DEVELOPMENT OF A PROTEIN SENSOR FOR COMBINE HARVESTERS

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ABSTRACT

Grain quality within fields shows a large variability, and by sorting the grain the overall economic value can be increased. The objectives of this study were to develop an on-line protein sensor for combine harvesters, and to test the system in the field.

A modified NIT-instrument, measuring 14 wavelengths (893 – 1045 nm) of transmitted light as well as of grain and sensor temperature, was installed within a sampling unit attached to the clean grain elevator of a combine harvester. The sensor was calibrated for protein and moisture content. For wheat the correlations (R²) between lab and sensor readings were 0.99 for moisture and 0.93 for protein. When using the system in the field, about 30 samples per hectare were measured. The collected data had a good spatial dependency and the average kriging standard deviation within the fields was 0.12%.

INTRODUCTION

Several studies have shown that crop quality within fields is highly variable (Mulla et al., 1992; Dawson, 1996; Reyns et al., 1999). This variability can have a major effect on the economic value of the crop. However, by sorting the grain the overall economic value can be increased (Thylén et al., 1999; Stafford, 1999). To be able to sort the grain into different fractions, a sensor detecting the grain quality either before or during the harvest is needed. Traditionally, samples are collected during the harvest and later analysed in the lab. This is usually done by Kjeldahl analysis or with a NIR/NIT instrument. The possibility to use NIR to measure protein content in whole grain was investigated by Williams et al (1985). An approach for measuring grain protein content on-line by the use of near infrared reflectance was described by Engel et al. (1997).

The aims of this study were to develop a system that can measure protein content on-line in a combine harvester, and to test the system during harvest.

MATERIAL AND METHODS

NIT-sensor

In this project we used a grain protein sensor which operates in the short-wavelength NIR, from 893 to 1045nm. The portable instrument, Zeltex ZX-50 (Rosenthal et al, 1999), can be calibrated to analyse moisture, protein and other constituent contents from the absorption spectra of the grains being tested. Besides measuring the spectra, the ambient and sample temperatures are measured. These data are used to calculate moisture and protein content of
the sample measured. When using the instrument in the lab, a sample cup is filled with grain and inserted into the sensor. The sample is illuminated and the transmitted light detected.

**Sampling and control device**

The protein sensor was installed in a sampling device mounted on the side of the clean grain elevator. To avoid problems caused by vibrations, the sensor was built into a unit, which dampened the vibrations. Vibrations do not affect the sensor directly, but moving kernels during measurements will cause bad data. Cutting a hole in the bottom of the NIT sensor and letting grain pass through the sample cup made it possible to intermittent measure grain protein content. Two flaps controlled the grain flow through the sensor. A level sensor between the flaps made sure that the sample cup was properly filled during light exposure (figure 1). During harvesting there is a risk that the sample cup will be scratched, therefore affecting the amount of light transmitted. To avoid this problem, every fifth reading was carried out with an empty sample cup thus taking the wear into account.

![Sampling device](image)

**FIGURE 1.** The sampling device was mounted on the side of the clean grain elevator. Two flaps controlled the flow of grain through the NIT-sensor. The level sensor made sure that the sample cup was properly filled during light exposure.

A control unit located next to the NIT-sensor controlled both the flaps and the NIT-sensor. To do so the software in the NIT-sensor was modified. The control unit also recorded the speed of the combine and the header position. When using the system in field all data was transmitted to a handheld PC in the cab of the combine. The PC was also connected to a GPS-receiver. During the harvest of 2000, two systems were installed on combine harvesters and tested in the field.

**Test bench trials**
Since the NIT-sensor was modified, the sensor was calibrated with grain samples of known protein and moisture content. This calibration was performed with the complete sampling-device. However, the sensor was filled with grain through a small hopper and not by the clean grain elevator.

RESULTS

Test bench trials

The calibration of the sensor was performed with wheat and barley and the measured constituents were protein and moisture content. Examples of the calibration curves for wheat are shown in figure 2.

![Calibration curves for wheat](image)

FIGURE 2. Results from calibration of one protein sensor with wheat. The graph to the left shows the protein content, and the graph to the right shows moisture content.

Field trials

The two sensor systems were tested during harvesting in 2000. During normal operation the system managed about 30 readings per ha. About two percent of the collected data were erroneous, but these were possible to detect when studying the transmitted data. The collected data was interpolated, using blockkriging (20*20 m) and local semivariograms, with the software Vesper (Minasny et al, 1999) and the kriging standard deviation was also calculated. An example is shown in figure 3. In this case the protein content ranged between 11 and 14.6 % and the average kriging standard deviation was 0.12 %. The moisture content of the grain was mainly depending of time of day, one example is shown in figure 4.
FIGURE 3. Example of maps showing yield and protein content from Hallby field. The field (ca 23 ha) was cropped with winter wheat, variety Kosack.

FIGURE 4. The moisture content of the harvested grain decreased during the day, but a slight increase in moisture content can be seen during the last hour of operation.

During harvesting, two problems occurred with the protein sensor. When combining grain with a moisture content close to 30%, the sensor got blocked with wet grain. We also had a mechanical problem with the flap controlling the inlet flow of grain to the sensor.

DISCUSSION

The possibility for on-line measurement of protein content during harvesting has been discussed for several years. Knowing grain protein quality can be used to sort grain into different fractions, thereby increasing the economic value of the harvested crop. The
information can, in conjunction with yield data, also be used to calculate the nitrogen uptake with the crop.

In this study we adapted an existing portable grain protein sensor for use on combine harvesters. The system worked properly during harvest, but the sensor tended to get blocked when the moisture content was close to 30%.

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REFERENCES