MONITORING OF MICROBIAL BIOMASS TO CHARACTERISE VINEYARD SOILS

CONTRÔLE DE LA BIOMASSE MICROBIENNE POUR CARACTÉRISER DES SOLS VITICOLES

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ABSTRACT

Indicators to characterize the quality and efficiency of vini-viticultural systems should be expanded in the point of view of a sustainable land-use. In vineyards in the Rhineland-Palatinate in Germany, soil biological parameters were analyzed to investigate effects of soil management and abiotic soil conditions on the soil environment. The results allowed a splitting of the investigated soil biological parameters into parameters to describe the effects of the management and into parameters to describe the influence of abiotic, site-related soil conditions, respectively.

RESUME

Le sol est un facteur important permettant la croissance de la vigne. Les propriétés physiques et chimiques, mais aussi microbiologiques ont une influence sur beaucoup des fonctions du sol comme la structure, le drainage, la fertilité, déterminant la vigueur des plantes et le potentiel œnologique des raisins. La gestion du sol et le contrôle des mauvaises herbes (techniques chimiques ou mécaniques, enherbement, travail du sol) sont des facteurs anthropiques qui interviennent aussi. Ainsi, en Rhénanie-Palatinat (Allemagne) certains paramètres biologiques des sols viticoles sont observés dans le cadre du programme «optimiser la qualité des sols viticoles».

Dans une première partie, des échantillons de sol de vignobles différant par leurs caractéristiques physiques et chimiques et les systèmes de gestion de sol (enherbement permanent, application d'herbicides de post-levée, labour) sont analysés en ce qui concerne les paramètres microbiologiques (respiration; biomasse microbienne; minéralisation d'azote sous engrais verts). Dans une deuxième partie, les résultats seront intégrés dans un système d'information géographique (SIG) et seront combinés avec d'autres données spatiales (des base de données) comme les caractéristiques physiques, chimiques et hydrologique du sol, le relief, des systèmes de gestion ou des paramètres de rendement de raisins pour établir un système de référence de qualité biologique du sol pour les vignobles.

Les résultats indiquent une différenciation claire des sites de vignoble selon des paramètres biologiques des sols. L'influence du système de gestion s'étend de très clair à non important,

selon le type de sol. Les résultats de ce travail contribueront à une meilleure compréhension des facteurs déterminant la biologie du sol en la viticulture et à établir des critères de qualité du sol spécifiquement viticoles.

INTRODUCTION

The soil is an important factor allowing the growth of vines. Soil physical and chemical, but also soil microbiological properties influence a lot of soil functions like soil structure, water infiltration and retention, nutrient supply and cycling, determining the vigour of plants and the oenological potential of grapes. Fertilization, manuring, mulching, ploughing and weed control are manmade factors interfering with these soil functions. Viticulture is a permanent culture with a rigid trellis system which superposes the structure of vine rows and inter-rows on the soil surface, resulting in different soil management within the same vineyard plot: for example rows with ploughed soil alternating with inter-rows covered by green cover; rows with herbicide treatments.

The biological activity of soil is a main focus concerning soil quality. The evaluation of soil quality has to be regarded in the context of the type of land use and the abiotic environmental conditions. Beside classical viticultural indicators, soil organic matter and soil microbiology should be applied in supplement to characterise secondary effects of soil management (ANDREUX *et al.*, 1996).

The aim of this work is to present the results of a study concerning the effects of soil management in viticulture on soil microbial biomass, and to give an outlook on a soil survey program for soil quality in viticulture.

MATERIALS AND METHODS

The investigations were carried out in four vineyard plots located in two different vineyard sites near Bad Dürkheim in the Palatinate (Germany). The vineyard sites are named "Dürkheimer Feuerberg" and "Ungsteiner Herrenberg". In the following, the terms Duerkheim and Ungstein, respectively, will be used. At each site, one vineyard plot was cultivated since 1990 according to the alternative viticulture (*EcoVin*), and one vineyard plot was cultivated in the integrated manner. The distance of vine-plants in the rows was 1 m, the width of the inter-rows was 1.8 m. The two sites were located on different geological formations. Therefore, the soil properties were different, but the soils of the two vineyard plots at each site showed only small differences (table 1).

Soil samples were taken in May, July, and October 1998 and in April 1999. The sampling was done separately for the rows of vines and for the inter-rows according to different soil managements (mechanical weed control in the line; alternation of inter-rows with permanent green cover and inter-rows with open soil by ploughing). Each vineyard was divided in two blocks. From each block and soil management 16 sampling points were taken and mixed to achieve one representative sample per block. Samples were taken from 0-15 cm soil depth. After sewing at 2 mm the soil samples were adjusted to a water content of 60% of maximum water holding capacity and stored at 4°C prior to further analysis. For the analysis of microbial parameters the soil samples were allowed to adapt to room temperature during a minimum of two days. Soil microbial biomass was analysed by the **S**ubstrate-**I**nduced-**R**espiration method (SIR) after ANDERSON & DOMSCH (1978). Soil respiration was analysed in parallel without the addition of substrate.

RESULTS AND DISCUSSION

Figure 1 shows an example of data obtained from the two different vineyard sites. This graphical presentation visualises in graph A, B, and C the non-uniformity of measured soil biological or chemical parameters even in the same vineyard site. The effect of different soil management systems is visible and resulted e.g. in higher soil microbial biomass, soil respiration and soil organic carbon in the inter-row with green cover compared to the row of vines.

By the analysis of related parameters (figure 1, graph D and E), it is possible to get a clear separation of the two sites by the C_{mic}/C_{org}-ratio and, in an inverse pattern, by the metabolic quotient. The C_{mic}/C_{org}-ratio is an indication for the quality of the soil organic matter to support microbial development, and the metabolic quotient indicates the efficiency of the metabolic rate of soil microorganisms.

The calculation of quotients like the C_{mic}/C_{org}-ratio or the metabolic quotient shows, that the soil management becomes less important to characterise biological conditions of soils, and that the investigated soil biological properties are clearly influenced by site-specific soil characteristics. This example shows, that it is necessary to focus on soil parameters which have a certain stability if they should be used for the characterisation of soils.

The results of this study were the basis to establish a soil survey program for soil quality in viticulture: therefore, top soils (0-15 cm) of vineyards in the Rhineland-Palatinate (Germany), which differ in abiotic soil characteristics and in soil management systems are sampled. Most of the vineyards are managed according to the alternative or the environmental friendly viticulture, respectively. The sampling of soil is done from spring to early summer and in autumn, when soil conditions are in an optimum range for biological activity (moisture and temperature). If different soil management systems are applied at one site, the sampling is performed separately for each system. The soil samples are analyzed for soil physical and chemical properties, for soil microbial biomass, and for carbon and nitrogen transformation processes. The collected data are evaluated according to relationships between soil biological parameters and soil management on the one hand, and between soil biological parameters and soil physical and chemical characteristics on the other hand. With the results of this evaluation a data-based reference system for the biological quality of vineyard soils in the investigated area will be established.

OUTLOOK

In the future, legislation will take more concern about soil as a habitat for organisms (ANONYMUS, 1998). Therefore, it is important to have a tool to define optimum values for soil quality, which are site-specific, and which are based on realistic scenarios with respect to the type of land-use. The reference system will provide information and analytical tools to predict the biological potential of soil. The most important abiotic factors influencing soil biology are the soil physical and chemical properties, the relief, the exposition, the hydrological characteristics and the climate. Information about these abiotic factors can be provided by a geographic information system (GIS). In the combination of the reference system with a GIS the data can be managed, analysed and presented site-specific (spatial data). Further, data from different sources but with the same spatial reference can be superposed and analysed together (merge).

Geo-data with spatial reference can be managed by GIS: e.g. topographic information, hydrology, geology, soil type, climatic conditions, air photos, and topographical maps as

raster data. These data are applicable at the scale of single vineyard plots. An example for geo-data provided by a GIS is the superposition (merge) of soil types and topographic map in figure 2. For the vine-growing area of the Rhineland-Palatinate data about physical and chemical soil characteristics exist in analogous format at a scale of 1:1000 or 1:5000 (the general distance of sampling points was approx. 30 to 50 meters). These data are in the process to be transformed into digital vector format. Figure 3 presents the potential soil water conditions at vineyard scale, analysed on the basis of soil physical data provided by GIS. Figure 4 presents the results of an analysis for simulated soil management systems with respect to soil physical (soil type, depth of rooting zone, hydrological conditions) and climatic conditions.

The characterisation of soils by biological parameters is an important tool to establish indicators for soil protection and a sustainable land-use.

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Table 1: Soil physical and chemical properties of vineyard plots

Vineyard site	**Duerkheim**		**Ungstein**	
Vineyard plot	**integrated**	**alternative**	**integrated**	**alternative**
Clay [%]	11.1	6.4	18.0	19.4
Silt [%]	31.2	35.8	33.6	30.1
Sand [%]	57.7	57.8	48.4	50.5
Soil type	loamy sand	silty sand	sandy loam	sandy loam
pH ($CaCl_2$)	7.3	6.1	7.6	7.5
Copper [ppm]	90	83	72	189
Last organic manuring	1998 cacao peel	1995 bio compost	1997 bio-waste compost	1995 green manure

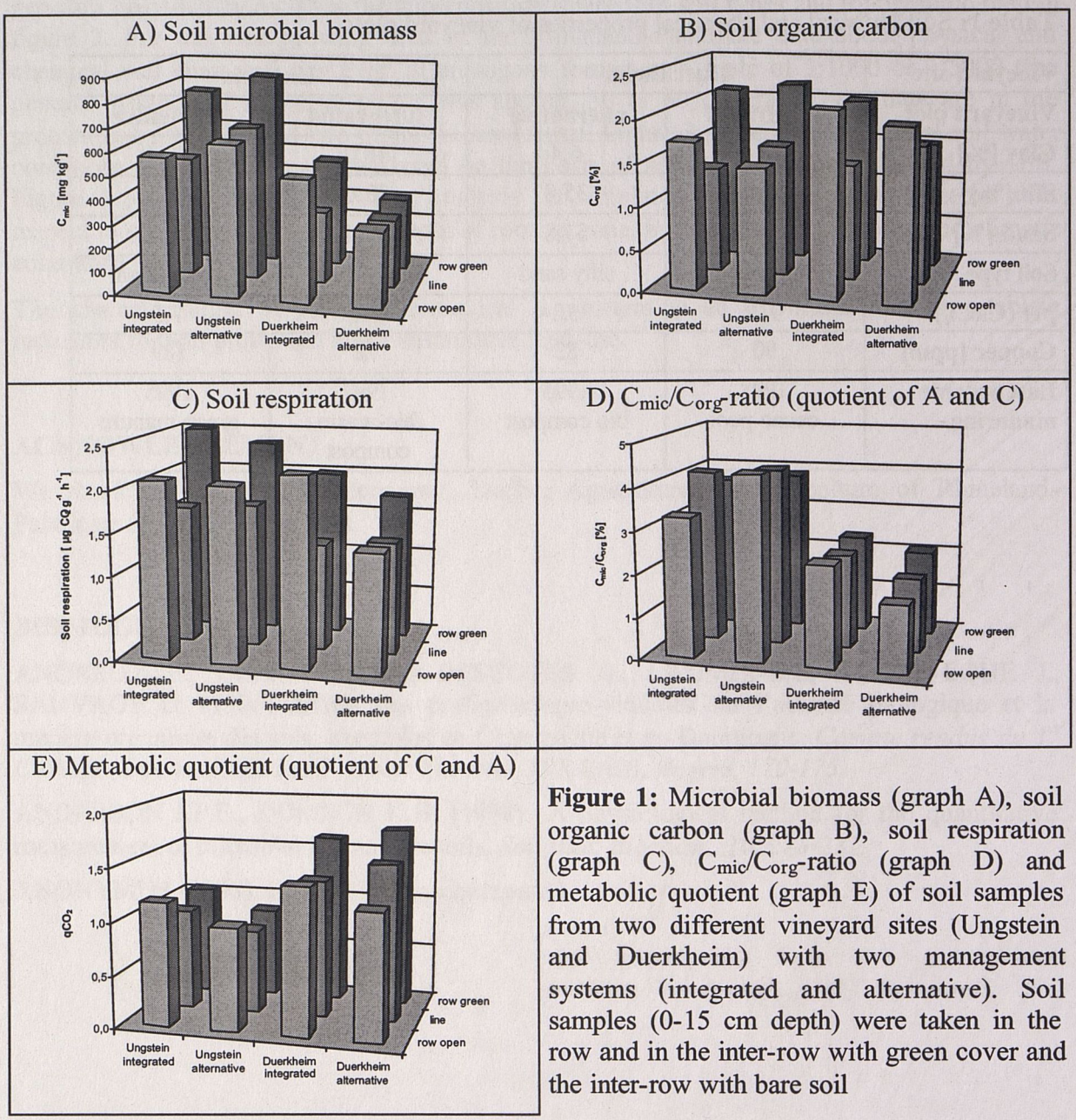

Figure 1: Microbial biomass (graph A), soil organic carbon (graph B), soil respiration (graph C), C_{mic}/C_{org}-ratio (graph D) and metabolic quotient (graph E) of soil samples from two different vineyard sites (Ungstein and Duerkheim) with two management systems (integrated and alternative). Soil samples (0-15 cm depth) were taken in the row and in the inter-row with green cover and the inter-row with bare soil

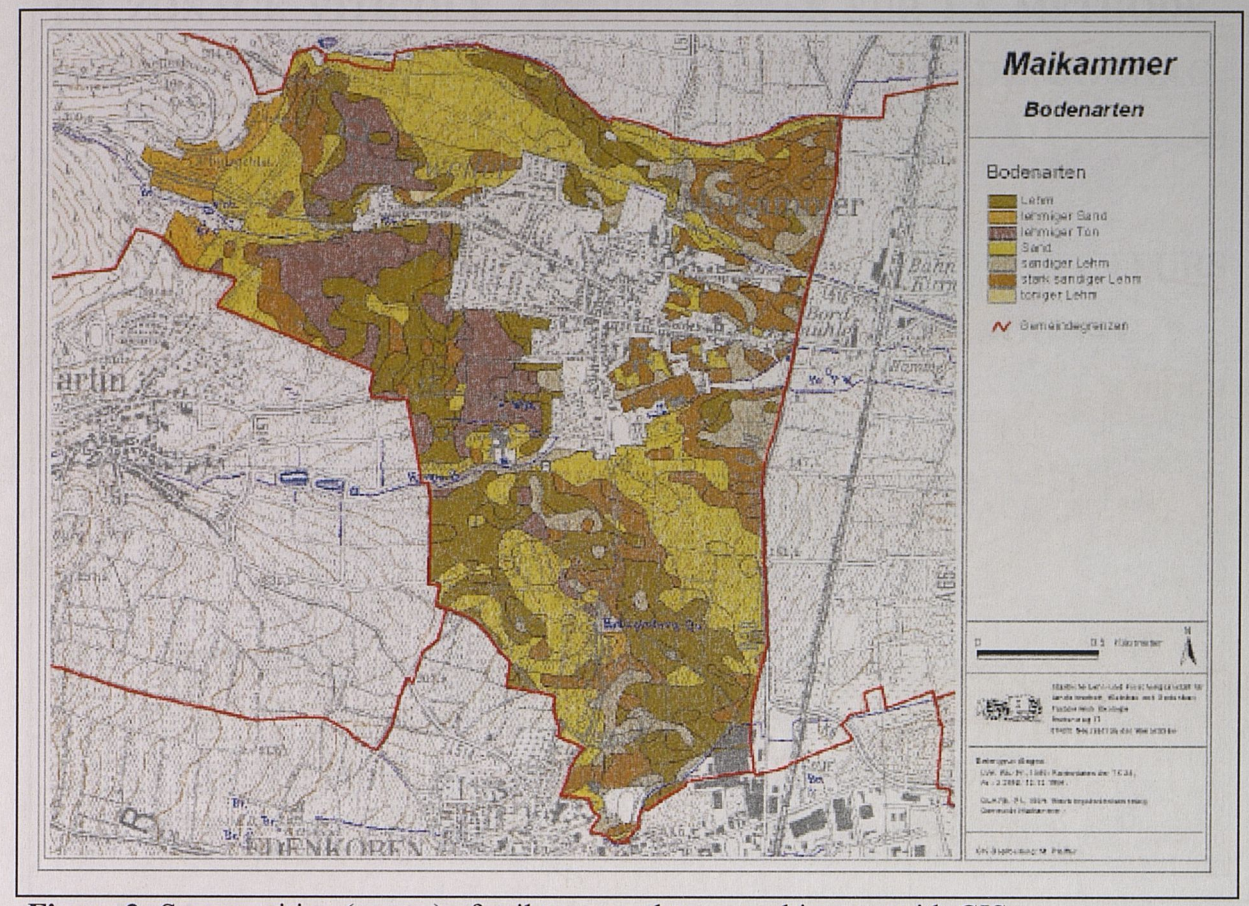

Figure 2: Superposition (merge) of soil types and topographic map with GIS

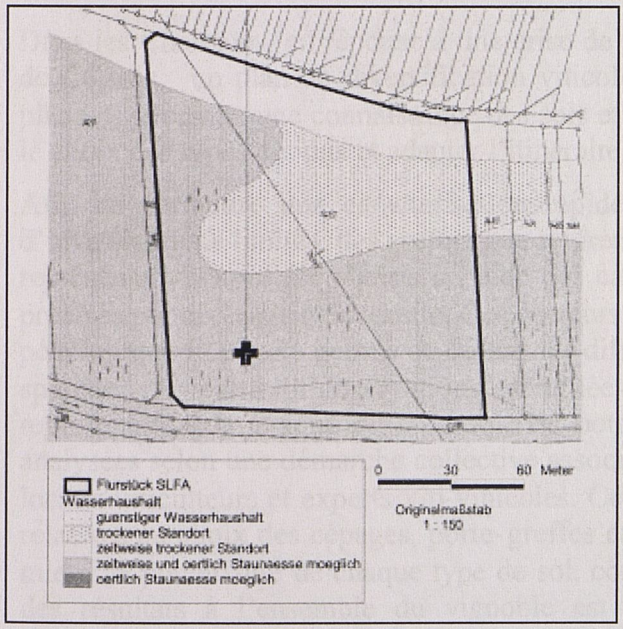

Figure 3: Cadastral register and soil water conditions calculated on the basis of soil physical data provided by GIS (Weinbergs-Bodenkartierung [1])

[1] Geologisches Landesamt Rheinland-Pfalz

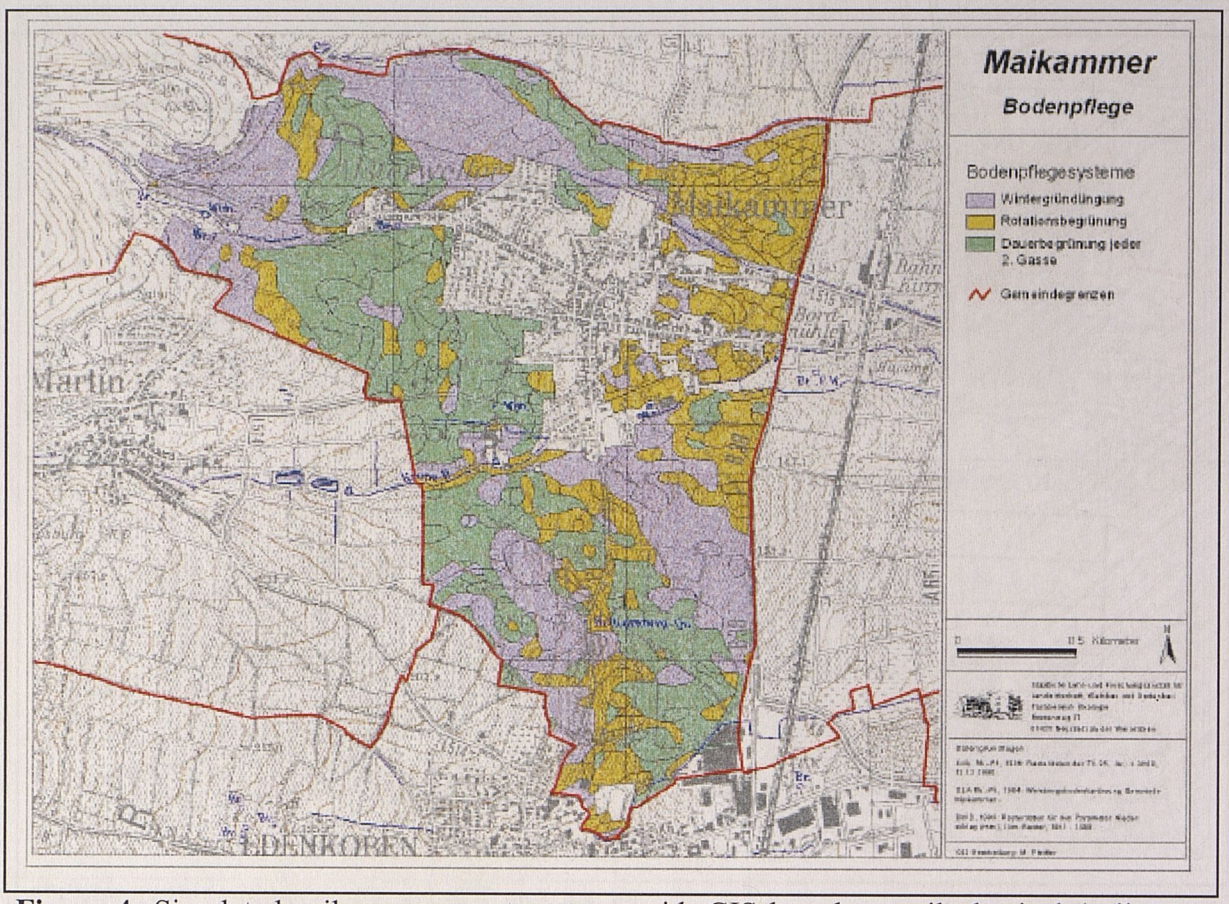

Figure 4: Simulated soil management systems with GIS based on soil physical (soil type, depth of rooting zone, hydrological conditions) and climatic conditions