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Short Communication

Quality assessment of rapeseed accessions by means of near-infrared spectroscopy on combine harvesters

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With 1 figure and 1 table

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Abstract

Optimization of data collection processes in plant breeding programmes is of the highest importance for plant breeders. In rapeseed-breeding, data collection and selection must be carried out in a very restricted period of time because of the short time span between harvesting and sowing. Near-infrared spectroscopy on combine harvesters (NOCH) improves the data collection processes in breeding programmes of grain crops such as maize, and it may also improve the data collection processes in breeding programmes of rapeseed. The objective of this study was to assess the potential of NOCH for the determination of dry matter (DM), crude protein (CP), oil and glucosinolate (GSL) contents in rapeseed. A plot combine harvester equipped with a near-infrared diode-array spectrometer was used. Reference values for DM content were determined by the oven method. Reference values for the quality traits were established by laboratory near-infrared spectroscopy. NOCH showed a high potential for the determination of DM, CP, oil, and GSL contents. Use of NOCH in breeding may increase the efficiency of data collection processes and might dramatically accelerate the development of rapeseed cultivars.

Key words: *Brassica napus* — near-infrared spectroscopy on combine harvesters — dry matter — protein — oil — glucosinolate

The determination of dry matter (DM) content and quality traits by laboratory near-infrared spectroscopy (NIRS) analysis of intact rapeseed has proved to be successful (Tkachuk 1981, Reinhardt 1992, Tillmann 1997, Míka et al. 2003, Font et al. 2005), and it is a method used routinely in many rapeseed breeding programmes. In comparison with wet chemistry analysis, laboratory NIRS analysis of intact rapeseed has three major advantages: grinding the material is not required, the seeds analysed can be grown to produce subsequent generations, and the relevant information is available earlier. However, laboratory NIRS analysis is still inefficient in terms of sample handling and time requirements in a plant breeding context.

In recent years, technical advances in instrumental NIRS have allowed spectrometers to be mounted on combine harvesters and choppers to measure plot spectra simultaneously with the harvest of field trials. This new area of NIRS applications has been implemented successfully in grain and silage maize breeding programmes (Welle et al. 2003, 2005, Pfitzner et al. 2004, Montes et al. 2006). It would seem that information about the determination of DM content and quality traits of rapeseed by near-infrared spectroscopy on combine harvesters (NOCH) has not been reported.

The objective of this study was to assess the potential of NOCH for determination of DM, crude protein (CP), oil, and glucosinolate (GSL) contents in rapeseed.

Experimental varieties of rapeseed, *Brassica napus* L., were grown at Böhnshausen, Germany, in 2004. A Haldrup plot combine harvester (J. Haldrup a/s, Løgstør, Denmark) equipped with a Zeiss Corona 45 near-infrared diode-array spectrometer (Carl Zeiss Jena GmbH, Jena, Germany) was used for harvesting and recording NOCH measurements. A total of 561 field plots was harvested, from which 273 and 288 plots corresponded to low and high harvest purity, respectively. Contrasting harvest purities were achieved by varying air flow in the combine harvester cleaning system. Near-infrared spectra were collected in the 960–1690 nm spectral range, with a distance of 6 nm between pixels interpolated to 2 nm increments, resulting in 366 wavelengths. A spectral filter was used to eliminate meaningless spectra indicative of an empty conveyor belt, by removing all spectra with absorbance values higher than a threshold set for defined wavelengths. Plot samples were collected, oven-dried, and measured with a laboratory NIRSystems 6500 spectrometer (FOSS NIRSystems, Inc. Silver Spring, MD, USA). DM content was determined by weight differences between fresh and dried samples. CP, oil, and GSL contents were determined by laboratory NIRS.

Mathematical procedures on the spectral information and calibration development were performed with WinISI III (Infrasoft International LLC, State College, PA, USA) software. The complete sample set (561 plots) was used for calibration development. Calibration models were developed by using the modified partial least squares algorithm (Shenk and Westerhaus 1991) with the following settings: wavelengths 960–1690 nm at 2-nm steps (366 wavelengths), four cross-validation segments, 2.5 as T residual limit (Shenk and Westerhaus 1991), 10.0 as global H outlier limit (Shenk and Westerhaus 1991), 10.0 as X limit (Shenk and Westerhaus 1992) and two outlier passes. Three mathematical treatments were tested for each calibration: 0,0,1,1 (raw data), 1,4,4,1 and 2,24,24,1, where the first number is the degree of the derivative, the second is the gap between data points for subtraction, and the third and fourth are the numbers of data points used for smoothing.

The standard error of calibration (SEC) and standard error of cross-validation (SECV) were calculated. The lowest SECV values were used as criteria for selection of the best calibration model. Furthermore, the coefficient of determination of calibration (R^2_C) and coefficient of determination of cross-validation (R^2_{CV}) were obtained. In addition, the ratio between the standard deviation of the reference values in the calibration set and the SECV for each trait was determined to assess the future applicability of the calibration.

Among all the traits investigated, DM content showed the highest potential for determination by NOCH, followed by oil, CP, and GSL

Table 1: Calibration statistics for the determination of dry matter content and quality traits in rapeseed by near-infrared spectroscopy on a combine harvester (NOCH). Descriptive statistics (mean, SD, range and CV) refer to the calibration set

Trait	No. samples in calibration set	Mean	SD	Range	CV	SEC	SECV	R^2_C	R^2_{CV}	SD : SECV
		%								
Dry matter	530	91.3	1.7	86.0–94.4	1.9	0.3	0.3	0.97	0.96	5.7
Crude protein	543	21.3	1.1	17.9–23.8	5.2	0.6	0.6	0.71	0.69	1.8
Oil	544	45.3	1.7	40.8–49.6	3.8	0.9	0.9	0.73	0.71	1.9
		μmol/g			%	μmol/g				
Glucosinolate	548	13.6	2.8	4.4–21.4	20.6	2.1	2.2	0.44	0.40	1.3

SD, standard deviation; CV, coefficient of variation; SEC, standard error of calibration; SECV, standard error of cross-validation; R^2_C, coefficient of determination of calibration; R^2_{CV}, coefficient of determination of cross-validation.

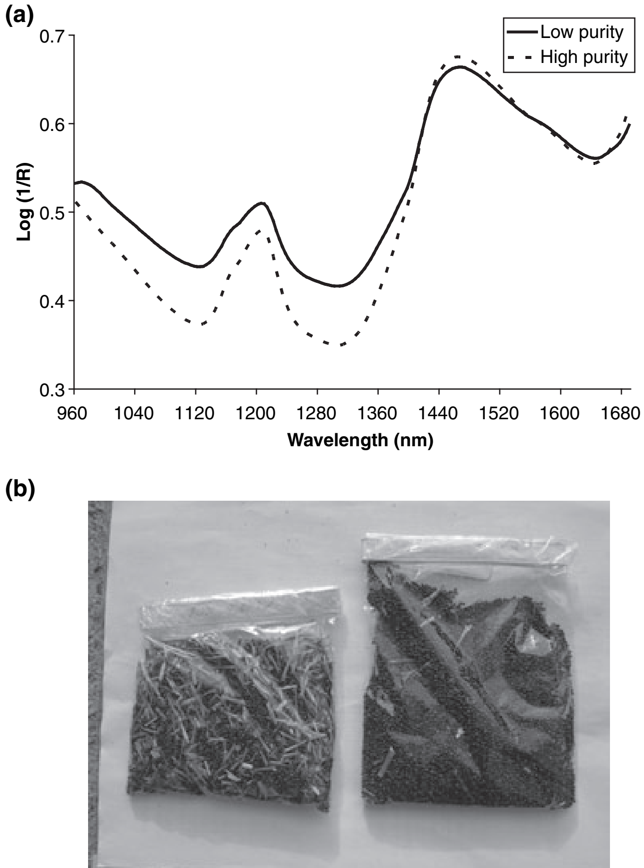

Fig. 1: (a) Average plot spectrum corresponding to low (273 plots) and high (288 plots) harvest purity of rapeseed. (b) Plot samples corresponding to low and high harvest purity of rapeseed

contents (Table 1). In addition, NOCH calibrations for DM, CP, oil and GSL yielded similar calibration performances to those reported for laboratory NIRS analysis of intact rapeseed (Tkachuk 1981, Tillmann 1997, Míka et al. 2003).

A first approximation to study the influence of harvest purity on the NOCH spectra revealed a considerable baseline-effect between 960 and 1400 nm when comparing two contrasting harvest purities (Fig. 1).

In breeding programmes of rapeseed, there is a very short and strict time span available between harvest and sowing for data collection and selection. Hence, plant breeders need fast and accurate data collection methods in order to analyse traits and make selection decisions for the next generations. This new study has shown that NOCH is a promising method for the assessment of DM content and quality traits in rapeseed accessions at the stage of harvesting. Further research is needed to validate NOCH calibrations by using data from different locations, harvest years, and combine harvesters, and to assess in detail the effect of harvest purity on the NOCH calibration.

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