THE POSSIBILITY TO ESTIMATE THE LEVEL OF SOIL FERTILITY BY MODULAR AND SYNTHETIC INDICES

Gheorghe ªtefanic, Mirela Emilia Irimescu Orzan and Niculina Gheorghiþã *)

ABSTRACT

The research results obtained in Romania in soil biology domain have contributed to the clarification of the fertility notion and the elimination of its confusion with soil productivity. The definition of fertility, as a fundamental feature of soil was the basis of carrying out the technology to objectively determine its level by pedologic, enzymatic and biotic indicators and finally by a synthetic indicator, which gives the possibility to make an efficient comparison between agricultural soils and a rational technology for increasing crop productivity. Consequently, soil fertility should no more be estimated be vegetal production because important evaluating errors could be introduced, connected to the intensity of certain antropic inter-ferences on a soil with uniform fertility.

Key words: soil chemistry, soil enzymology, soil fertility

INTRODUCTION

By the following definition: ‹‹Fertility is the capacity of soil to satisfy in a way or another, the living needs of plants››, Wiliams (1927) reduced the content of fertility notion within the limits of supplying the plant with water, mineral salts and their transformation into crops, though by his own research and scientific information, he described concretely soil genesis and its internal biologic mechanisms.

Starting from the above definition, the theory and practice of the modern agriculture based on intensive chemical inputs, has led to the confusion between soil fertility and soil productivity. Thus, the increase of crops levels by chemical fertilizers has been understood as an increase of soil fertility and for this reason, these chemicals as fertilizers and this operation as fertilization.

The theory drawn up by Dokuceaev (1846 - 1903), Winogradsky (1949), Wiliams (1927), Stoklasa (1929), Waksman (1927) and other scientists regarding the overwhelming part of microorganisms in soil genesis and its fertility, was later on confirmed by many researchers. In Romania, Pavlovschi and Groza (1947) noticed according to their research, that ‹‹soil fertility depends not only on the presence of nutritional substances in physiological balanced quantities but it is characterized by other factors identified only by special methods. By these methods the functions of arable soil can be pointed out and followed in the system of co-operation with plants and microorganisms.›› Ionescu-ªiºeºti (1947) was the first scientist who clarified the relationship between soil fertility and productivity by his definition: Fertility is a synthesis of favourable characteristics of the soil which are expressed by its durable productivity. These factors are of geographic origin: latitude, exposing, climatic, physical, chemical and biological origin.

The results of Romanian research on soil biology and chemistry in the last 50 years led to a more correct and comprehensive definition drawn up and supported by ªtefanic (1994 a; 1994 b): ‹‹Fertility is the fundamental characteristic of the soil which results from the vital activity of micropopulation, roots of plants, of accumulated enzymes and chemical processes generating biomass, humus, mineral salts and active biological substances.

Fertility level depends on the potential level of bioaccumulation and mineralization processes, they being connected with the programme and conditions of ecological undersystem evolution and antropic influence.››

The possibility to mix up soil fertility with its productivity is eliminated by this definition. Fertility performers, the importance of accumulation level and mineralization processes, the role of ecologic conditions and the way we can estimate by objective tests the fertility level of a soil no matter the way it is used, all these aspects are clearly explained.

Only the insufficient knowledge about soil and successes accumulated in soil biology could determine Sébillot (1989) to affirm that the concept of soil fertility belongs more to the field of social representation than to scientific conceptions, and that fertility would be a sub-

*) Research Institute for Cereals and Industrial Crops, 8264 Fundulea, Cãlãraºi County, Romania

jective notion, and Chaussod (1996) to consider that instead of the notion ‹‹soil ferti-lity›› should be used the notion ‹‹biological quality of soil››, which represents the capacity to carry out some functions connected with crops or with the surrounding environment, in a given system.

We consider that soil, as any living organism, is a complex organized system and this is the explanation why its fertility, as a fundamental objective and inseparable feature, cannot be characterized and estimated only by one or few features.

Medical sciences offer as such an example for how a man’s health and effort should be surveyed and estimated. They are estimated by various tests which describe lots of man’s manifestations.

In the case of soil we have acted in the same way. Considering the multitude of soil processes, accumulations and manifestations, we have considered only those for which we have objective methods of analysis.

In table 1, we suggest, for exemplification, the main directions of research for estimating soil fertility.

Table 1. Physiological and enzymic potentials and chemical contents necessary for determining soil fertility

Main physiological potentials:	Main enzymic potentials:	Main chemical contents:
1.Respiration	1. Catalase	1.Humus (Ct%)
2.Biomass	2. Saccharase	2.Extractable carbon (Ce%)
3.Cellulolyse	3. Urease	3.Humic acids (Cah%)
4.Di-nitrogen fixation	4.Total phosphatases	4.Fulvic acids (Caf%)
5.Proteolise		5. Total nitrogen - Kjeldahlization - (Nt%)
6.Ammonification		6. Organical phosphorus (PO%)
7.Nitrification		7. Acidity
		8. Base saturation

MATERIALS AND METHODS

Various methods to estimate soil fertility are known, the best being those which use numerical taxonomy (Verstraete and Voets, 1977; Suh et al., 1977; Misono, 1977; Teaci, 1980; Beck, 1984; ªtefanic et al., 1984; Benedetti, 1984; Drãgan-Bularda et al., 1987).

The methods used by us, elaborated after 1991, for putting together the results from various tests in a coherent estimation of soil fertility, represent a variant of numerical taxonomy which consists mainly of:

– the transformation of the result of each test in percentage from the maximum value obtained from numerous soil analyses (MEV), as follows:

$$X\% = \frac{Xa \cdot 100}{MEV} \qquad (1)$$

where: Xa = the absolute value obtained in the analytic test;

MEV = Maximum empiric value.

– Percentage results from the related tests (biotic, enzymatic, chemical or pedo-genetical) and the calculation of arithmetic average for certain modules of analysis, as follows:

Indicator of vital activity potential (IVAP %)

$$IVAP\ \% = \frac{\sum_{k=1}^{2}(R,C)}{2} \qquad (2)$$

where: R = Respiration; C = Cellulolyse.

The formula (2) can be amplified by introducing other analytical parameters as biomass or the most probable number of autotrophic nitrification bacteria, or *Azotobacter* number.

Indicator of enzymic activity potential (IEAP %)

$$IEAP\ \% = \frac{\sum_{k=1}^{4}(K,S,U,P)}{4} \qquad (3)$$

where: K = catalase; S = saccharase;
U = urease; P = total phosphatases.

Biological synthetic indicator (BSI %)

$$BSI\ \% = \frac{IPAV + IPAE}{2} \qquad (4)$$

Chemical synthetic indicator (CSI %)

$$\text{CSI \%} = \left(\frac{\sum_{k=1}^{5}(Ct, Ce, Cah, Nt, P)}{5} + \text{pH}\right) : 2 \quad (5)$$

where: Ct = humus; Ce = extractable carbon; Cah = carbon from humic acids; Nt = total nitrogen; P = organical phosphorus.

Pedo-genetic indicator (PGI %)

This indicator is calculated by transforming the Humic Global Index (Chiriþã, 1955) in equivalence between the note of humic class (NHC) and the interval of soil humus content (ISHC), instead of NHC and soil colour (Table 5). Totalizing NHC x thickness of soil horizon, in decimeters, from all horizons with humus (horizon A) and then by converting this value into a relative one, in relation to Maximum Empirical Value (MEV) from Mileanca chernozem, district Botoºani (known as the richest and deepest humus in Romania) we obtained the new Pedo-Genetic Index (PGI %). PGI operating calculation will be presented on the occasion of the characterization of some soils studied in Romania.

Biotic, enzymic and chemical analyses were carried out in the Research Institute for Cereals and Industrial Crops Fundulea (ªtefanic, 1994 a) for soil samples without chemical fertilizers and limestone, in 1966. The types of soil and the places where soil samples were taken from are the following:

- typical chernozem (vermic-limestone-calcium chernozem, classification FAO / UNESCO) – Valu lui Traian, district Constanþa (irrigated);
- cambic chernozem – Fundulea, district Cãlãraºi (irrigated);
- argiloilluvial chernozem (luvic phaeozem – FAO / UNESCO – Caracal, district Olt (irrigated);
- Brown - reddish soil (chromiluvic phaeozem – FAO / UNESCO - ªimnic, district Dolj;
- Albic luvisol – Livada, district Satu-Mare.

Soil samping was carried out at a depth of 0 – 20 cm in Agricultural Research Stations. The tests were performed in three replications and statistically analysed by Duncan's multiple test.

RESULTS AND DISCUSSIONS

For presenting the results of the tests, as a way of mathematical processing for obtaining various indices, we shall present the calculation algorithm step by step: first of all, we shall present the average results of each test and the obtained limit differences (LSD) operating with values of replications. Based on LSD, it was possible to group the experimental variants in classes (statistically significant) concerning biotical and chemical etc. features of soil.

The absolute average values from analyses, concerning respiration and cellulolytic potential of soils and their transformation into percentages from specific MEV by formula (1) are presented in table 2. The absolute average values from enzymic tests were transformed into percentages by formula (1) and then IEAP % was calculated using formula (3).

Considering LSD values (noted with asterisk) the soil types were classified into: the highest values from the specific chernozem of Valu lui Traian and cambic chernozem of Fundulea, noted with letter ‹‹a››, correspond to the highest enzymic potential and brown-reddish soil from ªimnic with the lowest potential (Table 3).

Table 2. Absolute and relative values for respiration potential (mg CO_2/100 g soil d.w./24 h), cellulolytic potential (g decayed cellulose / 100 g cotton tissue d.w. / 18 days) and Indicator of Vital Activity Potential (IVAP %) from different soil types

Soil type	Absolute values		Relative values		
	Respiration (R)	Cellulosolyse (C)	R%	C%	IVAP%
Vermic – typical chernozem	b 33.45	b 40.0	22.30	40.00	c 31.15
Cambic chernozem	a 40.70	a 47.3	27.13	47.30	b 3721
Argiloilluvial chemozem	a 45.30	a 59.4	30.20	59.40	a 44.80
Brown – reddish soil	b 33.50	b 39.7	22.33	39.70	c 31.01
Albic luvisol	c 13.90	c 15.3	9.27	15.30	e 12.28
Albic luvisol	a 39.80	c 13.9	26.53	13.90	d 20.22
Maximum Empirical Value (MEV)	150	100			
LSD 5%	3.2	7.4			3.33
1%	4.2	9.8			4.43
	5.5*	12.7*			5.76*

Table 3. Absolute and relative values for the following potentials: catalase (cm^3 O_2/minute), saccharase (mg monoses / 24 h), urease (mg NH_4^+/24 h) and total phosphatase (mg P/24 h); all values are reported to 100 g soil d.w. and the Indicator of Enzymic Activity Potential (IEAP %) from different soil types

Soil type	Absolute values				Relative values				
	Catalase (K)	Saccharase (Z)	Urease (U)	Phosphatase (F)	K%	Z%	U%	F%	IEAP %
Vermic – typical chernozem	a 1607	b 2744	c 35.8	b 2.81	80.35	78.40	23.87	11.24	a 48.46
Cambic chernozem	b 737	b 2320	a 81.1	a 5.60	36.85	66.29	54.07	22.40	a 44.90
Argiloilluvial chernozem	b 870	d 945	c 32.4	b 2.39	43.50	27.00	21.60	9.56	b 25.41
Brown – reddish soil	c 313	e 699	e 18.2	b 2.36	15.65	19.97	12.13	9.44	d 14.30
Albic luvisol	c 364	d 967	d 30.3	b 3.14	18.20	27.63	20.20	12.56	c 19.65
Albic luvisol	d 71	c 1882	b 43.3	b 2.64	3.55	53.77	28.87	10.56	b 24.19
Maximum Empiric Value (MEV)	2000	3500	150	25					
LSD 5%	85	71	2	0.71					2.32
1%	113	94	3	0.95					3.08
0.1%	147*	122*	4*	1.23*					4.01*

* LSD utilized for comparison

Table 4. Absolute and relative values from the soil chemical analyses: humus (Ct%), extractable carbon (Ce%), humic acids (Cah%), total nitrogen (Nt%), organical phosphorus (Po mg/100 g soil d.w.) and pH_{H_2O} and the Chemical Synthetic Indicator (CSI %)

Soil types	Absolute values						Relative values						
	Ct	Ce	Cah	Nt	PO	pH	Ct	Ce	Cah	Nt	PO	pH	CSI%
Vermic-typical chernozem	1.56	0.56	0.41	0.19	6.56	7.97	36.71	40.00	51.25	76.00	25.23	96.02	a 70.93
Cambic chernozem	1.55	0,74	0.59	0.14	7.46	7.29	36.47	52.86	73.75	56.00	28.69	87.83	b 66.69
Argiloilluvial chernozem	1.27	0.61	0.43	0.15	13.97	6.74	29.88	43.57	53.75	60.00	53.73	81.20	b 64.69
Brown-reddish soil	0.76	0.38	0.26	0.11	3.56	4.68	17.88	27.14	32.50	44.00	13.69	56.39	d 41.72
Albic luvisol	1.32	0.80	0.28	0.11	4.79	4.89	31.06	57.14	35.00	44.00	18.42	58.92	c [illegible]

The absolute values, from chemical tests, were transformed into percentages by the same formula (1); then CSI % was calculated by formula (5) (Table 4).

By our new research, we tried to pass over the limits of soil fertility estimation which has been used by us up to cnow (ªtefanic, 1994 a, 1994 b, ªtefanic et al., 1998) where fertility level was estimated only in arable soil. Such estimation made possible the over estimation of some biotops in thin and ecologically unfavourable soils but agrotechnically improved.

Introducing the pedo-genetical indicator (PGI %) in the algorithm of calculation of synthetic indicator of soil fertility, we obtain a better estimation of soil fertility, closer to the potential of agricultural production.

In table 5, we estimate the numeric values of humic horizon class, in the soil profile, by analogy with humus colour (Chiriþã, 1955) and by our analogy with the interval of humus content. We also give an example of calculation (Chiriþã, 1955) for obtaining the humic total index (HGI) of a specific chernozem. Then, we present the transformation of HGI into PGI %.

In table 6 we present with details the determination of HGI and PGI for the studied soils considering the pattern shown in table 5 (humus contents and humus level depth in decimeters are taken from Trips Guide, published by Romanian National Society for Soil Science). The modular and synthetic indicators, characterizing different activities of the studied soils and the new synthetic indicator for soil fertility (SISF%) are presented in table 7. The new SIFS % compared with the old SISF % (introduced now into table 6 as vital, energetic, trophic level – VETL %) differentiates better soil types, more concordant with the potential of agricultural production.

Table 5. Conversion of the Note of Humic Class (NHC) of humus horizons from the soil colour of qualitative description (Chiriþã, 1955), to the Interval of Soil Humus Content (ISHC)

Note of Humic Class (NHC)	Soil colour description referring to the humus content of horisons in soil profile	Interval of Soil Humus Content (ISHC) Ct%
1	Soil without humus; very light colour in superior horizon; yellowish, whitish, whitish - grey	< 1
2	Soil meagre in humus; brown – yellowish; yellowish – brown; brown - grey	1 – 1.49
3	Soil with moderate content in humus; chestnut, brown, reddish -brown, grey - brown	1.5 – 1.99
4	Soil rich in humus, black colour	2 – 3
5	Peaty soil, peat, swamp. Hardly one sees the minerals in organical matter	It is not used. They are not agricultural soil

Example of calculation for Humic Global Index (HGI) for a Vermi-typical chernozem:

HGI = 4 (2.5) + (0.5) + 2 (1.8) + 2 (2.2) = 19.5

Note: - figures in front of the parentheses = not of humic class horizons in soil profile

- figures into the parantheses = dimension in decimeters of horison

Transformation of Humic Global Index in Pedo-Genetical Indicator (PGI%):

$$PGI\% = \frac{HGI \times 100}{MEV}$$

MEV = 20 (a very fertile soil from Mileanca, Botoºani County)

Consequently, $PGI\% = \frac{19.5 \times 100}{20} = 97.5$

Table 6. Calculation made for determining Humic Global Index (HGI) and Pedo-Genetical Indicator (PGI%) for analysed soils

Station and soil type	Horizon	Thickness dm	Humus Ct%	Humic group	HGI ?(2 x 4) colons	PGI% $\frac{HGI \times 100}{MEV}$
Valu lui Traian Constanþa County Vermic-typical chernozem	Ap1	2.5	2.01	4		
	Ap 2 h	0.5	1.55	3	19.5	97.5
	Am k	1.8	1.49	2		
	Ac k	2.2	1.09	2		
Fundulea Cãlãraºi County Cambic chernozem	Ap	1.8	1.72	3		
	Ap h	1.2	1.72	3	15.4	77.0
	Am	1.5	1.38	2		
	AB	1.7	1.21	2		
Caracal Olt County Argiloilluvial chemozem	Ap 1	1.8	1.77	3		
	Ap 2	1.4	1.68	3	17.8	89.0
	Am	1.8	1.40	2		
	AB	2.3	1.31	2		
ªimnic Dolj County Brown-reddish soil	Ap	2.0	0.87	1		
	Ao	1.2	0.62	1	8.1	40.5
	AB	1.7	0.39	1		
Albota Argeº County Albic luvisol	Ap + Er	2.7	0.96	1	2.7	13.5
Livada Satu-Mare County Albic luvisol	Ap + Er	2.7	0.92	1	2.7	13.5

So, the most fertile soil is the typical chernozem (a), argiloilluvial chernozem (b), cambic chernozem (c). The last soils are brow-reddish soil (d) and albic luvisol soil (d).

These objective and precise ways of estimation and synthetic expression of soil fertility level by modular and synthetical indicators are considered to be an efficient instrument for grouping agricultural soils into classes of distinct fertility, for a better taxation.

At the same time, we could control the influence of agro-technologies by periodical analyses (at 10 – 12 years), estimating soil fertility by these indicators.

Table 7. Modular and synthetic indicators of fertility level of different soil types

Soil type	IVAP (%)	IEAP (%)	BSI(%) = $\frac{IVAP + IEAP}{2}$ (Biological Synthetic Indicator)	CSI (%)	VETL(%) = $\frac{BSI + CSI}{2}$ (Vital, Energetic and Trophic Level)	PGI(%) (Pedo-Genetical Indicator)	SISF(%) = $\frac{VETL + PGI}{2}$ (Sinthetic Indicator of Soil Fertility)
Vermic-typical chernozem	c 31.15	a 48.46	a 38.17	a 70.93	a 54.55	97.5	a 76.02
Cambic chernozem	b 37.21	a 44.90	a 41.05	b 66.69	a 53.87	77.0	c 65.43
Argiloilluvial chemozem	a 44.80	b 25.41	b 35.10	b 64.69	b 49.89	89.0	b 69.44
Brown-reddish soil	c 31.01	d 14.30	c 22.65	d 41.72	c 32.18	40.5	d 36.34
Albic luvisol	e 12.28	c 19.65	d 15.96	c 48.02	c 31.88	13.5	e 22.74
Albic luvisol	d 20.22	b 24.19	c 22.20	d 39.88	c 31.04	13.5	e 22.27
LD 5%	3.33	2.32	1.86	1.91	1.35		1.35
1%	4.43	3.08	2.47	2.55	1.81		1.81
0.1%	5.76*	4.01*	3.32	3.32*	2.35*		2.35*

*) utilized LD for comparison

CONCLUSIONS

Fertility, as a fundamental feature of soil, is an objective and quantitative parameter.

Fertility level of soil, determined on chemical and biological bases, estimated by trophic, energetic and vital level (VETL %) has a biological significance useful for the control of results produced by agro-technologies.

The level of soil fertility (estimated by the syntetic indicator of soil fertility – SISF %) has an agronomical significance because it also introduces, besides the parameter VETL %, the pedogenetic indicator parameter (PGI %).

This indicator (SISF %) differentiates better the fertility level of soils for a more objective grouping of agricultural soils in classes of fertility.

REFERENCES

Beck, Th., 1984. Methods and application domain of soil microbiological analysis at Landesanstalt für Bodenkultur und Pflanzenbau (LPB) in Münich for the determination of some aspects of soil fertility. Fifth Symp. on Soil Biology, Iaºi, Romanian National Society of Soil Science, 1981: 13-20.

Benedetti, A., 1984. Fertilitá biologica del terreno e concimi ad azota lenta. Annali dell'Instituto Sperimentale per la Nutrizione delle Piante, 1983-1984, XII, 3: 1-14.

Chaussod, R., 1996. La qualté biologique des sols: évaluation et implications. Étude et Gestion des Sols, 3, 4: 261-278, numéro spécial.

Chiriþã, C., 1995. General Pedology. Edit. Agro-Silvicã, Bucureºti.

Drãgan-Bularda, M., Blaga, G., Kiss, ª., Paºca, D., Gherasim, V., Vulcan, R., 1987. Effect of long-term fertilization on the enzyme activities in a technogenic soil resulted from the recultivation of iron strip mine soil. Studia Univ. Babeº-Bolyai, Biologia, 32, 2: 47-52.

Ionescu-ªiºeºti, G., 1947. Agrotehnica. Bucureºti.

Misono, S., 1977. Three phases distribution as a factor of soil fertility. Proc. Intern. Seminar on Soil Environment and Fertility Management in intensive Agriculture (SEFMIA), Tokyo: 154-160.

Pavlovshi, G., Groza, M., 1947. Sistemele fermentative ale solului. An. ICAR, XIX: 3-17.

Sébillotte, M., 1989. Fertilité et systémes de production. INRA Edit. Paris: 369.

Stoklasa, J., 1929. Quelles sont les méthodes biochimiques pour augmenter la fertilité du sol., XIV Congr. Internat. d'Agriculture, Bucarest: 1-18.

Suh, Y.S., Kyuma, K., Kawaguchi, k., 1977. A method of capability evaluation for upland soils. 4. Fertility evaluation and fertility classification. Soil Sci. and Plant Nutrition, 23, 3: 275-286.

ªtefanic, G., Eliade, G., Chirnogeanu, I., 1984. Researches concerning a biological index of soil fertility. Fifth Symp. on Soil Biolo. SNRSS, Iaºi, 1981: 35-45.

ªtefanic, G., 1994a. Cuantificarea fertilitãþii solului prin indici biologici. Luct. Conf. Naþ. ªtiinþa solului, Tulcea, SNRSS, 28a: 45-55.

ªtefanic, G., 1994b. Biological definition, quantifying method and agricultural interpretation of soil fertility. Romanian Agricultural Research, 2: 107-116.

Teaci, D., 1980. Bonitarea terenurilor agricole. Edit Ceres, Bucureºti.

Verstraete, W., Voets, J.P., 1977. Soil microbial and biochemical characteristics in relation to soil management and fertility. Soil Biol. Biochem., 9: 253-258.

Waksman, S.A., 1927. Principles of soil microbiology. London, Ed. Baillière, Tindall et Con.

Wiliams, V.R. 1927. Edition I. Translation in Romanian (1954). Pedologie. Agrotehnica cu baze de pedologie. Edit. Agro-Silvicã de Stat, Bucureºti.

Winogradsky, S., 1949. Microbiologie du sol. Paris.

*** Guide of trips, 9th Conf. of Soil Sci. Craiova:172; 201, Edit. Romanian National Society of Soil Science, Bucharest.

*** Guide of trips, 13th Conf. of Soil Sci., 1988 Piteºti: 128, Edit. Romanian National Society of Soil Science, Bucharest.

*** Guide of trips, 14th Conf. of Soil Sci., 1994 Tulcea: 88, Edit. Romanian National Society of Soil Science, Bucharest.

*** Guide of trips, 15th Conf. of Soil Sci., 1997 Bucureºti: 184, Edit. Romanian National Society of Soil Science, Bucharest.

Table 1. Soil manifests some physiological and enzymic potentials and chemical contents necessary for determining the soil fertility

Main physiological potentials:	Main enzymic potentials:	Main chemical contents:
1. Respiration	1. Catalase	1. Humus (Ct%)
2. Biomass	2. Saccharase	2. Extractable carbon (Ce%)
3. Cellulolyse	3. Urease	3. Humic acids (Cah%)
4. Di-nitrogen fixation	4. Total phosphatases	4. Fulvic acids (Caf%)
5. Proteolise		5. Total nitrogen – Kjeldahlization – (Nt%)
6. Ammonification		6. Organical phosphorus (PO%)
7. Nitrification		7. Acidity
		8. Base saturation

Table 2. Absolute and relative values for respiration potential (mg CO2/100 g soil d.w./24 h), cellulolytic potential (g decayed cellulose / 100 g cotton tissue d.w. / 18 days) and Indicator of Vital Activity Potential (IVAP %) from different soil types

Soil type	Absolute values				
	Respiration (R)	Cellulosolyse (C)	R%	C%	IVAP%
Vermic – typical chernozem	b 33.45	b 40.0	22.30	40.00	c 31.15
Cambic chernozem	a 40.70	a 47.3	27.13	47.30	b 3721
Argiloilluvial chernozem	a 45.30	a 59.4	30.20	59.40	a 44.80
Brown – reddish soil	b 33.50	b 39.7	22.33	39.70	c 31.01
Albic luvisol	c 13.90	c 15.3	9.27	15.30	e 12.28
Albic luvisol	a 39.80	c 13.9	26.53	13.90	d 20.22
Maximum Empiric Value (MEV)	150	100			
LD 5%	3.2	7.4			3.33
1%	4.2	9.8			4.43
	5.5*	12.7*			5.76*
*) utilized LD for comparison					

Table 3. Absolute and relative values for following potentials: catalase (cm^3 O_2/minute), saccharase (mg monoses / 24 h), urease (mg NH_4^+ / 24 h) and total phosphatase (mg P / 24 h), all values are reported to 100 g soil d.w. and the Indicator of Enzymic Activity Potential (IEAP %) from different soil types

Soil type	Absolute values	Relative values

	Catalase (K)	Sac-charase (Z)	Urease (U)	Phos-phatase (F)	K%	Z%	U%	F%	IEAP%
Vermic – typical chernozem	a 1607	b 2744	c 35.8	b 2.81	80.35	78.40	23.87	11.24	a 48.46
Cambic chernozem	b 737	b 2320	a 81.1	a 5.60	36.85	66.29	54.07	22.40	a 44.90
Argiloilluvial cher-nozem	b 870	d 945	c 32.4	b 2.39	43.50	27.00	21.60	9.56	b 25.41
Brown – reddish soil	c 313	e 699	e 18.2	b 2.36	15.65	19.97	12.13	9.44	d 14.30
Albic luvisol	c 364	d 967	d 30.3	b 3.14	18.20	27.63	20.20	12.56	c 19.65
Albic luvisol	d 71	c 1882	b 43.3	b 2.64	3.55	53.77	28.87	10.56	b 24.19
Maximum Empiric Value (MEV)	2000	3500	150	25					
LD 5%	85	71	2	0.71					2.32
1%	113	94	3	0.95					3.08
0.1%	147*	122*	4*	1.23*					4.01*
* utilized LD for comparison									

Table 4. Absolute and relative values from the soil chemical analyses: humus (Ct%), extractable carbon (Ce%), humic acids (Cah%), total nitrogen (Nt%), organical phosphorus (P mg/100 g soil d.w.) and pH-H_2O and the Chemical Synthetic Indicator (CSI %)

Soil type	Absolute values						Relative values						
	Ct	Ce	Cah	Nt	PO	pH	Ct	Ce	Cah	Nt	PO	pH	CSI%
Vermic-typical chernozem	1.56	0.56	0.41	0.19	6.56	7.97	36.71	40.00	51.25	76.00	25.23	96.02	a 70.93
Cambic cher-nozem	1.55	0,74	0.59	0.14	7.46	7.29	36.47	52.86	73.75	56.00	28.69	87.83	b 66.69
Argiloilluvial chernozem	1.27	0.61	0.43	0.15	13.97	6.74	29.88	43.57	53.75	60.00	53.73	81.20	b 64.69
Brown-reddish soil	0.76	0.38	0.26	0.11	3.56	4.68	17.88	27.14	32.50	44.00	13.69	56.39	d 41.72
Albic luvisol	1.32	0.80	0.28	0.11	4.79	4.89	31.06	57.14	35.00	44.00	18.42	58.92	c 48.02
Albic luvisol	0.81	0.36	0.09	0.08	8.45	4.62	19.06	25.71	11.25	32.00	32.50	55.66	d 39.88
Maximum Em-piric Value (MEV)	4.25	1.40	0.80	0.25	26	8.30							
LD 5% 1% 0.15													1.91 2.55 3.32*

* utilized LD for comparison

Table 5. Conversion of the Note of Humic Class (NHC) of humus horizons from the soil colour of qualitative description (Chiriþã, 1955), to the Interval of Soil Humus Content (ISHC)

Note of	Soil colour description referring to the	Interval of Soil Humus

Humic class (NHC)	humus content of horisons in soil profile	Content (ISHC) Ct%
1.	Soil without humus; very light colour in superior horizon; yellowish, whitish, whitish - grey	< 1
2.	Soil meagre in humus; brown – yellow-ish; yellowish – brown; brown - grey	1 – 1.49
3.	Soil with moderate content in humus; chestnut, brown, reddish-brown, grey - brown	1.5 – 1.99
4.	Soil rich in humus, black colour	2 – 3
5.	Peaty soil, peat, swamp. Hardly one sees the minerals in organical matter	It is not used. They are not agricultural soil

Example of calculation for Humic Global Index (HG) for a Vermi-typical chernozem:

HGI = 4 (2.5) + (0.5) + 2 (1.8) + 2 (2.2) = 19.5
Note: - figures in front of the parentheses = not of humic class horizons in soil profile
- figures into the parantheses = dimension in decimeters of horison
Transformation of Humic Global Index in Pedo-Genetical Indicator (PGI%):

$$PGI\% = \frac{HGI x 100}{MEV}$$

MEV = 20 (a very fertile soil from Mileanca, Boto°ani (county)

$$\text{Consequently, } PGI\% = \frac{19.5 x 100}{20} = 97.5$$

Table 6. Calculation made for determining Humic Global Index (HGI) and Pedo-Genetical Indicator (PGI%) for analysed soils

Station and soil type	Horizon	Thickness dm	Humus Ct%	Humic group	HGI ?(2 x 4)	PGI%

					colons	$\frac{HGIx100}{MEV}$
Colons	1	2	3	4	5	6
Valul lui Traian	Ap1	2.5	2.01	4		
Constanþa County	Ap 2 h	0.5	1.55	3	19.5	97.5
Vermic-typical cher-nozem	Am k	1.8	1.49	2		
	Ac k	2.2	1.09	2		
Fundulea	Ap	1.8	1.72	3		
Cãlãraºi County	Ap h	1.2	1.72	3	15.4	77.0
Cambic cher-nozem	Am	1.5	1.38	2		
	AB	1.7	1.21	2		
Caracal	Ap 1	1.8	1.77	3		
Olt County	Ap 2	1.4	1.68	3	17.8	89.0
Argiloilluvial chernozem	Am	1.8	1.40	2		
	AB	2.3	1.31	2		
ªimnic	Ap	2.0	0.87	1		
Dolj County	Ao	1.2	0.62	1	8.1	40.5
Brown-reddish soil	AB	1.7	0.39	1		
Albota						
Argeº County	Ap + Er	2.7	0.96	1	2.7	13.5
Albic luvisol						
Livada						
Satu-Mare County	Ap + Er	2.7	0.92	1	2.7	13.5
Albic luvisol						

Table 7. Modular and synthetic indicators of fertility level of different soil types

Soil type	IVAP (%)	IEAP (%)	BSI(%) = $\frac{IVAP + IEAP}{2}$ (Biological Syn-thetic Indicator)	CSI (%)	VETL(%) = $\frac{BSI + CSI}{2}$ (Vital, Energetic and Trophic Level)	PGI(%) (Pedo-Genetical Indicator)	SISF(%) = $\frac{VETL + PGI}{2}$
Vermic-	c	a	a 38.17	a	a 54.55	97.5	a 76.02

typical chernozem	31.15	48.46		70.93			
Cambic chernozem	b 37.21	a 44.90	a 41.05	b 66.69	a 53.87	77.0	c 65.43
Argiloilluvial chernozem	a 44.80	b 25.41	b 35.10	b 64.69	b 49.89	89.0	b 69.44
Brown-reddish soil	c 31.01	d 14.30	c 22.65	d 41.72	c 32.18	40.5	d 36.34
Albic luvisol	e 12.28	c 19.65	d 15.96	c 48.02	c 31.88	13.5	e 22.74
Albic luvisol	d 20.22	b 24.19	c 22.20	d 39.88	c 31.04	13.5	e 22.27
LD 5%	3.33	2.32	1.86	1.91	1.35		1.35
1%	4.43	3.08	2.47	2.55	1.81		1.81
0.1%	5.76*	4.01*	3.32	3.32*	2.35*		2.35*

*) utilized LD for comparison