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Measuring protein content during combining

Yield mapping has established itself during cereal combining but quality measurements in the field have still not emerged. However, there are new instruments that use Near-Infra-Red-Reflection-Spectroscopy (NIRS) to allow non-contact determination of protein in wheat grain. Laboratory equipment was installed in a combine to record grain quality in the field. The data produced in the first year allowed indirect calculation of grain protein content and the production of a field protein map. On-line measurement was possible in the second year. According to first on-line measurements, achieved precision involves a standard error of ~ 0.55% protein.

The principle of NIRS measuring seems simple: sample material is radiated with light whereby the applied energy on different wavelengths is absorbed at different intensities. The spectrometer measures the intensity of the light reflected from the sample on every wavelength and from this produces a reflection spectrum. For calculating concentration of grain components from this spectrum the measurement instrument must be calibrated. For this, spectral information is first of all collected from samples; the samples themselves are subsequently analysed in a wet chemical process at a reference laboratory for component concentrations. The spectral information and the laboratory results are then „chemometrically" merged via computer and, based on chemometry models, prepared on the basis of the spectral information which can then present the measurement value as a result.

The calibrated equipment allows direct and non-contact measurement without preparation of the sample material. Short measurement periods and dispensing with chemical processes are also among the great advantages of NIR measurement technology, as is the possibility of multi-component determination. Disadvantages include the high price of the equipment, the complicated calibration work and relatively high sensitivity to mechanical and environment influences.

Measurement

For on-line measurement during combining under practical conditions there are especial demands on energy supply and data recording as well as mechanical robustness and possibilities for fitting into the machine. Two types of instrument meet most of those demands: the ZEISS (Jena) Corona was specially developed for tough conditions; the PERTEN (Hamburg) instrument still contains elements of its laboratory version. Both instruments measure in the range from ~ 960 to 1700 nm.

In that the measuring operation should take place as near as possible to the harvesting operation in terms of time as well as position the equipment is installed on the grain elevator in front of the grain tank. For the trial, both instruments were fitted to measure the same material out of the grain flow via a bypass system. This material is lifted from the sump of the corn tank filler and channelled into the measuring equipment. After passing through the instruments the material is channelled back into the elevator return or by the touch of a button into a sample container. A robust notebook recorded in parallel the spectra IDs, temperature of grain and surroundings and yield data. The measurements are geo-referenced and can be later produced as a map.

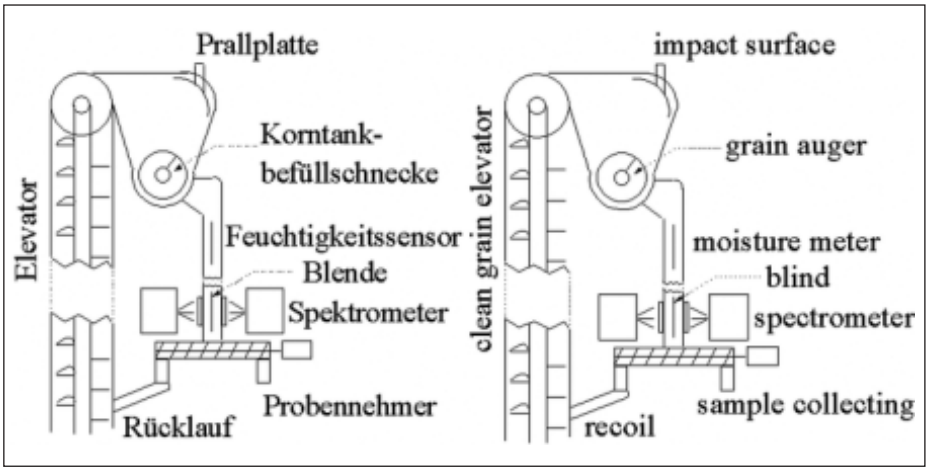

Fig. 1: Measurement-Unit

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Keywords

Combine harvesting, measuring system, quality assessment, protein content

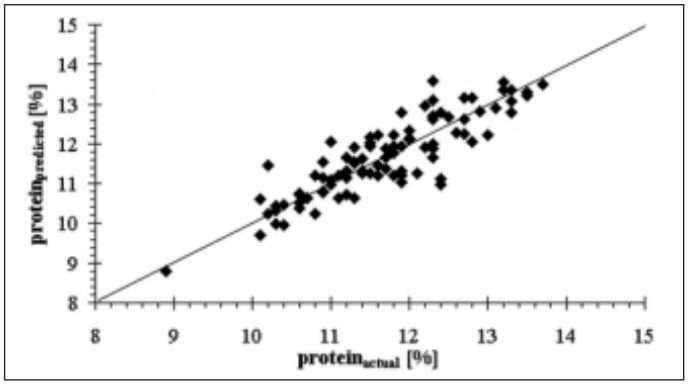

Fig. 2: Predicted versus measured protein content of winter wheat (calibration-set 2000/ validation-set 2001)

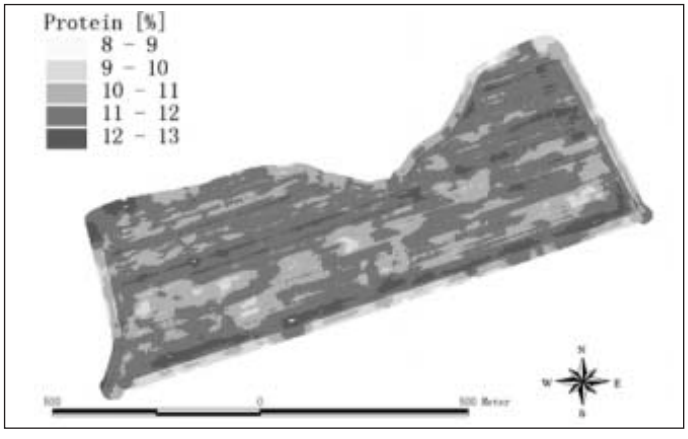

Fig. 3: Distribution of protein content of winter wheat in a field

Measurements of the Institute

Only collection of spectra and samples took place during the first year with a total of 528 samples taken from 93 ha of combined wheats of different varieties. After selection of 100 samples analyses took place in the laboratory via reference methods to determine components the results of which served for subsequent calibration. In the second year, on-line in-field measurements were able to be taken for the first time. During this season a great number of samples were once again taken with 100 of them wet-chemically analysed in the laboratory. The results were used for further checking of the calibration done in the previous year as well as for extending the calibration operations.

Measurement results

The results covering protein content of winter wheat are shown in *figure 2*. The image includes the laboratory values and, on the ordinate line, the results from one of the instruments are depicted. The diagonal marks the points where laboratory and instrument values agree. After correcting data bias (systematic error) the SEP(s) is 0.55%.

At first, the deviations between reference and measurement values might appear high. However, the following should be remembered: data from calibrations and from checking come from different years. Environment influences, which are controlled and eliminated in the laboratory, have effects on material and instruments. Additionally: as a comparison the permittable error of stationary equipment is ± 0.4%-points. This represents double the maximum permitted laboratory error in protein analysis according to Kjedahl (SEL = 0.2%).

Figure 2 contains measurement results from different fields and varieties in order to represent a broad spectrum. Even then protein content varies several percentage points, e.g. from 10.2 to 13.9% even on a single field. On the one hand, this would not even fulfil the intervention requirements, on the other hand the quality is that of E-wheat.

Parallel-recorded geo-coordinates enable the production of a protein content map (*fig. 3*). The map shows clearly the areas with different protein contents. The reasons can then be analysed and production/technical steps then developed. Thanks to spatial specific management nowadays the soil, fertiliser applications and yields are possibly known to help in determining influence factors.

Summary

An on-line measurement determining grain component concentrations is in principle possible. However, precision has still to be improved. Also working against serial production so far is complicated servicing and calibration work as well as high instrument costs.

With the help of continuous NIR measurements level and variability of content components can be recorded and presented. This data represents the starting point for reducing the differences in field production by specific actions such as Nr. fertilising.