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Experiences with sensor-controlled nitrogen fertilising

The technique of sensor-controlled nitrogen fertilising enables in a single pass the determination of crop N requirement and N application. Optical sensors measure the crop stand and convert this data into the amount of N to be applied. The measured value doesn't directly give N requirement but instead information over chlorophyll content of leaves and of plant density. These characteristics are converted to an application amount according to plant husbandry recommendations – the system has to be calibrated. This procedure, and the associated results, is presented in the following paper.

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Used as control parameter was the turning point from red to infrared (rise) of the reflection spectrum. This reflection index indicated a positive correlation to N supply because it is correlated with chlorophyll concentration per ground area [1].

A more precise description of the vehicle-supported system and the optical characteristics of the crop stand can be found in [2]. The basic idea is that undersupplied crop areas which have a low reflection index (sensor value) should be allocated a high N application and vice versa.

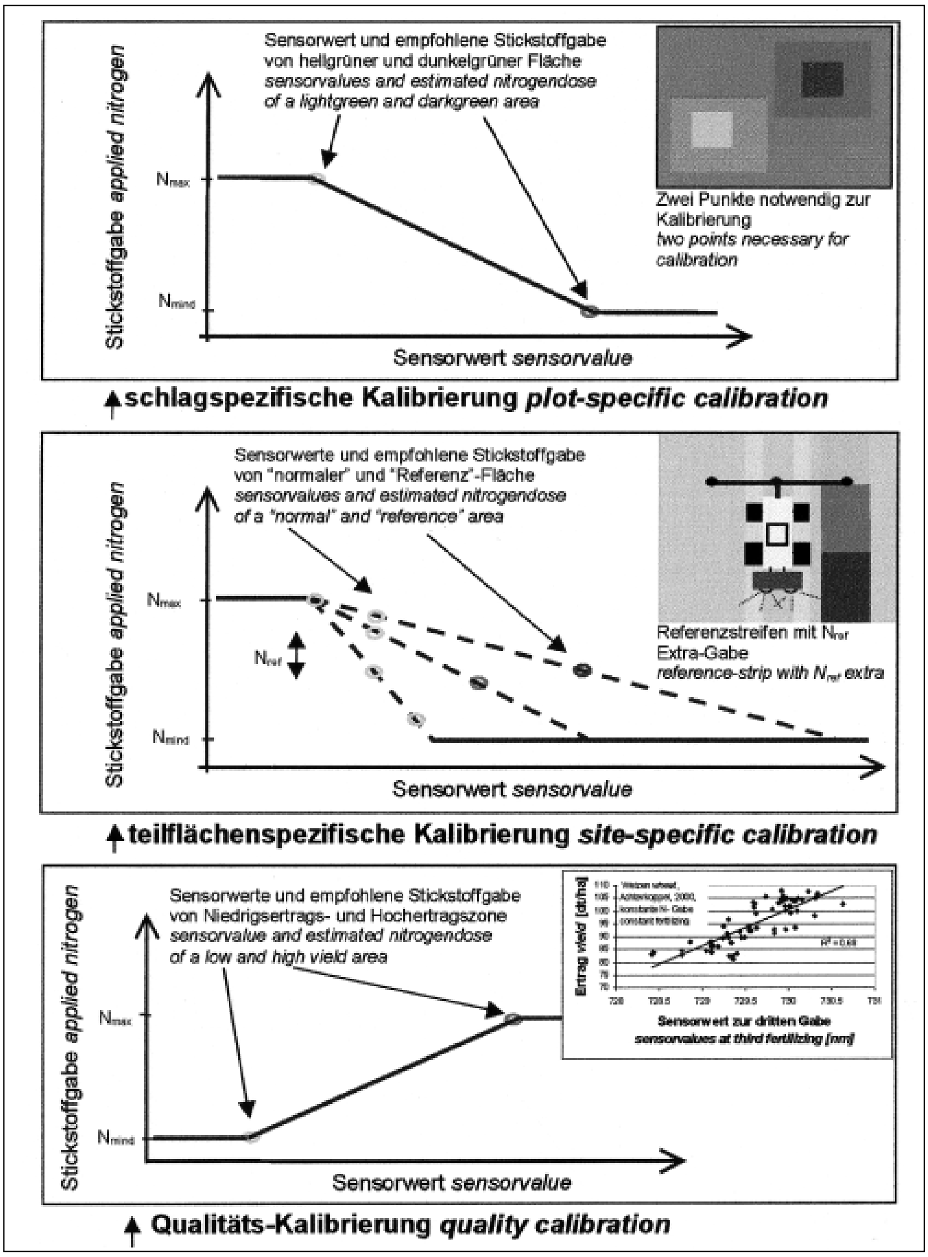

Fig. 1: Different sensor calibrations for sensor controlled nitrogen-fertilising

Corp/strategy Winter barley, Kronskoppel 2000 core zones per ha	Yield [dt/ha]	Nitrogen Total application amount [kg/ha]	Productivity [kg/kg]
Constant fertilising N1: 87 kg / ha N2: 40 kg / ha N3: 60 kg / ha	90. 0 ±6. 9	187 ±0	48 ±3
Sensor-controlled fertilising N1: Constant, 87 kg / ha N2 and N3: Field uniform calibration	91. 1 ±7.9	175 ±11	52 ±6
Sensor-controlled fertilising N1: Constant, 87 kg / ha N2: Site-specific calibration N3: Field uniform calibration	90. 0 ±6. 2	183 ±12	49 ±5
Winter wheat, Achterkoppel 2000 core zones 25 or 1 ha			
Sensor-controlled fertilising N1: Constant, 90 kg / ha N2: Site-specific calibration N3:Qualityfertilising	94 .3 ±12	188 ±16	50 ±8
Constant fertilising N1: 90 kg / ha N2: 67 kg / ha N3: 70 kg / ha	96. 7 ±12	227 ±0	43 ±5

Table 1: Yield and applied nitrogen of the trials. The mean and standard deviation is given for sites (10 m²) in the core-zones.

Problem

Because N-requirement is determined only over the reflection measurements, no difference can be made between the reasons for the signal variations. For instance, on a sandy low-yield soil the N requirement is certainly less than on a loamy high-yielding soil. Plants on the latter location are, however, mostly characterised by a higher sensor value and normally would receive less N during sensor-controlled fertilising than plants on poor ground.

Calibration

The calibration should be a practical attribution of sensor values to the application amount. In the following, three types are differentiated *(fig. 1)*.

Field specific calibration
Here the amount of N to be applied is according to the simple linear relationship to the sensor value, whereby the farmer decides that on a poorly-supplied spatial area the maximum N amount N_{max} is to be applied, and on a well-supplied spatial area the minimum N, N_{mind}.

Spatial site-specific calibration with reference strips
The basic idea here is, through utilisation of an extra, earlier established, reference strip (3 m) with a higher application of fertiliser, N_{ref}, more N is applied along the tramlines with the calibration automatically carried out on every spatial area during the pass. During this it is established whether the spatial areas driven on react to an N application with increased growth on the reference strip compared with the rest of the crop, or not. Thus the mentioned problem of soil differences enters into the calibration.

Quality calibration

With the third N application (especially wheat, quality application) the protein content of the grain should be maximised. For calibration this means that on spatial areas with high yield expectation – i.e. high sensor value (see *fig. 1*, quality calibration, above right) – more N should be applied compared with on spatial areas with low yield expectation. The latter is not able to convert so much applied N into the grain. The respective algorithm is appropriately precise contrary to field-uniform calibration.

Trial method

In a practical trial with winter barley (10 ha) and winter wheat (30 ha) the different calibrations were investigated in comparison with uniform application. At the dates of the second and third application the areas were driven over with the sensor system and simultaneously were fertilised with an electronically controlled broadcaster (Bredal B2).

At harvest yield mapping was conducted with the combine and wheat was tested for protein content.

Results

In *table 1* are given the different N applications and yields of the variants. In general it can be said that the difference between the variants is small; their standard errors overlap. However, the sensor-controlled fertilising indicated in every case a higher NJ productivity, i.e. a better utilisation of the applied N.

The quality calibration for wheat delivered no significant difference in protein content (10.5% ± 0.5% with sensor variants compared with 10.8% ± 0.7% with uniform fertilising).

If one looked at crop differences at the time of the third N application for barley, the standard error in sensor values for the spatial specific area in the calibration is 33% less when compared with the uniform application. This is to be expected in agreement with [3] (42%) in that this method applies a lot of N to the poorer area and thus encourages growth there and vice versa.

The association between N application and yield is certainly interesting *(fig. 2)*: As expected the yield decreased with sensor-controlled N fertilising with field-specific calibrations in-line with increased N application, whereas with spatial area specific calibration it remained relatively constant. Here, the poor areas (under 8.5 t/ha yield) got a lot of N in the case of field uniform calibration but remained low yielding or were over-fertilised whereas by the spatial area specific calibration the areas with good N efficiency received a lot of N which was then translated into yield.

Literature

Books are identified by •

[1] • *Reusch, S.*: Entwicklung eines reflexionsoptischen Sensors zur Erfassung der Stickstoffversorgung landwirtschaftlicher Kulturpflanzen. Dissertation, Kiel, 1997

[2] *Thiessen, E.*: Sensorgesteuerte Stickstoffdüngung. Landtechnik, 55 (2000), H. 2, S. 144-145,

[3] *Wollring, J., S. Reusch und C. Karlsson*: Variable Nitrogen Application based on Crop Sensing. The International Fertiliser Society, Proc. 423, 1998

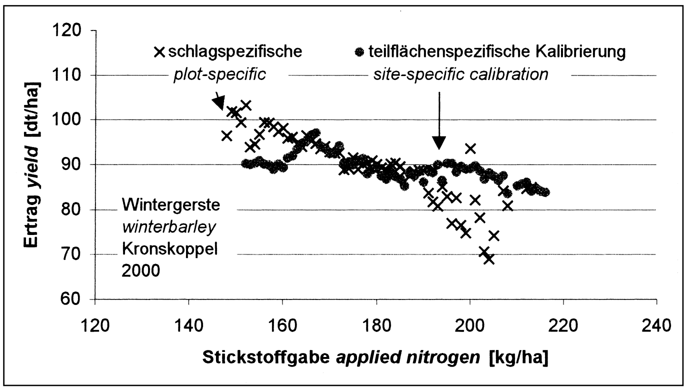

Fig. 2: Yield and applied nitrogen at different calibrations. The mean of each site (10 m²) is drawn in the figure