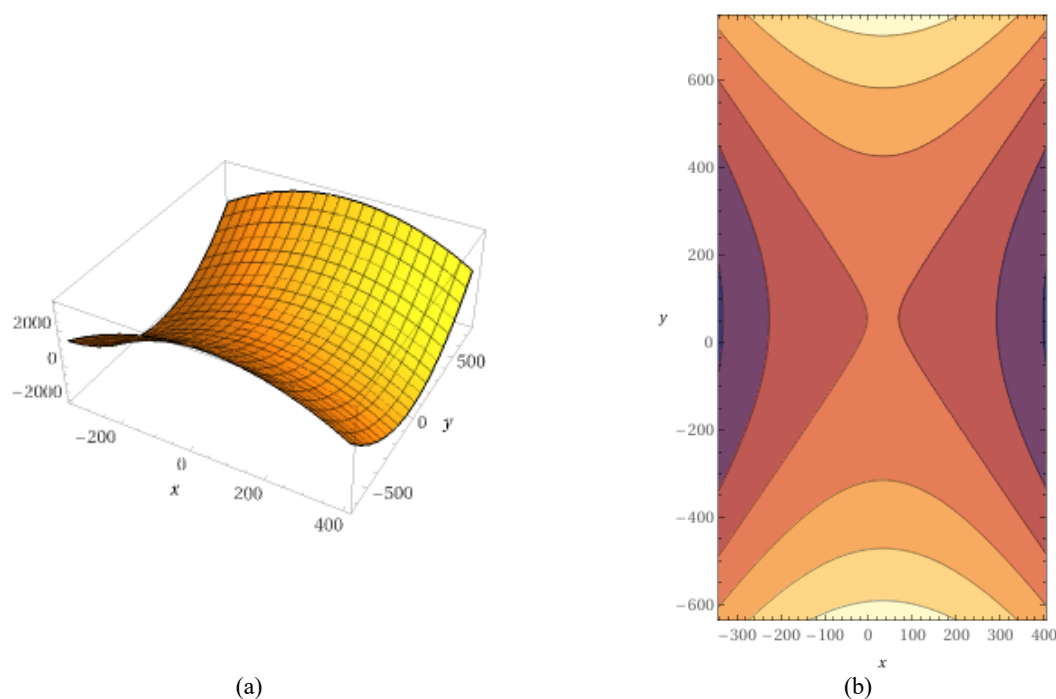


Figure 10. FC variation in relation to FS (x axis) and PC (y axis); (a) 3D model, (b) isoquant model

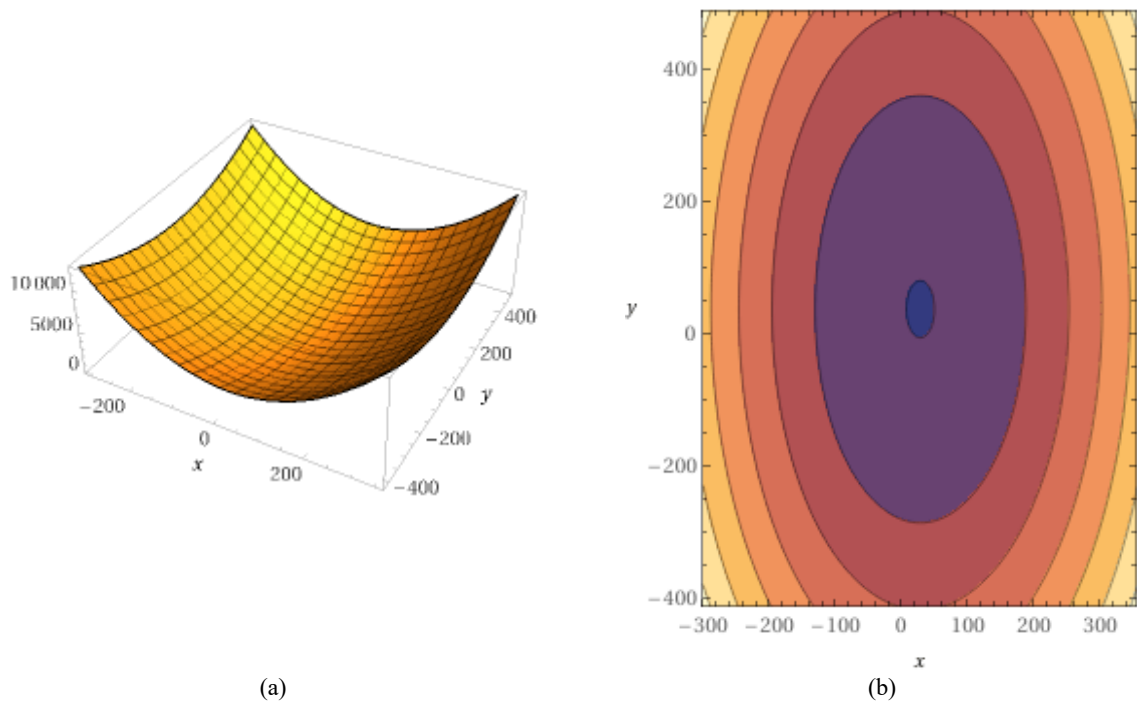


Figure 11. FC variation in relation to CS (x axis) and CC (y axis); (a) 3D model, (b) isoquant model

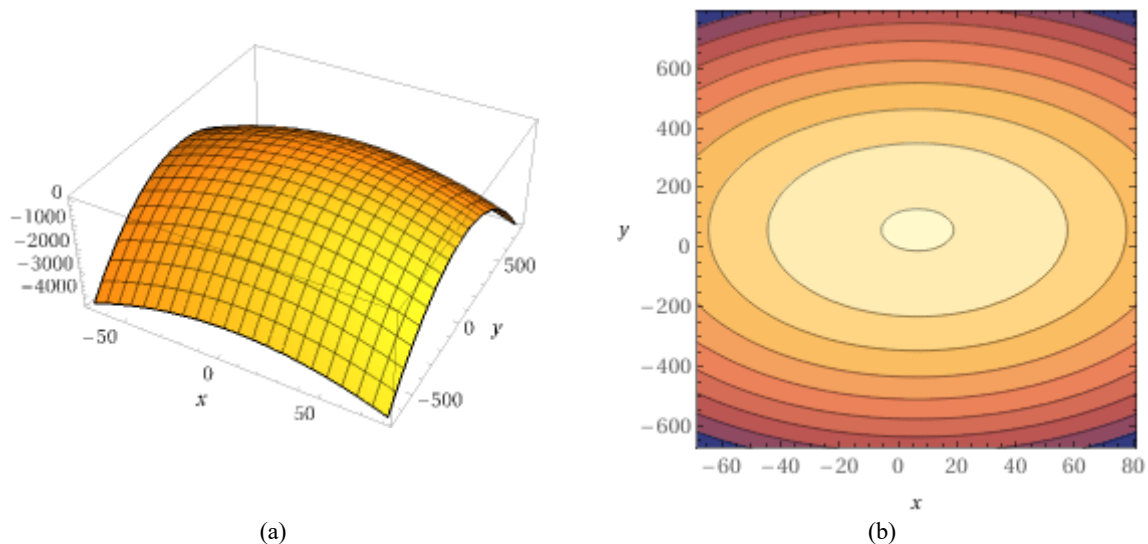


Figure 12. FC variation in relation to CS (x axis) and PC (y axis); (a) 3D model, (b) isoquant model

The variation of Useful water capacity (UWC) in relation to physical indices (CS, FS, Dst, CC and PC) in different combinations was described by equation (4), under conditions of statistical safety, according to the data in Table 6.

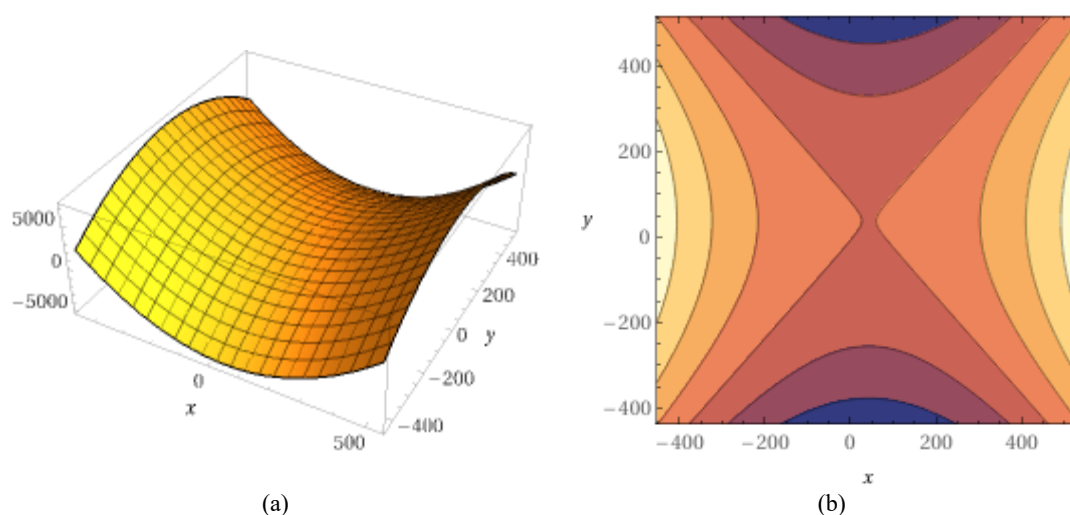
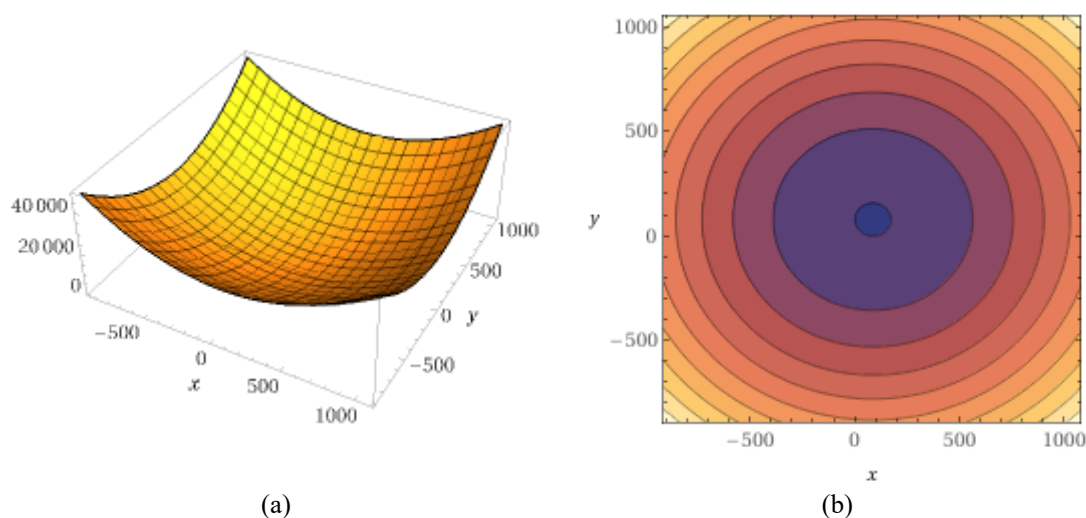
$$UWC = ax^2 + by^2 + cx + dy + exy + f \quad (4)$$

where: UWC - Usefull water capacity; x, y – the variables of equation (4), according to Table 6; a, b, c, d, e, f – the coefficients of equation (4), according to Table 6

The results recorded based on equation (4), Table 6, presented statistical safety at the $p < 0.05$ level in five cases, and at the $p < 0.001$ level in five cases. Based on the equation (5) coefficient values, divergent action was observed in the case of four variables combinations, with graphic sample in Figure 13. In the case of the other variables combinations, convergent action was recorded, with graphic sample in Figure 14 and Figure 15.

Table 6. The values related to equation (4) in the description of the FC variation

Indice	Variables	Coefficients of equation (4) values						Statistical parameters		
		a	b	c	d	e	f	R ²	F	p
UWC	x = CS; y = FS	0.7167673	0.0480831	10.1342288	-3.0032368	-0.3170060	56.2489802	0.864	11.4348	0.0011
	x = CS; y = Dst	0.3327058	0.0635352	-1.0387282	-2.9186626	0.0256704	43.1741555	0.846	9.9172	0.0018
	x = CS; y = CC	0.0809988	0.0195399	-4.3962902	-1.8177093	0.1268044	50.4621713	0.981	94.1370	<0.001
	x = CS; y = PC	0.2476601	0.0077786	-1.8059124	-0.9308555	0.0223224	38.3587085	0.711	4.4260	0.0259
	x = FS; y = Dst	-0.0042984	-0.0285536	0.8885415	1.9785655	-0.0074504	-41.0436504	0.919	20.4255	<0.001
	x = FS; y = CC	0.0227076	0.0272853	-3.7810855	-4.4332197	0.0572517	167.4561158	0.977	76.9061	<0.001
	x = FS; y = PC	0.0297640	-0.0232655	-2.4563574	1.8465712	0.0116032	5.7462369	0.850	10.2110	0.0016
	x = Dst; y = CC	-0.0057537	-0.0066507	1.0060277	0.6862499	-0.0214205	-7.5348822	0.963	73.8158	<0.001
	x = Dst; y = FC	0.0351677	0.0173952	-0.8103997	-1.5877350	-0.0128040	60.6363751	0.831	8.8598	0.0027
	x = CC; y = FC	0.0172363	-0.0038305	-0.5331921	1.0155407	-0.0190441	0.8037861	0.977	77.9482	<0.001

**Figure 13.** UWC variation in relation to FS (x axis) and PC (y axis); (a) 3D model, (b) isoquant model**Figure 14.** UWC variation in relation to FS (x axis) and CC (y axis); (a) 3D model, (b) isoquant model

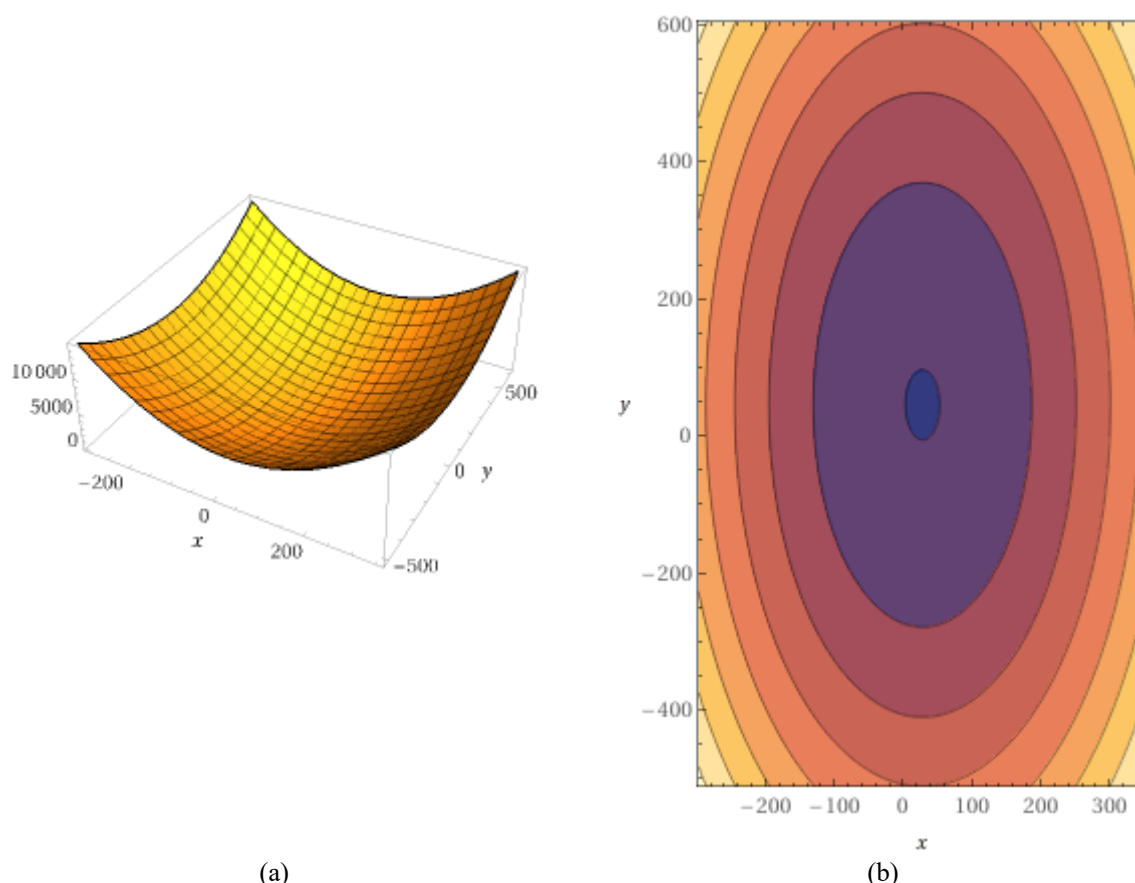


Figure 15. UWC variation in relation to CS (x axis) and CC (y axis); (a) 3D model, (b) isoquant model

Soil properties are important for the functionality of the "soil - plant" relationship in the quantitative and qualitative formation of agricultural production, in relation to the differentiated requirements of the vegetation cover and crop plants (Oliver et al., 2013; He et al., 2023).

The hydrophysical properties of the soil are determined by the parent materials, the spatial variability of the relief forms, climatic and biological factors, respectively by the plant cover (Gökbülak and Özcan, 2008). The use of agricultural land (use categories), agricultural systems, plant cultivation technologies influence the hydrophysical properties of the soil, contributing to the variation of the hydrophysical properties of the soil (Alhassan and Askira, 2021; Dhaliwal and Kumar, 2021).

In the present study, the data series for soil parameters and properties, under the conditions of an agricultural land category pasture, presented normal distribution, and differentiated variability, according to statistical analysis. Very high variability was shown by Coarse sand ($CV_{CS} = 83.04$) and Hydraulic conductivity ($CV_{HydC} = 54.17$). Moderate variability was shown by Aeration porosity ($CV_{AP} = 26.36$) and Compaction degree ($CV_{CD} = 24.29$). The other parameters presented low variability.

Soil texture influences the hydrophysical properties and water regime in the soil, the nutrient content in the soil, and their availability in the "plant - soil" relationship (Wankmüller et al., 2024; Ye et al., 2024). In turn, the hydrophysical properties of the soil influence the "soil - water" dynamics, the nutrient regime in the soil, the organic matter content and the activity of soil microorganisms, the health and functionality of the soil (Ye et al., 2024; Vidana Gamagat et al., 2025).

As a result of the zonal and local specificity of soil formation and evolution, positive and negative interdependence relationships of different intensity levels were found between the studied parameters, expressed by the correlation coefficient (Figure 4). The results of the correlation analysis identified soil parameters with which the indices defining the hydrophysical properties of the soil presented very strong and strong intensity interdependence, as well as parameters with low action in the hydrophysical properties of the soil.

The regression analysis (Ordinary Least Squares Regression – OLSR) showed the trend of the distribution of the data series for the hydrophysical indices considered in the study (HygC, WC, FC, and UWC). In the case of HygC, WC, FC, a variation with an increasing slope of the data series was indicated, and in the case of UWC a decreasing slope of the data series was recorded, under the study conditions.

The variation of some soil properties has been described by different models in relation to anthropogenic activities and climate change. (Filippi et al., 2016; Schlutow et al., 2021). The modeling analysis was useful to describe the variation of soil hydrophysical properties in relation to certain soil parameters, under climate change conditions (Bovi et al., 2022; Barga  s-Tobella et al., 2024; Ishola et al., 2025).

The variation of the indices HygC, WC, FC, and UWC was analyzed in relation to parameters that defined the soil texture (CS, FS, Dst, CC and PC) in different combinations. Mathematical models in the form of polynomial equations and graphical models were obtained, under conditions of statistical reliability. The textural components presented both convergent and divergent contributions in the variation of the indices that define the hydrophysical properties of the soil, under the study conditions.

CONCLUSIONS

In the description of the soil of some lands classified as pastures, the physical and hydrophysical parameters considered presented normal distribution and differentiated variability, high (CS, HydC), moderate (AP, CD) and low in the case of the other parameters and indices.

Variable levels of interdependence, such as intensity (e.g. very strong, strong, moderate) and action (e.g. positive or negative) were found between the parameters and indices considered in the soil analysis, for the pasture land use category of agricultural land.

For the parameters HygC, WC, FC that describe the hydrophysical properties of the soil, a positive slope of variation was found through OLS analysis (Slope $a = 0.2425$, $r^2 = 0.8854$ in the case of HygC, respectively with Slope $a = 0.3635$, $r^2 = 0.8861$ in the case of WC), and for the parameter UWC a negative slope of variation was found (Slope $a = -0.2895$, $r^2 = 0.8113$) under the study conditions.

Polynomial models described the variation of the parameters HygC, WC, FC and UWC in relation to the textural components, in conditions of statistical safety. Both convergent contribution and divergent action of the textural components were recorded in the variation of the parameters that described the hydrophysical properties of the soil, in the studied agricultural pastures.

The recorded results present scientific and practical importance for establishing technological measures to improve the hydrophysical properties of the soil, and management decisions for ecosystem performance.

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