COMPLEX INDICATOR FOR ASSESSING SOIL FERTILITY

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Abstract: *The need to define more comprehensive the concept of soil fertility, but also to offer a practical tool to measure it, both for natural and agricultural soils without penalty interdictions and for soils affected by anthropogenesis processes, respectively urban soils, has led to elaboration of a complex indicator for assessing fertility (CIF). In order to quantify fertility, major soil features were grouped into two categories: potentiating and penalty indicators. The first category includes: climatic indicators (precipitation, temperature), indicators to characterize the nutritive space, also for water and air regime (edaphic volume, and the level of gleyzation and pseudo - gleyzation), physical indicators (texture, bulk density), chemical indicators (pH, humus content and the content of macro elements). The second category includes levels of salinization, alkalization, carbonation, pollution and artifacts content. Analytical values and morphological observations of each of the indicators mentioned above, are appreciated by giving points (notes) from 1-5, depending on their role in increasing soil fertility. The difference between the sum of notes granted to potentiating indicators and the sum of notes accorded to penalty indicators represents the value of complex indicator for assessing fertility (CIF). CIF values are interpreted according to a scale of values which separates soils into classes, from those with low fertility to high fertility. The calculation procedure and interpretation of CIF values for four soil types contrasting in terms of fertility level are exemplified. Three soil types, contrasting in terms of fertility, and an urban soil were selected. For each soil type, on the genetic horizons up to a depth of 60 cm, notes for each potentiating or penalty features were calculated.By summing the potentiating notes and, eventually, subtracting the amount of penalty notes was obtained the value for complex index of fertility. The results showed that: the Cambic Chernozems from Sârca has high fertility, with CIF value by 39, Fragic Alisol[1] and Gleyc Salic Vertic Cambisol have an average fertility, and with CIF value of 33, 25 respectively, and finally, Urbic Regosol has a low fertility, CIF value being only 21.*

Key words: *soil fertility, evaluation, complex indicator*

INTRODUCTION

The fertility represents the essential feature of soil that contributes to maintaining the life on our planet. This feature is determined by many physical, chemical and biological factors with an incontestable complexity.

Soil fertility has been defined as "the ability of soils to provide a permanent and simultaneously plant nutrients and water in plentiful amounts to their needs and to ensure the physical and biochemical conditions necessary for plant growth and development, overall satisfaction of other vegetation factors" (VILIAMS, 1950; DAVIDESCU, 1963). Therefore, fertilization (F) is connected with the dietary nutrients (N), water (A) and air (a) regime of the soil. F = f (N, A, a).

In order to quantify these qualities, some researchers have developed a series of indices of a greater or lesser complexity. But for their calculation is necessary to know a wide range of physical, chemical and biological analysis. Their disadvantage is the fact that they looked unilateral phenomenon, with only one major importance to microbiological (Ştefanic, 1998) or agrochemicals aspects (DAVIDESCU & DAVIDESCU, 1981), biophysical or trophicity ones (CHIRIŢĂ, 1974).

Trying to bring contributions to the problem of quantifying soil fertility we initially developed a simple indicator of soil fertility (LĂCĂTUȘU et al., 2008), and in this paper we present a complex indicator of this property that respond to parameterize fertility both for agricultural soils, without penalty interdictions, and for anthropogenic or natural degraded soils, and finally for urban soils.

MATERIALS AND METHODS

In order to define the complex indicator for assessing soil fertility have been used a set of simple indicators taken from the field measurements, morphological indicators, resulted from soil profile description and analytical indicators derived from physical and chemical analysis conducted in the laboratory. Scattering range of values of each indicator was divided into five areas according to their tendency to influence fertility, and receiving notes from 1 to 5. In achieving this objective were used the values of ecopedological indicators, too (Florea et al., 1987).

To illustrate the methodology of calculation and interpretation of the complex indicator for assessing soil fertility were used morphological and analytical data from four different soil types, contrasting in terms of fertility and pollution levels, data taken from the guidelines of the Romanian National Soil Science Society conferences and a specialty paper (LĂCĂTUȘU et al., 2005).

RESULTS AND DISCUSSION

1. Method Description

To quantify soil fertility, those major features of the soil, but also of the geographical environment where the soils are, that contribute substantially to plant growth and harvest development were chosen. The features, presented as indicators, were grouped into potentiating and penalty indicators. The first group includes: climatic indicators (precipitation, temperature), indicators to characterize the nutritive space, also for water and air regime (edaphic volume, and the level of gleyzation and pseudo - gleyzation), physical indicators (texture, bulk density), chemical indicators (pH, humus content and the content of macro elements). Penalty indicators are represented by levels of: salinization, alkalization, carbonation, pollution and the artifacts content. This last feature is taken into account, in addition, for urban soils. Most indicators are characterized by analytical values, except gleyzation and pseudo - gleyzation levels, which are characterized by morphological observations.

Analytical values of each property have been grouped into five classes, generally in ascending order of their importance in enhancing the soil fertility level, receiving notes from 1 to 5. Classes are presented in the tables attached (Table 1 - 11).

Table 1.

Evaluation notes according to climatic indicators of soil fertility

Notes	Annual average precipitations, mm	Annual average temperature, °C
1	<400 >1000	<4 >11
2	400-500	4-6
3	500-600	6-8
4	800-1000	10-11
5	600-800	8-10

Table 2.

Notes to characterize the nutritive space, and water and air regime of soils

Notes	Edaphic volume, %	Level of gleyzation	Level of pseudo-gleyzation
1	<10	bogs	swamp stagnic soils (histic soils)
2	10-20	gley soils	stagnic soils
3	20-50	gleyc soils	mesostagnic soils
4	50-100	gleyed soils	hypomesostagnic soils
5	>100	soils with shallow groundwater table	bathystagnic soils

Table 3.

Evaluation notes according to textural class

Notes	Clay <2μ %	Textural class
1	< 6 > 45	Sand Clay
2	6 - 12	Sandy loam
3	32.1 - 45	Loamy clay
4	12.1 - 20	Loamy sand
5	20.1 - 32	Loam

Table 4.

Evaluation notes according to bulk density (BD) values

Notes	AD, g/cm^3					
	S (sand)	SL (sandy loam)	LS (loamy sand)	L (loam)	LC (loamy clay)	C (clay)
1	<1.28 ≥1.80	<1.21 ≥1.76	<1.18 ≥1.73	<1.13 ≥1.67	<1.05 ≥1.59	<0.94 ≥1.48
2	1.67-1.79	1.62-1.75	1.59-1.72	1.54-1.66	1.46-1.58	1.35-1.47
3	1.66-1.54	1.48-1.61	1.46-1.58	1.40-1.53	1.32-1.45	1.21-1.34
4	1.41-1.53	1.35-1.47	1.32-1.45	1.26-1.39	1.19-1.31	1.08-1.20
5	1.28-1.40	1.21-1.34	1.18-1.35	1.13-1.25	1.05-1.18	0.94-1.07

Table 5

Evaluation notes according to soil reaction

Notes	pH_{H2O}	Soil reaction class
1	< 3.5	Extremely acid
	3.6-5.0	Very strong and strong acid
	8.5-9.0	Moderate alkaline
	9.1-10.0	Strong and very strong alkaline
	>10.1	Extremely alkaline
2	5.1-5.8	Moderate acid
3	5.9-6.4	Weak acid
	7.9-8.4	Weak alkaline
4	6.5-6.8	Very weak acid
	7.3-7.8	Very weak alkaline
5	6.9-7.2	Neutral

Table 6

Evaluation notes according to humus content

Notes	Humus content limits (%) according with textural class						Content class
	S	SL	LS	L	LC	C	
	sand	sandy loam	loamy sand	loam	loamy clay	clay	
1	<0.2	<0.4	<0.5	<0.6	<0.8	<1	extremely small
2	0.3-0.5	0.5-0.8	0.6-1.1	0.7-1.3	0.9-1.5	1.1-2.0	very small
3	0.6-1.0	0.9-1.7	1.2-2.2	1.4-3.0	1.6-3.5	2.1-5.0	small
4	1.1-2.0	1.8-4.0	2.3-5.5	3.1-6.5	3.6-8.0	5.1-10.0	medium
5	2.1-5.0	4.1-7.0	5.6-8.5	6.6-10.5	8.1-12.5	10.1-16.0	high

Table 7

Evaluation notes according to macro elements content

Notes	N total	NI	P_{AL}	K_{AL}	Content class
	%	-	$mgkg^{-1}$	$mgkg^{-1}$	
1	<0.100	<1.0	<8	<65	very small
2	0.100-0.0140	1.1-2.0	8.1-18	65.1-130	small
3	0.141-0.270	2.1-3.0	18.1-36	130.1-200	medium
4	0.271-0.600	3.1-4.0	36.1-72	200.1-300	high
5	>0.600	4.1-5.0	>72	>	very high

Table 8

Penalty notes of indicators for assessing soil salinization and alkalinization

Penalty notes	Salinization level	Alkalization level
1	weak	weak
2	moderate	moderate
3	strong	strong
4	very strong	very strong
5	excessive	excessive

Table 9

Penalty notes according with carbonates content from soil

Penalty notes	Carbonates content %	Content class
1	<5	small
2	5-10	moderate
3	10-25	high
4	25-40	very high
5	>40	excessive

Table 10

Penalty notes according with the general pollution level

Penalty notes	Pollution level
1	Contamination
2	Low pollution
3	Medium pollution
4	Strong pollution
5	Excessive pollution

Table 11

Penalty notes according with artifacts content in urban soils

Penalty notes	Artifacts percent into the soil volume %	Content class
1	<10.0	Soil with very low artifacts content
2	10.1-15.0	Soil with low artifacts content
3	15.1-25.0	Soil with medium artifacts content
4	25.1-50.0	Soil with high artifacts content
5	>50.0	Soil with very high artifacts content

The complex indicator of fertility (CIF) is, in fact, the difference between the sum of potentiating indicators and the sum of the penalty indicators. For agricultural soils the formula is:

$$CIF = \sum_{i=1}^{12} x_i - \sum_{p=1}^{4} x_p$$

For urban soils, the percentage of artifacts occurs, so that the formula becomes:

$$CIFUS = \sum_{i=1}^{12} x_i - \sum_{p=1}^{5} x_p$$

The terms of equations are represented by potentiating indicators:

xi.1 = annual average precipitations, mm
xi.2 = annual average temperature, °C
xi.3 = level of gleyzation
xi.4 = level of pseudo-gleyzation
xi.5 = textural class, clay content of <2μ, %
xi.6 = edaphic volume, %
xi.7 = bulk density, g/cm^3
xi.8 = reaction, pH_{H2O}
xi.9 = humus content, %
xi.10 = total nitrogen content (%) or the amount of nitrogen index (NI)
xi.11 = mobile phosphorus content, PAL, $mg \cdot kg^{-1}$
xi.12 = mobile potassium content, KAL, $mg \cdot kg^{-1}$,

and, indicators for penalty:

xp.1 = level of salinity
xp.2 = level of alkalization
xp.3 = level of carbonation
xp.4 = level of pollution
xp.5 = level of artifacts, %.

Morphological observations, together with analytical data used to establish the content classes, or the stage of pedogenesis or anthropic process, gives each of the above mentioned features, a certain note. By summing the individual notes of potentiating indicators we obtain a number of points that can represent the fertility level, if the soil is not affected by one or more degradation processes, both natural (salinization, alkalization, carbonation) or anthropogenic (pollution, containing artifacts). The final number of points signifies the fertility level assessed by the data in Table 12.

If the soil is affected by one or more processes that adversely affect fertility, the notes of each of these degradation processes, evidenced by indicators, are added together resulting in a number of points. The value obtained will be subtracted from the number of points that resulted from summing of potentiating indicators values. The final number of points signifies the fertility level assessed by the data in Table 12.

Table 12

Soil fertility assessment according with accumulated points

Number of accumulated points	Soil fertility level
0 - 12.0	very low
12.1 - 24.0	low
24.1 - 36.0	moderate
36.1 – 48.0	high
48.1 – 60.0	very high

If we do not have all the analytical data, or soil that we investigate do not have some of the features enunciated above, that term / terms shall be eliminated from the equation, but the fertility interpretation intervals will change. Thus, in the case of elimination of the two properties from the 12 potentiating indicators, the maximum number of points will become 50 and equidistant between fertility levels will be only 10 points. Basically, the upper term of sum, designate equidistance between the levels of fertility.

2. Example of calculating the complex index of fertility (CIF)

Three soil types, contrasting in terms of fertility, and an urban soil were selected. For each soil type, on the genetic horizons up to a depth of 60 cm, notes for each potentiating or penalty features were calculated, and then, were established the average value of every property in agreement with the depth of each horizon.

Table 13

Calculating procedure of complex indicator of soil fertility (CIF)

Indicators		Soil type[1]			
		Cambic Chernozem, Sârca, Iassy county	Fragic Alisol, Baia Sprie, Maramureş county	Gleyc Salic Vertic Cambisol, Osoi, Iassy county	Urbic Regosol, Iassy city
Potentiation notes	xi_1	3	4	3	3
	xi_2	5	3	5	5
	xi_3	0	4	4	0
	xi_4	0	4	4	0
	xi_5	3	5	1	2
	xi_6	5	4	1	1
	xi_7	4	5	3	4
	xi_8	4	1	2	3
	xi_9	3	3	2	2
	xi_{10}	3	1	3	2
	xi_{11}	5	1	2	3
	xi_{12}	4	1	2	5
Penalty notes	xp_1	0	0	3	4
	xp_2	0	0	4	0
	xp_3	0	0	0	1
	xp_4	0	3	0	2
	xp_5	0	0	0	2
CIF		**39**	**33**	**25**	**21**
Fertility level		**high**	**medium**	**medium**	**low**

By summing the potentiating notes and, eventually, subtracting the amount of penalty notes was obtained the value for complex index of fertility (Table 13). Its values have been interpreted in accord with the limits shown in Table 12.

The results showed that: the Cambic Chernozems[1] from Sârca has high fertility, with CIF value by 39, Fragic Alisol[1] and Gleyc Salic Vertic Cambisol[1] have an average fertility, and with CIF value of 33, 25 respectively, and finally, Urbic Regosol[1] has a low fertility, CIF value being only 21.

CONCLUSIONS

It presents a method for assessing the level of soil fertility on the basis of calculating a "complex indicator of fertility."

The complex indicator of fertility is the sum of evaluation notes for potentiating indicators, represented by: climatic indicators, indicators for the characterization of nutrient space, air and water regime, physical and chemical indicators, having subtracted the sum of penalty indicators notes, generated by levels of salinization, alkalization, carbonation, pollution, and the content of artifacts.

ICF values are interpreted according to a scale of values which separates soils into classes, from those with low fertility to high fertility.

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