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Field Methods for the Evaluation of the Soil Structure and Soil Quality under Arable and Grass Lands

Lothar Mueller [a]***, Graham Shepherd*** [b]***, Bev Kay*** [c]***, Axel Behrendt*** [a]***, Uwe Schindler*** [a]

[a]***Centre for Agricultural Landscape Research (ZALF) Muencheberg, Germany, Email: lmueller@zalf.de*** [b]***Nutri-Link, New Zealand,*** [c] ***University of Guelph, Canada***

Abstract

Two methods of examination of the soil structure and soil quality have been performed in two regions of a temperate climate in Germany and Canada. The aim was to check their feasibility and reliability to characterize the crop yield potential and status of structure/compaction by traffic and trampling. The methods were **VSA** (**V**isual **S**oil **A**ssessment) and **SQR** (**S**oil **Q**uality **R**ating). Additional soil parameters and crop yields were also measured. Results show the feasibility and reliability of both methods to characterize the soil potential for cropping (SQR) and structural status (VSA) in terms of good, moderate or poor. Soils in the vicinity of Berlin indicated a severe compaction status of field headlands. The crop yield in this region was governed by the deep rooting potential of the soil substrate and the water holding capacity of the root zone. It was fairly correlated with the SQR score.

Introduction

During the past years, progress was achieved in understanding soil properties, processes in soils, and their functions in the Geo- and Biosphere. Sophisticated methods of measuring, modelling and monitoring particular aspects of soils and their interaction with plants have been developed.

Worldwide, the dominant function of soils is to produce plant biomass in a sustainable manner for feeding a growing population. However, internationally comparable methods of evaluating soil quality for arable and grassland are missing. The aim of this study was to elaborate and test approaches to assess soil quality. The hypothesis is basic aspects of soil quality may be recognized by field diagnostic indicators of the soil structure. Background photographs and tables have to enable a quantification of the indicator values with a minimum of individual misclassifications. The methods should allow an assessment of the main soil properties and deficiencies, and calculation of an overall soil quality index with a minimum of fieldwork. A typical assessment point or paddock should be reliably evaluated within one hour or less.

Material and methods

A dual set of field methods to assess soil quality was tested (Table 1), the New Zealand VSA method (Visual Soil Assessment according to Shepherd, 2000) and the Muencheberg SQR method (Soil Quality Rating according to Mueller et al., 2005). Indicators and their weighting factors for the total soil quality index scores of both methods for arable and grass land are listed in Table 2. Both field methods utilize scores of 6-8 relevant parameters (indicators). Scoring of single features rank from 0 = poor to 2 = good. Indicator scores are multiplied by weighting factors of 1 to 3 (Table 2, in brackets). Sample photographs (Shepherd, 2000) or

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score tables related to orientation indicator values of the AG Boden (2005) enable a reliable and quick scoring method. As an additional reference method the structure was scored by the Peerlkamp method (Peerlkamp, 1967, Batey, 2005). Soil parameters including texture, stratification, depth to water table, bulk density, infiltration rate, air permeability and penetration resistance were measured. Crop yields were either measured (experimental plots) or estimated by local growers (farm land, pastures).

Table 1: Characterization of the VSA and SQR methods

	VSA	SQR
Goal	Sustainable soil management	Sustainable land use and estimation of crop yield potential
Focus	Assessing management-induced changes (Dynamic soil quality)	Assessing longterm quality for cropping (Inherent soil quality)
Soil layer	Manageable soil depth (topsoil and upper subsoil, 0-0.4 m)	Total soil depth profile (1.5 m)
Crucial indicators	Structure after drop shatter test, porosity, colour and mottles	Potential rooting depth and soil water supply
Tool kit	Spade, plastic basin, hard square board, plastic bag, knife, field guide, score card	Like VSA, additionally hand- borer 1.5 m and score tables
Time (separate)	20 Minutes	30 Minutes
(combined)	40-45 Minutes	

Table 2: Indicators of the VSA and SQR methods

	VSA method		SQR method	
	Arable Land	**Grassland**	**Arable Land**	**Grassland**
1	Structure (3)*	Structure (3)	Soil substrate (3)	Soil substrate (3)
2	Porosity (3)	Porosity (3)	A horizon depth (1)	Depth of humosity (2)
3	Colour (2)	Colour (2)	Aggregates and porosity (1)	Aggregates and porosity (1)
4	Mottles (2)	Mottles (2)	Subsoil compaction (1)	Hydromorphy (1)
5	Earthworms (2)	Earthworms (3)	Rooting depth (3)	Biological activity (2)
6	Tillage pan (2)	Surface relief (1)	Water capacity (3)	Water capacity (3)
7	Clods (1)		Wetness and ponding (3)	Wetness and ponding (3)
8	Erosion (1)		Slope and relief (2)	Slope and relief (2)

* Values in parentheses represent the weighting factor

Soils in the vicinity of Berlin are from Holocene and Young Pleistocene parent material and range in texture from sand to clay. Holocene soils are Gleysols, and Pleistocene soils are Luvisols. Soils in the region of Guelph, Canada, are loamy Luvisols from the late Pleistocene.

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Results and Discussion

Both methods were feasible and reliable in characterizing the soil potential for cropping (SQR) and structural status (VSA) in terms of good, moderate or poor. Single parameters indicated soil deficiencies. Soils in the vicinity of Berlin showed a severe compaction status of field headlands both in the topsoil and partly in the subsoil. Coarse blocky soil aggregates were a reliable indicator of the loss of soil structure. Compaction of headlands was indicated by both measured parameters like dry bulk density (DBD) or penetration resistance and by single VSA and SQR scores (Table 3). The variability of scores and measurement parameters was larger on soils of higher clay content.

Table 3: Structure parameters of the field and headlands on arable land in the vicinity of Berlin, Germany

Parameter	Clay g $100g^{-1}$	Depth	Unit	Field sites	Headlands
DBD	< 20	Topsoil	Mg m^{-3}	1.52	1.75 *
	> 20			1.33	1.44
	< 20	Subsoil		1.58	1.67
	> 20			1.32	1.39
Penetration resistance	< 20	Topsoil	N mm^{-2}	1.09	1.81
	< 20	Subsoil		2.25	3.26 *
Porosity score VSA [1)]	< 20	Topsoil		1.25	0.63 *
	> 20			0.98	0.83
	< 20	Subsoil		1.29	0.88
	> 20			1.38	0.67
Structure score VSA	< 20	Topsoil		1.85	1.50 *
	> 20			0.63	0.58
Compaction score SQR		Subsoil		1.25	0.55 *

[1)] VSA and SQR scores of 2 are maximum and the minimum is 0
*= significant different at 0.05 level

Some parameters of the VSA method like earthworm numbers were seasonally and regionally dependent and have to be adapted. Wetness was a locally limiting phenomenon, and clearly indicated by both methods, crop yields and physical measurements.
In the Elora rotation of Guelph, Canada, both the Peerlkamp and the VSA methods indicated significant impacts of tillage and crop rotation on soil structure. Structure scores were correlated with dry bulk densities and infiltration rates of soil. Best structures were found under alfalfa and maize after ploughing, while poorest structures occurred under wheel tracks and maize after no-till.
The crop yield in the region of Berlin was governed by the deep rooting potential of the soil substrate and the water holding capacity of the root zone. Above ground biomass was moderate to strongly correlated with the SQR score (Fig. 1).
The depth of the water table was the decisive parameter that controls soil quality and dry matter production in grassland regions of low precipitation. The soil structure of stock tracks in the upper 15 cm was significantly worse compared with moderate grazed and trampled areas. A moderate drainage status of 0.4-0.7 m suggested the best soil quality for pasture and meadow on peatlands.

Conclusion

Methods of visual soil assessment like the New Zealand VSA and Muencheberg SQR methods are feasible tools of evaluating the dynamic and inherent soil quality in the field.
Soil compaction states could be detected by these methods and confirmed by physical measurements
The Muencheberg SQR method allows a good estimate of the crop yield potential.

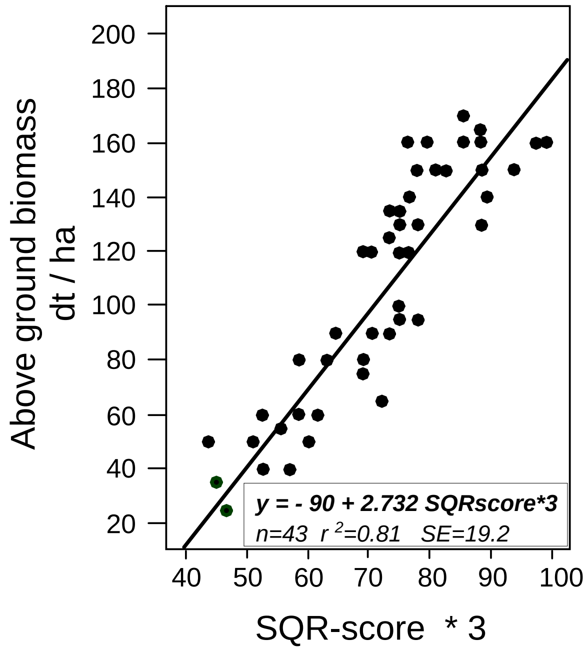

Fig. 1: SQR-score and above ground biomass of the main cereals (wheat, rye) in the vicinity of Berlin, Germany

References

AG Boden (2005): Bodenkundliche Kartieranleitung (KA5), Hannover, 432 pp.

Batey, T. (2005): The Peerlkamp method, In: “Visual Soil Examination and Evaluation”, short report on FIELD MEETING “VISUAL SOIL structure assessment”, Held at the INRA Research Station, Estrées-Mons, France, 25-27 May 2005

Mueller, L., Shepherd, T.G., Schindler, U., Eulenstein, F., Behrendt, A. (2005): Test of field methods to assess soil quality under arable and grass land. DBG Mitteilungen, in print

Peerlkamp, P. K. (1967): A visual method of soil structure evaluation. In: West European methods for soil structure determination /edited by the West-European Working group on Soil Structure of the International Soil Science Survey, Ghent, p. 216-223

Shepherd, T. G. (2000): Visual soil assessment. Volume 1. Field guide for cropping and pastoral grazing on flat to rolling country. Horizons.mw/Landcare Research, Palmerston North. 84 p.