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Correlations between soil and plant parameters

A requirement for site-specific management is effective methods of determining different location-related characteristics of soil and plant parameters. To these belong factors of soil fertility, the current crop development and also the yield. For this reason measuring and comparison of apparent electrical conductivity of the ground using the EM-38, of crop mass using a pendulum sensor and of threshed yield on reference areas was carried out. The calculated average coefficients of less than 0.5 indicated only limited correlations between these.

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Keywords

Site specific farming, electrical soil conductivity, pendulum-meter, combine harvester

The results of the soil evaluation programme inclusive of later supplementation represents a valuable basis for measures taken in cultivation and cropping and this also for practical application of site specific management. Despite apparent relationships between soil fertility and recorded yields, the exact limits of the respective areas agree with one another only conditionally [1]. In this paper, the relationship between average values of soil electrical conductivity, mass of the mature plant, and grain yield has been investigated in association with location.

The non-contact recording instrument EM-38 from the Canadian firm Geonics was used in mainly vertical and partly horizontal measurement mode for the determination of soil electrical conductivity with the integral value for electrical conductivity of the soil recorded at depths of 1.5 m or 0.75 m (*fig. 1*).

At the Institute for Agricultural Engineering Bornim a sensor was developed for indirect measurement of plant mass within the standing crop [2]. The sensor comprises a vehicle-mounted physical pendulum with an arc of around 1 m. This was moved through the standing crop in the tramlines at a constant fulcrum height. The arc of the pendulum was affected in relationship to the mass of the mature crop. The resultant angle of swing was recorded by a potentiometer and created the basis for the determination of crop mass. Technical solutions for yield mapping on combines are now available on the market as an option from all important combine producers and have been presented in specialist literature [3]. Used in the trials here were combines from Claas and New Holland equipped with yield mapping systems.

Fig. 1: Equipment for measuring electrical soil conductivity (EM-38)

Method

To investigate relationships between the observed characteristics, data were collected on farms during preceding years. The intensity of the data was not consistent, this being related to recording frequency and the distance between the recording tracks through the crop in the respective fields which, for application of the EM-38 and the pendulum sensor, was determined according to the tramlines and the working width of the combine. The recording frequency was 1 Hz for the EM-38 instrument and for the pendulum sensor.

In order to accurately evaluate the different location-correlated data collected, the geographical information system Arcview was used. The areas were divided into grid elements and from the value of every cha-

Table 1: Coefficient of agreement for the functional relationship between electrical conductivity and pendulum angle

Location/ field	Crop Year	Grid (m)	Area (ha)	Coefficient
Bornim/ Heineberg	Winter rye 2000	12x12	6.2	0.41/0.55*
Bornim/ Heineberg	Winter wheat 2000	18x18	21.1	0.50/0.62*
Bornim/ Schneider-fichten	Winter rye 2000	18x18	21.6** 24.7	0.22/0.33* 0.20/0.40
Niedergörs-dorf	Winter wheat 2000	18x18	26.4	0.15/0.17*
Total			100	0.30/0.41*

* Value without exceptions ** Horizontal recording mode

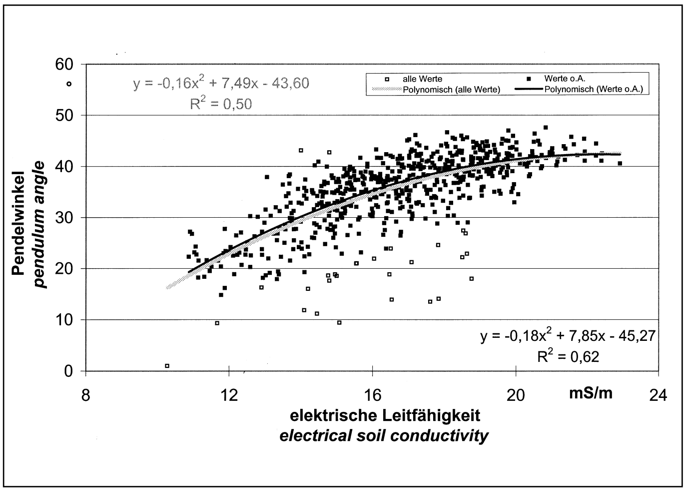

Fig. 2: Example for a good co-relation between measurement values of pendulum-meter and electrical soil conductivity

racteristic belonging to each grid element an arithmetical average calculated in each case. The grid pattern was selected according to the distance between the tramlines and direction of travel. Grid elements which included values of only one, or no characteristics at all were eliminated. So that non-linear relationships between the characteristic values could be included in the comparisons, all regressions were calculated with a polynomial calculation to the second degree.

Results

Soil electrical conductivity - pendulum angle
The functional relationship between the soil electrical conductivity and the pendulum angle showed coefficients of agreement between 0.15 and 0.62 *(table 1, fig. 2)*. Basically, it was clear that there was no typical coefficient. Apparently, the degree of agreement is influenced from the existing specific location conditions.

Soil electrical conductivity – grain yield
The investigated association between the electrical conductivity of the soil and grain yield conducted in three field strips over different years also returned no high coefficient of agreement *(table 2)*. While the coefficients for winter wheat with no exception were very well balanced, that for the grain maize fell clearly with 0.19. In another investigation, as with field number 43, over 50% of yield variability in winter wheat could also be explained through soil electrical conductivity [4].

Pendulum angle – grain yield
In that it is often assumed in cereal production that grain and straw proportions stay in a somewhat similar relationship to one another, high correlations between pendulum angle and corn yield can be expected. With the measurement factors pendulum angle and yield recorded over 77 ha, the highest average coefficients in the conducted comparisons of 0.38 and 0.45 were determined for the functional dependencies *(table 3)*. Here too, a limited correlation could be assumed in absolute terms. If one included new site-specifically determined scientific results which gave a location-dependent grain/straw relationship in the region of 0 to 3 [5], one can certainly explain the relatively limited correlation from this.

Conclusions

In the evaluation of trial results it must be remembered that there are objectively based causes, as well as measuring procedure ones, for the relatively limited correlation.

The values for the electrical conductivity of the soil reflect, in the main, average ground water and clay content, whereby higher clay content means also higher water content. With increasing clay content the potential yield capacity of the location rose in areas between sand and loam soils. In the area loam/clay soil, rising clay content, on the other, characterised the reduction of potential yield capacity. For loam soils, no secure relationship can be expected.

30% of the conductivity measurement signals emitted from the area underneath of official measuring depth so that the effective root area decisive for plant growth was not identical with the soil area evaluated through ground conductivity.

The actual ground conditions are only one factor of influence for the actual development of crop mass. Sub-optimal growth conditions, as well as disease and pests during the year, also influence plant growth and lead to clear deviations of actually recorded plant parameters from the potential yield expectations of a location.

Because of the effects from these mentioned influences, it can be assumed from the investigation results that, under the given trial conditions, the functional relationships between the measurements collected in a small area regarding electricity conductivity of soil, pendulum sensor and grain yield are not close enough to be able to explain one factor with the help of another. Replacing the traditional soil quality pointage system with values linked to the electrical conductivity of soil in the investigations of relationships between soil and plant parameters led to higher correlations. Coefficients of agreement over 0.5 were, however, only achieved in a few field strips.

Location/ field	Crop/ year	Grid (m)	Area (ha)	Coefficient
Nieder-görsdorf	Winterw./2000	18x18	26.5	0.22/0.32*
Golzow/	Winterw. /1995	18x18	15.1	0.28/0.35*
Nr. 48	Winterw./1996	18x18	15.7	0.31/0.33*
	Grain maize/1997	18x18	12.6	0.09/0.19*
	Winetrw./1998	18x18	14.7	0.42/0.48*
	Winterw./1999	18x18	14.8	0.30/0.48*
Golzow/	Grain maize/1999	36x36	63.7	0.30/0.40*
Nr. 43**	Winterw,/2000	36x36	63.7	0.54/0.58*
Total			226. 8	0.30/0.39*

* Value without exceptions** Measurement from Lück et al.

Table 2: Coefficient of agrement for the functional relationships between electrical conductivity and yield

Location/ field	Crop/ year	Grid (m)	Area (ha)	Coefficient
Nieder-görsdorf	Winterw./2000	18x18	26.4	0.44/0.52*
Golzow/Nr. 47	Winterw./1999	18x18	24.3	0.31/0.33
Golzow/Nr. 48	Winterw./1999	18x18	26.4	0.39/0.50*
Total			77.1	0.38/0.45*

* Value without exceptions

Table 3: Coefficient of agrement for functional relationship between pendulum angle and yield

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