An applicable field method for the evaluation of some ecologically significant soil-function-parameters in science and agricultural consulting practice

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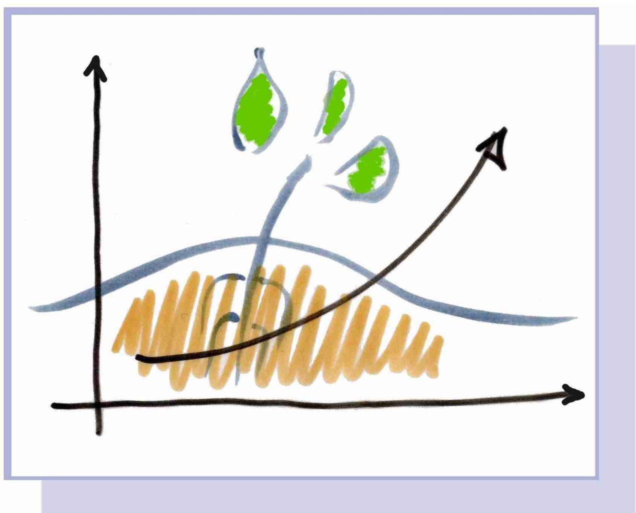

Institute for Soil Conservation
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Sustainable Agriculture

Introduction

The soil, like water, air, and energy, is one of our most important resources. Our future living conditions will depend most fundamentally on how well we manage this nourishing resource. A serious endangerment of ecological soil vitality caused by the effects of pollution and high external input management systems, can be confirmed at a global level. Besides the contamination of soil, groundwater and drinking water with foreign substances, the rapid decrease of soil-biota - biological degradation - and, amplified by this, the high susceptibility of soils for compaction and erosion - physical degradation, represent two more syndromes which have been termed as a serious threat for the global resources of food production (UNEP/ISRIC 1990, WBGU 1994, HURNI 1996). The development and application of ecologically appropriate soil and land management systems, which allow the long term-maintenance of ecological soil functions, represents an urgent challenge and imperative. To document the effects of soil and land management systems on ecological soil functions, scientific methods have to be developed which are able to show the influence of management on the state of soil vitality.

Some conclusions made by the last Conference of the International Soil Conservation Organisation in Bonn 1996, show the necessity of research concerning these issues.

To progress in combating soil degradation there is a need of comparing soil management practices and land use systems due to their sustainability. Therefore we have to elaborate indicators with great evidence about the change of organic matter in soils, natural soil fertility, buffer capacity as well as indicators of quality for sustainable soil management.[...]
Not only sophisticated methods but also quick methods that can be applied by non-researchers should be developed.[...] Although there is a dominant interest in quantitative data, qualitative data often is more relevant and revealing (GFME 1996).

To assess the effects of human land management on the condition of ecological soil-functions and the resilience of soils, there exist various methods to investigate soil parameters (e.g. water circulation, supply of nutrients, activity of soil biota, soil physics). Most of them are rather complicated or very time-consuming.

With reference to ecological soil vitality, the condition of soil structure represents a complex and sensitive indicator. Water circulation, soil life activity and transformation capacity are interconnected complexely with the state of soil structure. Therefore, in a sustainable management system the capability of soil structure to maintain stability under frequent agricultural drive-over and to resist the erosive effects of precipitation is of great interest.

Spade diagnosis - complex evaluation of soil conditions

Methods which aim to assess effects of management practices on this complex ecosystem have to be able to mediate a comprehensive qualitative impression of the actual state of health. As they have to be comparable they should also deliver exact data of common soil parameters.

The practice of the spade diagnosis, developed by J. GÖRBING about 1930 (GÖRBING 1947) is to dig a ‘soil-brick’ with the so-called flat spade out of the field (Fig.1).

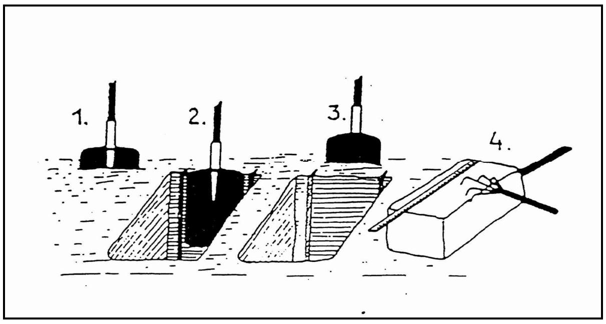


Fig. 1

The soil brick is immediately examined with reference to the condition of soil structure (loose, medium, dense, possible existance of compaction layers) and other parameters (moisture: dry, less wet, medium-wet, wet). In support of this method the condition of soil structure, size, shape and arrangement of soil particles and aggregates as well as density, root growth and soil moisture can be examined with little effort.

Spade diagnosis by GÖRBING

Date:			**Remarks**:			
Plot:	**Crop:**					
			(Organic matter, earth worms, worm dropping)			
	Soil structure		**Roots**		**Soil moisture**	
Topsoil	loose crumble-structure		many and fine roots		wet	
	crumbles and clods		few roots		medium	
0-15 cm	sharp-edged compacted clods		scarcely roots		dry	
Subsoil	crumble-structure		many and fine roots		wet	
	crumbles and clods		few roots		medium	
15-30 cm	sharp-edged compacted clods		scarcely roots		dry	

Fig. 2 Field record

This comprehensive impression has been proved to be very helpful for the judgement of previous management practices (crop-rotations, tillage-systems ...) and appropriate decisions about modifications of future soil management by agricultural consulters and farmers. „With no other method a farmer can provide so much information about the condition of soil crumb as quickly, as simply and as cheaply" (HAMPL 1995).The immediate and almost holistic view on the actual state of health of a soil crumb, which is of great importance taking into account the complexity of this ecosystem, has to be emphasised as a great advantage and cannot be delivered by data from laboratory studies with isolated samples only.

For the scientific use of the complex ecological information gained by this method some modifications and extensions have been done in 1994 by U. HAMPL and N. KUSSEL in order to collect data with scientific evidence about the condition of soil crumb. Additional development, further modifications and experimentation of the now called EXTENDED SPADE DIAGNOSIS (ESD) has been implemented since 1996 by A. BESTE, based on investigations under different management (organic / integrated), different crop rotation and different tillage systems.
To gain an impression of the condition of soil crumb with respect to biological activity, some new soil evaluation schemes and laboratory tests have been developed. They are implemented in combination with investigations of common soil parameters.

<u>The following parameters are examined with the EXTENDED SPADE DIAGNOSIS[1]:</u>

- Structure evaluation and root growth by means of a new developed evaluation scheme
- Aggregate stability and morphology in each layer
- Soil moisture, pore volume and bulk density using 3 short core samples for each layer
- Measurement of shear strength in each layer.

The initial practice of ESD is like the GÖRBING method. First a location is selected which is representative in vegetation and surface. There the profile spade and the flat spade have to be driven vertically into the soil. In front of the flat spade a pit has to be dug to bring out the brick-like profile. Using the flat spade as a 'table' the profile can now be placed on two pillars for the diagnose. Now the structure is graduated at the profile.

[1] Tables and Data taken with reservation from the PhD-thesis of A. BESTE.

Structure evaluation scheme

The main criteria for the structure evaluation marks is the condition of root growth and habitat conditions for soil biota. All attributes which are proved to support a well-balanced distribution of water and air and consequently good preconditions for root growth and biological activity gain high marks, all which signal conditions to the contrary gain low marks.

Tab. 1: Evaluation scheme for soil structure in loamy soils (BESTE 1999)

Layer	Appearance	Structure mark
	Rough, unite aggregates visible-not silted up, worm dropping, no crusts	**5**
	intermediate mark	4
Surface 0-1 cm	Aggregates silted up, scarcely worm dropping, beginning crust-formation	**3**
	intermediate mark	2
	Crusts, tears, aggregates silted up, surface sealed	**1**
	About 80 % crumbles, loose, in case of clayey soil: little polyeder, few fragments	**5**
	intermediate mark	4
Upper Crumb 0-15cm	Mixed structure, containing crumbles (little polyeders) and fragments	**3**
	intermediate mark	2
	Fragments and sharp-edged clods with smooth surface, scarcely crumbles	**1**
	Mixed structure, containing crumbles (little polyeders) and fragments	**5**
	intermediate mark	4
Lower Crumb 15-30cm	Fragments and few sharp-edged clods with smooth surface	**3**
	intermediate mark	2
	About 80 % sharp edged clods, higher part of distinct smooth surfaces, coherent structure	**1**
	Structure with high appearance of pores with middle sized fragments of rough surface or layering in coherent structure / typical undisturbed loess structure	**5**
	intermediate mark	4
Subsoil 30-40cm	Structure with low appearance of pores, higher part of distinct smooth surfaces, big sharp-edged clods	**3**
	intermediate mark	2
	Plat-like structure or coherent structure with low appearance of pores	**1**

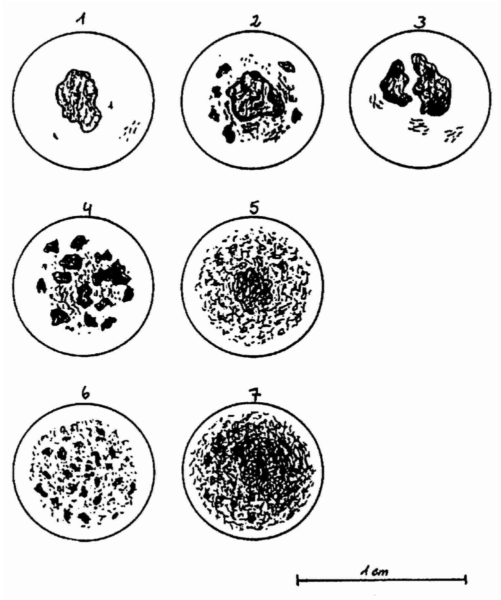
For the test of aggregate stability and morphology soil samples are dissected out of all layers mentioned above. On the one hand aggregation is defined as coagulation and forming of clay-humus complexes (physio-chemical compound) and on the other hand as the biological building up of soil particles with organic matter, excrements of soil organisms, fungal hyphaes and mucus of bacterial colonies (glycocalyx), that is to say: vital stabilisation (MÜCKENHAUSEN 1993). Stability of biogen aggregates depends on the state of vitality of soil biota. The better living conditions for soil biota, the higher is their metabolic activity and positive influence on aggregate formation and structural stability (ANDERSON 1991). Water stability represents a decisive factor for susceptibility of soil to erosion and depletion. Thus water stability of aggregates is of high importance, in order to evaluate the con-dition and resilience of soil with special focus on the dynamic of biological activity. The idea to silt up aggregates in a bowl and to attach marks to their grade of decomposition goes back to F. SEKERA and A. BRUNNER (1943) and is here implemented with the improved bowl-method. Forty aggregates of each sample are conveyed into two bowls with 20 cavities and then carefully moistened.The grade of decomposition of each aggregate is awarded marks accordingly (Fig. 3):

Fig. 3: Evaluation scheme of silting during water stability test (BESTE 1999).

stable, mark: 2
silting type 1: stable
st 2: big stable aggregate with some particles
st 3: shared into two aggregates

half silted, mark: 1
st 4: silted into middle sized aggregate particles
st 5: silted into little particles but stabilised with mucus

silted, mark: 0
st 6: silted into little particles
st 7: silted up totally, muddy water



Pore volume, soil moisture, shearing resistance

Three short core samples with defined volume are taken out of each layer. Pore volume and soil moisture are elevated by the gravimetric determination of water content. Representing the location where all metabolisms in soil take place, pore volume represents a parameter of high importance concerning water regime and soil structure. Soil moisture depends on precipitation and/or condensation, the groundwater distance, the vegetation cover and the soil structure conditions. It has influence on most measurements of physical soil parameters (e.g. shearing resistance) so it represents a regularly measured standard parameter. Besides that, in the case of same climatic conditions and same vegetation cover, well loosened soils have a much higher capability for water storage than compacted soils of the same soil type. Hence soil moisture also represents an important indicator for effects of soil management (e.g. tillage).

At each location where the ESD is implemented, two measurements of shear strength near to the pit are done. The power needed for shearing up a vane apparatus is measured with a torquemeter in Newton-meters. With that method, information about the compaction grade of soil structure can be obtained.

Concluding remark

Advantages of the scientific evaluation method can be summarised as:

- ESD is based on farmers knowledge. Comunication between science and agricultural practice can readily be facilitated with this method.
- ESD combines the actual comprehensive and qualitative impression of soil condition in the field with exact and quantitative data information about soil parameters from same location.
- This method offers the possibility to document applicable as well as scientifically ecological effects of different management systems on soil vitality without high-technology expenditure.
- The information and results gained by this method are well adapted for demonstrations in consulting work with farmers because of its high connection to farmers experiences with soil.

Experiences made with consultants of rural development-projects in Brazil have shown that ESD has furthermore great advantages especially in regions or projects where investigation-methods requiring high-technology equipment are too expensive or not well adapted for consultance presentation. With the GÖRBING estimate-version there already exists a method, which can be implemented by farmers themselves to verify their success in modified management practices. So ESD can be a helpful tool for appropriate decisions about soil management and the foresighted planning of land management.

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