

EVALUATION SOIL PARAMETERS WITH PRINCIPAL COMPONENT ANALYSIS*L. HUZSVAI – T. RÁTONYI – A. MEGYES – D. SÜLYÖK*

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Introduction

Changes in soil-profile nutrient distribution could have a significant impact on the productivity and ecology of land management system (Franzluebbers et al. 1996). Soil parameters are in a sophisticated relationship with each other. Due to their multiconality it makes sense to examine them jointly (Zsigrai 1999).

Káta J. (2005) found, after evaluating the soil samples from chernozem soil with lime deposits in 1999 and 2000, that the acidity of soils decreased with increased fertilizer dosages both in watery and M KCl soil suspensions. In general, the acidity of soils radically decreases until medium-high fertilizer doses. The organic matter content of soils in irrigated treatments was lower than that of the unirrigated treatments. However, nitrate-N and AL-soluble phosphorous and potassium content gradually increased with the fertilizer dosages. It was apparent that the AL-soluble phosphorous and potassium content of soils significantly decreased with irrigation.

Methods

We have carried out soil examinations at the Látókép Experimental Station of Debrecen University, Center of Agricultural Sciences on lowland pseudomycelial chernozem soil in 2003. The experiment was set up in 1979 (Table 1).

Table 1. Examined treatments at the fertilization and irrigation experiment

Treatment	Irrigation	Fertilization 1979- 1995 (kg/ha)	Fertilization 1996- 2003 (kg/ha)
1.	not irrigated	not fertilized	not fertilized
2.	not irrigated	N60, P45, K53	N30, P23, K27
3.	not irrigated	N240, P180, K265	N120, P90, K133
4.	irrigated	not fertilized	not fertilized
5.	irrigated	N60, P45, K53	N30, P23, K27
6.	irrigated	N240, P180, K265	N120, P90, K133

Soil samples were taken to the depth of 3 meters, separating the 20 cm layers, in three replications so 18 sample taking spots were made. The number of observations was 270, and the number of variables 14. The evaluation was carried out by using the SPSS 11.0 computer software with main components analysis. We only determined the main components that were larger than one (larger than average). The main components were rotated with Varimax rotation for the sake of better interpretation. We have displayed the alignment of variables in a two dimensional figure.

Results and discussion

The descriptive statistics of the 14 variables is indicated table 2. The typical values of chernozem soil can be clearly identified in the average values of the table.

A few measurement values were missing from deeper layers, e.g.: liquid limit, soluble salt content, or they could not be interpreted, so we included a total of 200 observations into the

analysis. The factor analysis could usually be calculated from scale independent, normal distribution data. During the main component analysis we have used a Pearson-type correlation matrix.

We examined the distribution of variables by using the Kolmogorov-Smirnov test and examined whether their distribution is normal or not.

Table 2. Descriptive statistics of soil parameters

	N	Minimum	Maximum	Mean	Std. Deviation
pH-KCl	269	5.71	7.86	7.2507	.48737
Liquid limit [KA]	201	35	46	40.19	2.126
Soluble salt content (m/m%)	201	.020	.130	.03016	.019455
CaCO ₃ [m/m%]	269	.0	20.1	5.978	4.5504
Humus [m/m%]	269	.42	2.61	1.0348	.62759
NO ₃ --NO ₂ --N [ppm]	263	1.0	38.2	4.767	6.0945
NH ₄ ++-N [ppm]	269	1.0	6.5	2.017	1.1251
P ₂ O ₅ [ppm]	269	5.3	202.6	39.784	39.5165
K ₂ O [ppm]	269	52.8	318.8	119.302	50.7560
Mg [ppm]	269	170.9	1301.6	429.404	244.0402
Na [ppm]	269	22.7	162.4	71.124	26.0790
Zn [ppm]	269	.1	1.7	.452	.3063
Cu [ppm]	269	.9	5.0	2.091	1.0947
Mn [ppm]	269	2.1	470.8	111.483	173.8026
Valid N (listwise)	200				

The nitrate and ammonium distribution is not normal therefore, we have excluded them from further analysis. We could describe the total variance of soil parameter coherence to 83.6% with the three main components which is in accordance with the strictest requirements (Table 3). Naturally, this value does not change with a rectangular rotation (Varimax rotation), it only rearranges among the main components. In the original solution (unrotated), the main component only describes 58.8%, the second 15.9% while the third 8.8% of total variance of the first component. Following the rotation, rearrangement is moderate, 57.6%, 15% and 10.9% in order. Following the standardization of variables, all variables became 1 distribution standard normal distribution variable. We could reproduce 70-93% of this distribution (1) or variance with main component analysis, which can be considered very good (Table 4.).

Table 3. Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	7.060	58.832	58.832	7.060	58.832	58.832	6.913	57.609	57.609
2	1.913	15.938	74.770	1.913	15.938	74.770	1.810	15.079	72.689
3	1.060	8.837	83.606	1.060	8.837	83.606	1.310	10.918	83.606
4	.603	5.026	88.633						
5	.379	3.157	91.790						
6	.356	2.968	94.758						
7	.200	1.669	96.427						
8	.151	1.259	97.686						
9	.122	1.014	98.700						
10	7.912E-02	.659	99.360						
11	5.360E-02	.447	99.806						
12	2.325E-02	.194	100.000						

Extraction Method: Principal Component Analysis.

Suppress absolute values less than 0.10 were not displayed in the tables. Can background variables be detected in the main components? Evaluating the solution received after the rotation (Table 5.) pH, lime, humus, phosphorous, potassium, sodium, zinc, copper and manganese are located in the main component.

Table 4. Communalities

	Initial	Extraction
pH-KCl	1.000	.888
Liquid limit [KA]	1.000	.768
Soluble salt content (m/m%)	1.000	.793
CaCO ₃ [m/m%]	1.000	.791
Humus [m/m%]	1.000	.933
P ₂ O ₅ [ppm]	1.000	.791
K ₂ O [ppm]	1.000	.895
Mg [ppm]	1.000	.797
Na [ppm]	1.000	.699
Zn [ppm]	1.000	.842
Cu [ppm]	1.000	.926
Mn [ppm]	1.000	.908

Extraction Method: Principal Component Analysis.

Table 5. Rotated component matrix

	Component		
	1	2	3
pH-KCl	-.927	.162	
Liquid limit [KA]		.264	-.834
Soluble salt content (m/m%)	.152	.877	
CaCO ₃ [m/m%]	-.856	-.182	.162
Humus [m/m%]	.961		.101
P ₂ O ₅ [ppm]	.747	.215	.431
K ₂ O [ppm]	.871	.114	.353
Mg [ppm]		.870	-.189
Na [ppm]	-.780	-.250	.169
Zn [ppm]	.787	.151	.448
Cu [ppm]	.962		
Mn [ppm]	.947		

Extraction Method: Principal Component Analysis.

Rotation Method: Varimax with Kaiser Normalization.

Humus content is in negative relationship with pH, lime content and sodium while it shows strong positive relationship with phosphorous, potassium, zinc, copper and manganese. What could that background variable that changes these characteristics of the soil in such a way? In long-term experiments, large fertilizer doses have been used for decades. Let's assume that the first component is fertilization. According to this, fertilizer makes soil more acidic, reduces lime content in other words increases lime leaching. However, humus increases phosphorous and potassium content. Káta J. (2005) received very similar results after taking samples from a neighbouring area in 1999 and 2000. According to our examinations not only macronutrients, but also zinc, copper, manganese content increases significantly. The pH, lime and sodium content are in strong positive relationship with each other which is clearly depicted in figure 1. On chernozem soil, which is under intensive cultivation, this relationship can also be observed towards deeper layers. The higher the lime content of the specific soil layer, the higher its pH is or its alkalinity. The deeper we go into the soil, the higher its sodium content gets. The quantity of macro and micro elements however decreases with depth. We can detect a very close relationship between lime and sodium content by using main component analysis. So in the first component we can detect fertilization and soil depth. In the second main component, the water soluble total saline content and magnesium is present with great emphasis. This is probably related to irrigation. According to this, irrigation increases the saline and magnesium content of soil at the same time. These were not confirmed by additional examinations. The positive relationship of magnesium and total saline content is indicated in figure 1. Only the Arany-type liquid limit is displayed with considerable impact in the third main component. It can be found that the irrigation and fertilization applied in the experiment did not effect this value.

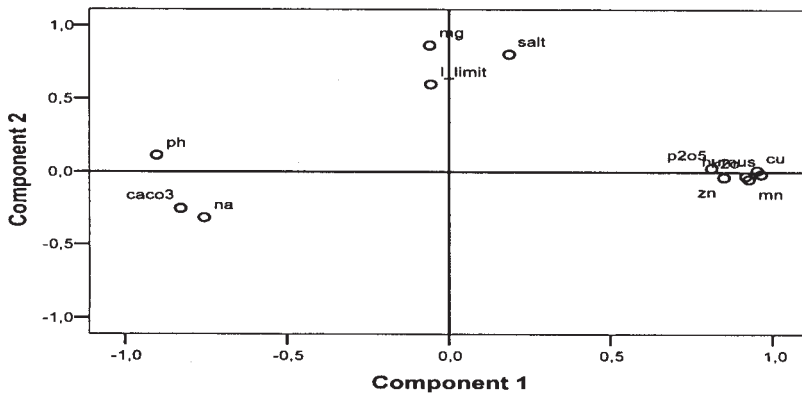


Figure 1. Component plot in rotated space

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