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Recording electrical conductivity of soil

Estimating maximum possible spacing between measuring points

Records of soil electrical conductivity within a field or spatial area of land have proved valuable for diverse spatially specific management decisions. The costs per area unit for recording, processing and presentation of the data are, in comparison to non-continual sampling, relatively low. In this report the maximum permissible distances between measurement points for measurement of soil electrical conductivity are estimated. The spatial variability is sufficiently taken account of where tramlines are used as sampling guidelines.

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Keywords

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The Electrical conductivity of ground is mainly influenced by the average soil moisture content, average cation exchange capacity (which is mainly determined by the clay content) and the ion content of the soil in solution. The soil temperature is a further influence parameter and this can be compensated for in calculations. In that a soil profile with higher clay content also has a higher water retention capacity a soil electrical conductivity map mainly reflects soil texture characteristics. These are relatively stable over time so that a single survey can be used for decades. This in turn means that a new survey later on may only be required when certain measurement conditions during the first survey, e.g. distance between the measurement lines, are no longer suitable for future interpretation of the results. This is to be avoided.

Interpretation of the soil electrical conductivity

Distribution maps of soil electrical conductivity serve within spatially specific management mainly for the estimation of yield potential of a site as well as for establishing management zones. It was tested whether EC data could also be used for estimation of soil moisture content.

There are three different basic methods for estimating yield from EC data (*table 1*). The direct method, which is only quantitative, sees the farmer estimating the borders of EC classification areas and correcting them where required through altering the classification basis and ordering the areas according to yield. The assessment effort involved is small.

Complementing EC data with information on soil profile and crop details in a direct but quantitative estimation involves an increasing effort in information collection and processing, but increases the reliability in determination of zones of different yield potential. These results, however, cannot be accepted without recourse to farmer knowledge.

The third variant features indirect estimation. Here EC data is used to support the creation of large-scale soil maps. In this way imprecision of EC data caused by it being possible to end with the same values from differently layered profile areas with differing yield potentials, is corrected. Knowledge of the soil composition in the rooting zone is relatively the most reliable variant for determining yield potential areas. Evaluation precision can be increased through including spatial precipitation and temperature distribution.

Methods for estimating the maximum possible distance between measurement lines and for the conducting of the trial

The more precise the estimation of yield potential within a zone must be, the greater number and distribution of EC data required. The individual values can be determined through measurements or through interpolation. Measurement results are accepted as true independently of their measurement error. The interpolated values show an error value which increases with the distance from

Tab. 1: Using EC data to estimate yield potential

Estimate of yield potential from EC values		
Direct		Indirect
Qualitative	Quantitative	Quantitative
The EC result is divided according to farmer experience into zones of different yield potential	The EC data is complemented with other data (DGM, crop reflection, yield) before zone-based yield potentials are decided upon	Pedotopical areas are formed from EC results and other data such as that from soil tests. From this information yields can be assessed relatively reliably.

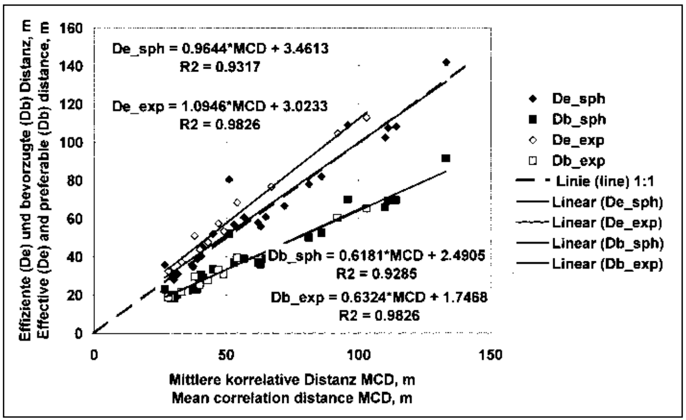

Fig. 1: Effective and preferable distance depending on the mean correlative

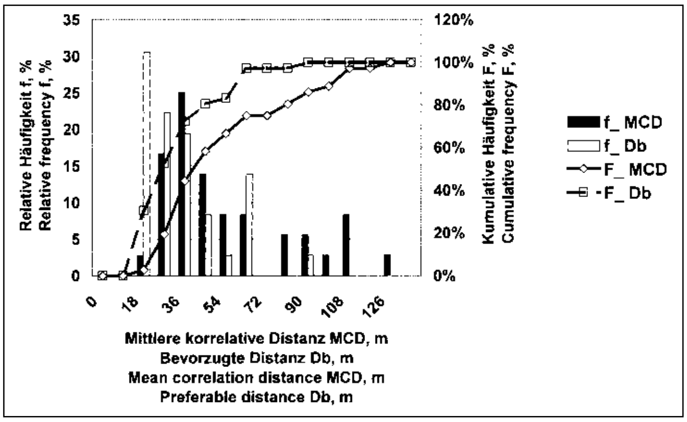

Fig. 2: Relative and cumulative frequency of mean correlative distance and preferable distance

the recording and which can be estimated from the specifications of the related semivariogramme model (Kriging). For calculation of the maximum possible distance between measuring points and with that the distance between recording lines, different calculation methods are recommended.

1. Here, an upper limit is predetermined for estimation error with interpolated values. Serving as estimated error, e.g. could be the root of the average squared error of the interpolated value [1] or the correlation coefficient between measured and interpolated values [2].
2. In this case it is established that a certain proportion of the spatial variability in recording should be determined. Herbst et al. defined the efficient distance De and the preferred distance Db as the distance whereby 1/2 or 2/3 of the geostructural semivariance is determined [3]. The distance is thus a parameter for the estimation of which certain points in the variogramme curve are used.
3. In this, the mean correlative distance (MCD) is estimated which can at the same time be defined as the possible distance between the recording lines [4]. In this form of distance calculation, the total curve progress of the variogramme model is considered, even though in indirect form.

In this report only the calculation methods 2 and 3 are compared whereby the MCD is selected as reference value. For this, 36 spatial areas on ten farms in four federal states were recorded via semivariogramme models for EC values.

Results and conclusions

The MCD and De mainly agree with the spherical semivariogramme model (*fig. 1*). If the amount of data was better presented via an exponential model, the De would be a little larger than the MCD. Comparing the MCD with the Db shows a model influence is no longer recognisable. On average, the Db is one third smaller than the MCD. With this, the MCD is the same or smaller than the De, but larger than the Db. The MCD or the De are reference parameters for the distance between the recording lines when precision and effort are optimised. If the Db is not exceeded a still higher precision is achievable through interpolation.

The MCD varied between 27 and 133 m. An MCD between 27 and 35 m was actually recorded on every fifth field (*fig. 2*). Most strongly represented with 25% were the classes with an MCD between 36 and 44 – 45 m. With increasing MCD the relative frequency of the values in the other classes decreased continually thus producing positively skewed distribution.

The greatest relative frequency of Db with easily 30% can already be noted as in the group between 18 and 27 m. In the further classes this was in the main continually reduced. The positively skewed distribution is thus even more strongly characterised than with the MCD.

A limitation of MCD for certain site conditions is only possible to a certain extent (*table 2*). On Saxony-Anhalt farms with mostly black earth soils (SA2 to SA4) no MCD of less than 37 m was determined, however. In fact the dominating MCD in farm SA4 was over 73 m. If, on the other hand, one takes the Db, the area on black soil farms between 18 to 36 m is occupied with only a single exception. Up until now it has been normal to use the tramlines as sampling lines. On larger areas the distance between these is between 18 and 36 m. The use of 18 m sampling lines in spot tests guaranteed, in fact, that the preferred distances were generally conformed with. Using the tramlines with up to 36 m spacings proved necessary for around 20% of the areas for MCD and over 50% for Db but also met necessary requirements. Sampling lines in areas between the tramlines are therefore not required. It could be appreciated, however, that using only every second available tramline as measuring line increased the risk of moving out of the area offering more precise EC data. The aim of reducing the costs of soil electrical conductivity recording should, e.g. lead to missing out every second tramline only on land that has been previously tested.

Literature

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Table 2: Number of fields within a farm belonging to a MCD range or a Db range (in brackets)

Farm	18 to 36 cm	37 to 54 cm	55 to 72 cm	> 73 cm
BB1	3 (4)	1 (1)	1 (1)	1
BB2	1 (2)	1		
BB3		(1)	1	
N1	1 (3)	2		
N2	1 (1)	1 (2)		1
SA1	1 (2)	3 (2)		
SA2	(3)	2	1 (3)	3
SA3	(3)	3 (2)	2	
SA4		(2)	1 (2)	4 (1)
TH	(1)	1		