Scientific Papers, UASVM Bucharest, Series A, Vol. LIII, 2010, ISSN 1222-5339

STUDIES AND METHODICAL APPLICATIONS FOR ESTIMATING THE FERTILITY STATE OF SOILS

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Keywords: *soil fertility, biological tests, biological indicators*

Abstract

The information from China (En-feng Chen et al., 1982), confirms that with 4000 years ago, the peasants considered that soil is fertile if its physical state is good, it shows a high resistance to the action of unfavourable factors and adaptation to the agricultural practices. In the second half of 20^th^ century, agrochemists, agro-phytotechnics and farmers appreciated (and they do it today also) the level of soil fertility according to the crop size. Contrarily, biologists state that the level of soil fertility may be quantified by the level of vital and biochemical processes, chemical and physical features, and not by its vegetal productivity, which is dependent, in the greatest measure, on the agrotechnologies employed. The achieved progress in Soil Biology and Pedoenzymology, at the end of 20^th^ century and the beginning of the 21^st^, lead to the establishment of some Indicators of Soil Fertility Potential: in Romania (Ştefanic, 1984; 1994 and 2001), in West Germany (Beck, 1984), in Italy (Benedetti, 1984) and in the USA (Liebig et al., 2001). The present paper shows, the mode of elaboration of the Synthetic Indicator of Soil Fertility (SISF%) is showed (Ştefanic et al., 2001).

INTRODUCTION

Agriculture experience, transmitted to descendats, made possible to associate the quality of climate and soil physical aspects with crop size. En-feng Chen *et al.* (1982), citing ancient writing sources (4000 years) from China, mentioned: „ *the Chinese peasants considered that the soil is fertile, whether its physical state is good, whether it shows high resistance to the action of unfavourable factors and adaptability to the agricultural practices".*

The accumulation of agricultural and scietific information (particularly of soil chemistry) determined the conception of agrochemists, agronomists and of farmers, that the soil fertility is the same with soil productivity, that soil fertility may be estimated by crop size.

Soil Microbiology and then Soil Biology, at the end of the 19th century and in the first part of the 20th one, determined a biodynamic perception of soil fertility as the consequence of the physical, chemical, biochemical and vital processes developed in the loose layer from the surface of mother rocks, which in the higher plant organisms adapted themselves to growth. This is the working manner even since

1901, Vaillant wrote: „ *...both the humus content is higher, and the soil is more fertile and this fertility seems to be due, particularly, to a high number of organisms, fixing of diazote, which live here”*. Prediction of defining the soil fertility by the size of vegetal production there is no in this definition! Microbiological, pedoenzymical, chemical and pedological researchs has established the decisive contribution of the vegetal cover to soil formation and evolution processes.

Agrophytotechnical interventions have determined some alterations in the soil fertility features. At the beginning, crops (for many years) were utilized as guide mark to constitute some agronomical indices for the estimation of the quality of antropic interventions on cultivated soil quality. Later, both the crops and the contents of macro- and microelements in soil, chemical reaction and physical state of soils became, for agrochemists, quide marks for other indices of soil fertility. Thus, Nieschlag (1965), cited by Davidescu (1972), proposed as Index of Fertility, IF = 33,33 Nt x (Nt : Ct) x 4 x clay %. Some index corresponds to the approximate estimation of the quality of organic matter, but suffers a statical vision of result interpretation of the soil chemical analyses.

The biological theory of soil fertility and agrotechnology recommended by Steiner (1924), Pfeiffer (1938 and 1966), Howard (1941) and the agricultural currents, included today in Ecological Agricultures, are beginning to be accepted at the present.

Soil biologists have tried to evaluate, by synthetic indicators, the level of soil fertility, as a basic feature. Thus, Ştefanic (1994), Ştefanic and Gheorghiță (2006) proposed a Synthetic Indicator of Soil Fertility, Beck (1984) proposed an Enzymatic Number of Soil Fertility and Benedetti (1984) proposed Biological Index of Soil Fertility based on soil respiration potential, ammonification and nitrification potentials.

A strange ignorance of the word semantics provoked a serious confusion: one proposes to use the syntagma *soil quality* instead of *soil fertility*. Chaussod (1996) has affirmed: *„the notion of soil quality ..... tends to replace the ancient notion of soil fertility”* and in the USA was founded, in 1993, the Institute of Soil Quality, marking an equality between Soil Quality and Soil Fertility. In fact, Fertility is a phenomenon, it is a reality that can be measured, but Quality is an abstraction that may be apreciated (good, bad *etc.*), being at the same time a subjective notion (good, in my interest, for building a house, or an airport, or for agriculture).

A group of researchers from the USA [12] who studied a limited set of treatments in a long time experiment initiated in 1983, from the west of Corn Belt, avoiding the syntagms Soil Quality and Soil Fertility, choose the syntagm Agrosystem Performance for measuring soil fertility and productivity. Here is their formula:
Agrosystem performance = f [(food production x Wfp), (raw materials production x Wrmp), (nutrient cycling x Wnc), (greenhouse gas regulation x Wggr)], where:

all letters W represent the initial of word Weight (the value of each function), and the smal letters represent the initial of the functions.

We mention that the author's intention is valuable for estimating objectively, by figures, the Agroecosystem performance, but it includes food production and raw materials which depend on the quality of technology, more than soil fertility.

Towards the end of the 20^{th} century, the signals of alarm, regarding the continuous increase in the production expenses (for maintaining the high level of crops), increasing of agriculture product stocks in farms and alarming and rapid degradation of fertile soils determined the European Comission for Agriculture to propose, in 1991, at the Conference Bruxelles, New Communitary Agricultural Policies, that to stimulate the farmers to use managerial practices of production, fewer intensive, dimminishing, in this way, the impact on the enviroment and the surplus of crops. That new official attitude stimulated the manifestation of the scientific biological currents and the agronomical recommendation for the protection of fertile soil, degradated by agrotechnologies oriented towards *„to pull up from soils some rich crops"*.

Towards the 20^{th} century and the beginning of the 21^{st} it became extremely necessary to find some control tests of the agricultural soil evolution and application of biological agrotechnologies which stop the antropic degradation of soils with good fertility, as well as the improvement of acid and salinized soils.

Ştefanic (1984, 1994 a and b) and Ştefanic *et. al.,* (1997; 2001; 2008; 2010) elaborated and improved laboratory technology for a complex analysis of the horizon 0-20 cm of soils and calculated a Synthetic Indicator of Soil Fertility (SISF%), for grouping the analysed sols in different classes of fertility potential.

MATERIAL AND METHODS

a. Analysis of the main physiological potentials of soil:* respiration–R (MEV=150 mg CO_2), cellulolyse–C (MEV=100 g cellulose) and, unsymbiotical dinitrogen fixation, from atmosphere –UDFA (MEV= 20 mg N)

b. Analysis of the main pedoenzymatic potentials:* catalase-K (MEV=2000 cmc), saccharase-S (MEV=3500 mg), total amidase–At (MEV=0.8, and total phosphatase-Pt MEV=25 mg).
*– all methods (*a* and *b*) are original or improved by Ştefanic, and Ştefanic *et al.,*1984, 1988, 1994, 1997, 1998, 2000, 2006).

c. Chemical analysis of of soil: humus-Ct (MEV=4.25 g), extractable organic carbon- Ce-(MEV=1.40 g), huminic acid-Cah (MEV=0.80 g), fulvic acid-Caf (MEV=0.60 by Kononova and Belcikova method (1968) and Salfeld, (1974), total nitrogen, Kjeldahl-Nt (MEV=0.250 g), organical phosphorus-PO (MEV=25 mg), by Legg and Black method (1955), chemical reaction-pH (MEV=8.30), base saturation-V% (MEV=100).

d. Pedo-genetic Indicator (Ştefanic *et al.,* 2001): a conversion of Humic Class Note (Chiriță, 1955) from the soil colour, in Humus Content Interval of Soil (HCIS), MEV = 19.5

N.B.: One established for each test a maximum value – Maximum Empiric Value (MEV), for transforming the test values of an analysis in percents by the formula: X%=Xa x 100 : MEV where: X%= test result in percent; Xa=test result to be transformed in percent; MEV= maximum empiric value indicated for each test.

The test results, transformed in percent values, have become *Primary Specific Indicators (PSI%)* with which one makes the first quantifications for calculating the *Modular Synthetic Indicators for quantifyng the level of soil vitality* by the formulae:

1. Indicator of Vital Activity Potential : (IVAP%)=R%+C%+UDFA% : 3;
2. Indicator of Enzymic Activity Potential (IEAP%)= K%+S%+At%+Pt% : 4, and
3. Biologic Synthetic Indicator (BSI%)= IVAP% + IEAP% : 2

RESULTS AND DISCUSSION

Table 1

Modular and synthetic indicators of fertility level, on different soil types

Soil type	IPAV (%)	IEAP (%)	BSI (%)	CSI (%)	VETL (%)	PGI (%)	SISF (%)
Vermic-typical chernozem (Valu lui Traian)	31.15	48.46	38.17	70.93	54.55	97.50	76.02
Cambic chernozem (Fundulea)	37.21	44.90	41.05	66.69	53.87	77.00	65.43
Argiloilluvial chernozem (Caracal)	44.80	25.41	35.10	64.69	49.89	89.00	69.44
Reddish preluvosol (Simnic)	31.01	14.30	22.65	41.72	32.18	40.50	36.34
Albic luvisol (Albota)	12.28	19.65	15.96	48.02	31.88	13.50	22.74
Albic luvisol (Livada)	20.22	24.19	22.20	39.88	31.04	13.50	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

Modular Synthetic Indicator for quantifying the chemical features of soils- Chemical Synthetic Indicator (CSI%) by the formula:

CSI%= {[(C%+Ce%+Cah%+Caf%+Nt%+V%) : 6] + pH%} : 2

Modular Synthetic Indicator for quantifying the level of Energetic and Trophic Level of Soil (SIETLS%) by the formula: SIETLS% = BSI% + CSI% : 2

Modular Synthetic Indicator for quantifying the Pedo-Genetic Potential (IPGP%)
IPGP% = HCIS% x 100 : MEV in which: HCIS = humic content interval of soil ü
Synthetic Estimation of Soil Fertility

At the end, being in possession of all calculation elements, we can compute the Synthetic Indicator of Soil Fertility (SISF%), by the formula:

SISF% = (SIETL% + IPGP%) : 2

CONCLUSIONS

1. By the Synthetic Indicator of Soil Fertility, calculated based on the Modular Indicators, both the level of Fertility Potential of agricultural soils and of those with other utilization modes, may be quantified objectively.

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