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Soil electrical conductivity and texture

Spatially specific management requires more information on soil and crop. The measurement of soil electricity conductivity can contribute to a cost-efficient determination of soil parameters. From the conductivity can be estimated the average clay content in a considerable area of ground in Brandenburg.

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Keywords

Site specific farming, soil electrical conductivity, soil texture, EM38

Environmentally-supportive and sustainable farming orients itself on the characteristics of locality and crops. Spatially-specific management requires a site-based reference associated with the differences within a field. The input for such measures must not, however, endanger economic viability of farm production.

Seed and fertiliser rates are, above all, associated with a location's yield potential under German production conditions; this depends mainly on water availability. To enable the estimation of moisture retention capacity and water permeability of soil, sufficient information is required on the soil in the rooting area.

This requirement is met best by the finance bureau's soil quality surveys which can be also seen in map form in most farm offices. In order to be able to use them more efficiently some states have begun to digitalise and geo-reference these. However, neither classification borders not ground value points are sufficiently precise to serve as a basis for spatially-specific management.

For a few years now, measurement equipment has been applied for continual recording of soil electrical conductivity at speeds of around 20 km/h. Areas with the same soil electrical conductivity are also areas with around the same soil profile. In this way it is possible to classify areas which, by using soil information either available or to be re-evaluated, can then serve as basis for highly detailed soil maps.

Aim of this work was to analyse whether the relationship between soil conductivity as determined by the EM38 equipment and the average clay content of the soil for a typical Brandenburg location can be accepted as generally applicable.

Knowledge level

E38 measurement principle

The E38 equipment from the Canadian Geonics Ltd. uses electromagnetic induction measurement methods. At both ends of a carrier about 1 m long is a coil. The transmitting coil is supplied with AC electricity at 14.6 kHz and creates a primary magnetic field. In an electrically conductive medium such as soil this alternating field forms an eddy currents which in turn form a secondary magnetic field. The effect of both magnetic fields is recorded by the receiver coil. The relationship of secondary and primary field is directly proportional to the electrical conductivity of the soil. A computer within the equipment processes the measurement signal so that the electrical conductivity of the soil can be read from a display or be transmitted as analogue current signal to an external computer [1].

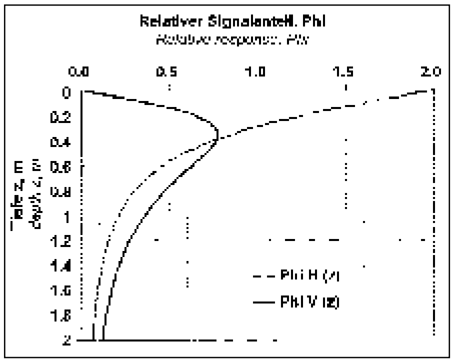

Fig. 1: Relative response of thin soil layers versus depth for vertical and horizontal dipoles (according to [2])

This measurement principle requires no contact between equipment and ground. It can be mounted on sledge-like transport and pulled over the field surface. The additional utilisation of DGPS allows every measurement value to be given an exact location.

The EM 38 offers two variants of soil evaluation. If the coil axis is positioned vertical to the field surface then one speaks of a vertical dipole mode. If parallel, then it is a horizontal dipole mode [2].

The apparent electrical conductivity of the soil is an average, weighted, value composed of the conductivity of the individual layers of the total soil profile influenced by the magnetic field.

The signal proportion of a particular layer regarding this value depends on its distance from the equipment (*fig. 1*). The cumulative signal proportion indicates which signal part comes from the area under the depth z (*fig. 2*).

The measuring depth is defined as that through which only 30% of the signals from deeper layers can be read. The theoretical

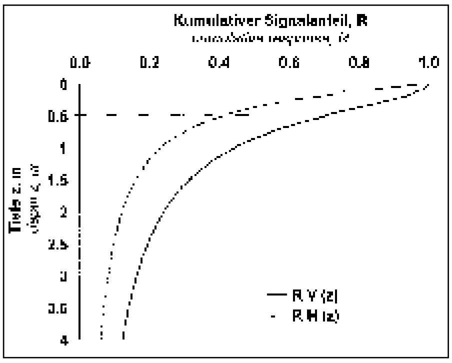

Fig. 2: Cumulative response of thin soil layers versus depth for vertical and horizontal dipoles (according to [2])

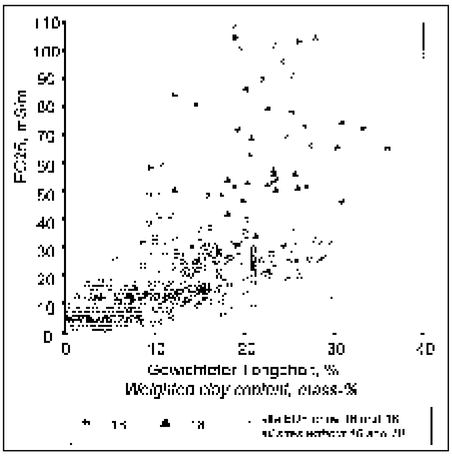

Fig. 3: Soil electrical conductivity EC_{25} of all observed soil profiles versus weighted clay content

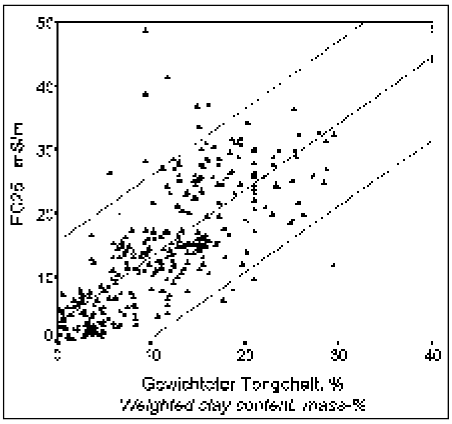

Fig. 4: Soil electrical conductivity EC_{25} of mineral soil profiles without slack water versus weighted clay content

measurement depth in the vertical dipole mode was thus 1.5 m, in the horizontal 0.75 m, although these were surpassed in practice (*fig. 2*) [1].

The factors influencing soil conductivity

The apparent electrical conductivity of soil reflects as a value different characteristics of a soil profile. Important influence factors are water content of ground, clay content and ground temperature. The influence of the latter can be compensated for in calculations [3]. Thus the mapping of soil electrical conductivity is suitable for determination of its texture (clay content) where the ground water content can be regarded as sufficiently constant.

The association of texture and soil electrical conductivity

The relationship between apparent soil electrical conductivity and average clay content in the soil profile of individual areas has been demonstrated many times. Investigation results applying to a standardised soil electricity conductivity and large farm areas could not, however, be found.

From investigations on 360 ha cropland in Germany Neudecker et al concluded that values of from 5 to 15 mS/m were typical for sandy soil, higher values of from 30 to 60 mS/m reflected the clay soils and the area in between was typical for loams [4].

Method

The target was comparison of soil electrical conductivity values with the average clay content of soil typical for Brandenburg. Profile descriptions for representative soils from the state and their positions were supplied by the State Environmental Bureau in Brandenburg. These are profiles recorded during setting-up the long-term soil observation areas in Brandenburg. In the given positions there followed in spring 2000, at full field moisture capacity, the investigation into soil conductivity with the EM 38 in vertical dipole mode directly over the ground surface.

The value of the soil electrical conductivity was determined by Durlesser transmitting function [3] on the basis of a uniform soil temperature of 25°C. From soil type and layer thickness of individual soil horizon of a profile and with regard to the response functions (*figs. 1 and 2*) a weighted clay content could be determined for each profile.

Results

The investigations took place on a total of 16 long-term observation areas (DBF) distributed throughout Brandenburg. In total this produced 439 profiles for evaluation [5]. The majority of the measurement points could be seen to have, as a basic tendency, a linear relationship between the weighted clay content and the soil electrical conductivity as measured at 25°C (*fig. 3*). Main exceptions were profiles at locations 16 and 18.

The influence of water-affected horizons was visible if the profiles, with regard to thicknesses of mineral, water uninfluenced horizons and water-blocking gley horizons, were recorded and grouped according to cluster analysis.

316 profiles remained in the cluster of mainly water-uninfluenced mineral soils (*fig. 4*). For this cluster there applies the description

$EC_{25} = 2.735 + 1.044\ T_W$

which explains 59% of the variability of the soil electrical conductivity through the weighted clay content (EC_{25} = Electrical Soil Conductivity at 25°C (mS/m); T_W = weighted clay content of the soil (%)).

The profile of the long-term observation areas 16 and 18 are characterised by gley horizons and are no longer included in this cluster. It can be assumed that the gley horizons at the time of the measurement had a moisture content above the field capacity and thus did not represent the established measurement conditions.

Conclusions

Data on soil electrical conductivity from different measurements can be analysed together when measuring conditions established for the investigation are closely followed. Thus it would be possible to determine relationships for soil over the whole of Brandenburg.

Following conditions for measurement reduced the operational period for measuring the soil electrical conductivity, which caused an increase in costs.

Measurements on gley at field capacity were very difficult to realise.

Literature

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