

SOIL MAPPING AT FIELD LEVEL BY AIR-DRY MOISTURE DETECTION

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Introduction

Nowadays, farmed fields are not at all uniform in fertility etc., partly due to the scale increase of parcels as a by-product of farm mechanization. Due to this development, small land units of specific soil composition and crop rotation were brought together in bigger plots. The above variations could not all be alleviated by means of land reclamation and measures of soil profile improvement.

Till now, local shortcomings in productivity might have been covered up by an overdose of farm inputs i.c. nutrients. This approach is increasingly associated with ecological and economical constraints and is therefore criticized now.

Soil, crop and field management could be further optimized by utilizing location-specific information. This concept is implemented in prescription tillage and precision farming, meaning that each small-scale land unit or spot ought to be treated according to its specific soil qualities and short and long term crop requirements (Blackmore, 1994). Detecting field variations in a quick, easy and accurate way is an essential part of the solution.

Usually, soil texture will initiate the differences in soil physical and mechanical behaviour on the one hand and soil fertility on the other. Therefore, detection of soil composition in terms of clay content of upper and lower soil horizons is a useful starting point.

It is hypothesized, that soil water at high pF value is just absorbed by the clay minerals, irrespective of pore geometry and state of compactness. In other words: at high pF, soil structure is irrelevant and texture completely rules moisture content. If the above hypothesis proves to be true, then expensive soil granular analysis could largely be replaced by simple gravimetric soil moisture determination.

Methods

Field research was carried out in the oldest polder of the former Zuiderzee i.e. Wieringermeer, at the experimental farm Van Bemmelenhoeve. The soil composition of the observed field plot is rather heterogeneous, due to its origin and sedimentation process.

Samples of about 50 g were taken in a 10 x 10 m grid from the soil surface of the arable layer for gravimetric air-dry moisture determination. Consequently 628 moisture data are involved in the 6 ha field in question. Simultaneously, 17 of those samples, within the range occurring from light to heavy soil have separately been analyzed for granular composition, to be used for the texture-moisture correlation.

The sampling positions were located by a hand held DGPS receiver (differential global positioning system), having an accuracy of ± 1.5 cm.

In the laboratory, the samples were air-dried, crumbled in aggregates < 8 mm

while crop residues were removed. After 2 days with minimum fluctuations of humidity and temperature (50% Rh, 20°C), the samples were oven-dried for 24 hours at 105°C, so that air-dry moisture content, in this case at pF 5.98 (de Boodt et. al., 1966) could be determined.

The contour map of clay content was produced by Surfer, based on a 5 x 5 m kriging grid. Kriging was performed by Mapit, based on an exponential semivariogram calculated by Spatanal (Staritsky, 1989).

Results and Discussion

Fig. 1 shows the relation between air-dry moisture and clay content, in weight %, for 17 samples. There is a good linear relationship between texture and moisture over the entire range. $R^2 = 0.98$ is high and the standard deviation of clay content amounts to 0.69.

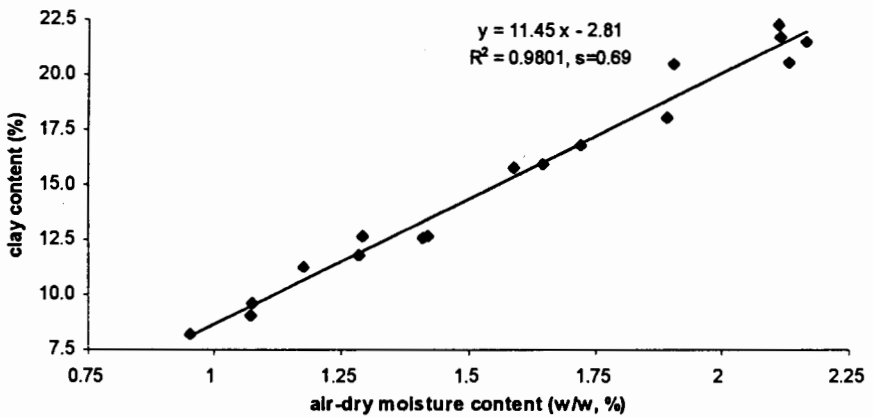


Fig. 1 Texture-moisture correlation based on 17 soil samples.

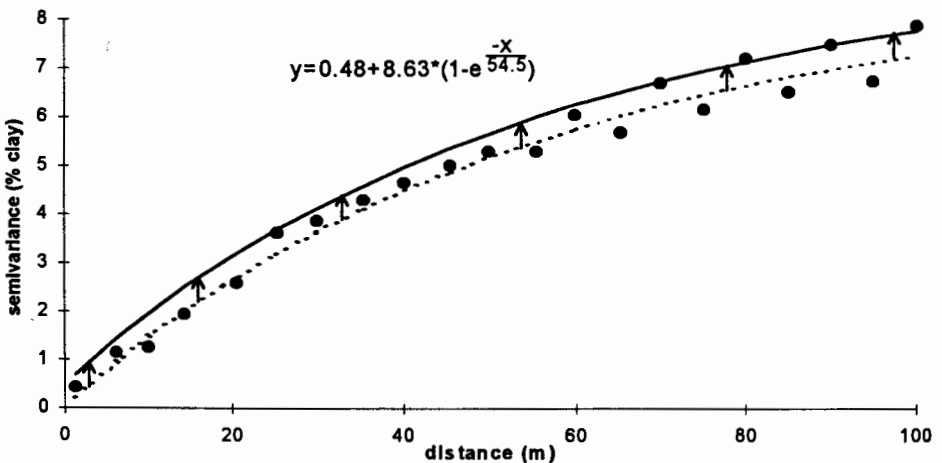


Fig. 2 Clay content semivariogram shifted upwards by 0.48 % for nugget effect

The clay contents for the 628 moisture data were calculated from the equation in Fig. 1. The 95% confidence interval of individual sampling positions equals to $\pm 1.4\%$ clay. The estimation error for points between those sample positions is higher and increasing with distance. The accuracy can be calculated from the kriging variance, which is calculated for each grid node, using the semivariogram of Fig. 2 (Cressie, 1993). By introducing a nugget effect of 0.48 ($= 0.69^2$), the kriging variance accounts for the prediction standard error of the linear moisture-clay content relationship.

Fig. 3 shows the clay content map of the sampled field. The X and Y coordinates of the test field refer to the Dutch system of coordinates. The range from sand to loamy clay has been subdivided into steps of 2% clay roughly coinciding with the 95% confidence limit, Table 1.

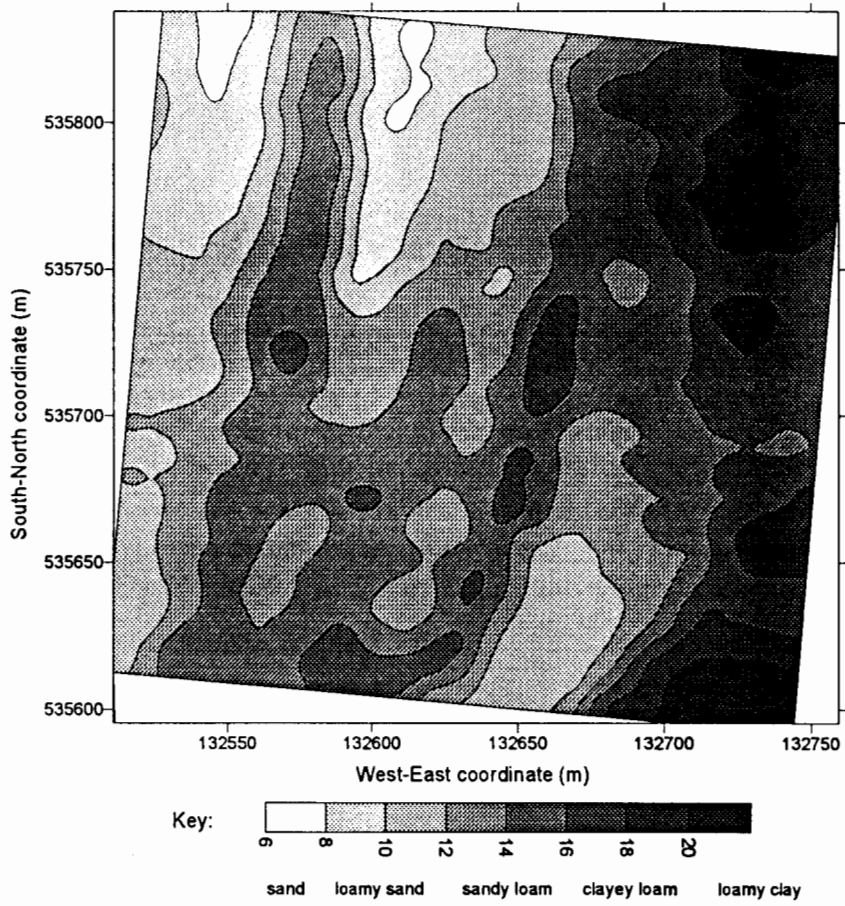


Fig. 3 Clay content map using 628 samples in a 10x10 m grid

If clay content maps were produced based on a reduced number of sampling positions, the estimation accuracy would decrease (Table 1). At the same time, some small-scale information is lost. This loss of information can be expressed by the area that would be classified differently, compared to the most detailed

Table 1. Effect of sampling grid on estimation accuracy and loss of map detail

sampling grid	# data points	average kriging variance	95% confidence limit (+/- %clay)	% area classified differently
10 x 10 m	628	1.15	2.10	-
20 x 20 m	159	1.41	2.33	0.6%
30 x 30 m	76	1.62	2.50	4.7%
40 x 40 m	42	1.81	2.64	9.3%

information available (see Fig. 2). In this case, a point is classified differently if its interpolated clay content differs more than 2% from the interpolation based on a 10 x 10 m sampling grid.

In view of further utilization in the context of precision farming and prescription tillage, this information is thought to be adequate and accurate enough, although quantitative information is still lacking (Perdok et al., 1994). For the time being, it seems impractical to detect and to respond to smaller field variations, as far as monitoring and control of farm machinery in practice is concerned.

For research purposes the above procedure can help to improve the layout of field trials where texture-dependent phenomena are involved.

Conclusions

Moisture content at high pF value, about 6, is closely correlated to clay content. This procedure circumvents the expensive soil granular analysis of many samples and provides a quick and easy determinant for variations in soil texture. Gravimetric moisture determination under controlled air-dry conditions is relatively cheap (40 working hours for 628 samples) as compared to the external costs of specialized texture analysis (Dfl 175, = per sample).

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