DETERMINATION OF SPECTRAL CHARACTERISTICS OF WINTER WHEAT CANOPY

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ABSTRACT

Spectroradiometric methods are widely used to evaluate canopy variables like above ground biomass or canopy chlorophyll content from remotely sensed spectral data. The aim of this study is obtaining a successful model for optimizing N doses without reducing wheat yield. In this study we described the methods associated with the estimation of canopy characteristics from ground truth measurements. By using the portable device "FieldSpec Hand Held 2" the spectral reflectance of winter wheat crop stands in visible region (400-700 nm) and near infrared (700-1000 nm) spectrum was measured at Experimental station of Mendel University in Brno located in Žabčice during different growth phases in 2013. The preliminary results showed that both parts of spectrums are sensitive to changes of crop parameters. The reflectance of crop stand under good nutritional condition increased clearly increased in the visible region and increased in the near-infrared region. A further research is needed to study the relationships between the reflectance and crop parameters for correct interpretation of spectral properties of winter wheat.

Key words: cereals, spectroscopy, plant nutrient, spectral analysis, crop management

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INTRODUCTION

The large amount of nitrogen fertilizers is used every year which could threat the ground and surface waters by non-adequate use in crop management, At the same time it is wasting of our resources and reducing the chance to have an economic wheat production and increase the environmental pollution (Shanahan *et al.* 2008; Ju *et al.* 2009; Wang Wei *et al.* 2012). With technical progress in recent years, spectral remote sensing is becoming a great tool for feasible and credible methodology for estimating the nitrogen status in agronomic crops and the stand of cereals, although traditional procedures such as chemical analysis are still under practical use (Hansen and Schjoerring.2003; Mistele and Schmidhalter.2008). One possibility to quantify vegetation parameters from spectral data is to use any vegetation index. The normalized difference vegetation index (NDVI) is the classical index, where the normalized ratio of red reflectance (RRED) and near-infrared reflectance (RNIR) is used (NDVI=RNIR−RRED/RNIR+RRED). This vegetation index has been related to crop variables such as biomass, leaf area, plant cover, leaf gap fraction, nitrogen, and chlorophyll in cereals (Brogea and Mortensen 2002). Spectroradiometrical sensors measure reflectance in a large number of narrow wavebands, generally with band widths of less than 10 nm. With these narrow bands; reflectance and absorption features related to specific crop physical and chemical characteristics can be detected (Hansen and Schjoerring.2003).

The overall objective of this study is the diagnosis of crop nutrient status by applying the information content of spectral characteristics to improve the performance and the accuracy of nitrogen doses and wheat yield. This includes proposing of new method for the assessment of wheat canopy parameters which could be utilized in Precision Agriculture system. This paper describes the first part of the study focused on the measurement of spectral characteristics of winter wheat crop stands.

MATERIAL AND METHODS

Experimental design and site description

The experimental work was carrying out in 2013 at Field Experimental Station of Mendel University in Brno located in Žabčice (49°1'18"N, 16°36'54"E). A field experiment of winter wheat was established (fore crop winter oilseed rape) in general block design with combination of three factors: three varieties (Bohemia, Mulan and Seladon), three levels of seeding rate (2, 3.5 and 5 MGS.ha-1) and three levels of nitrogen doses (0, 80 and 160 Kg N.ha-1) applied during the vegetation season in form of LAD 27% N fertilizer (Ledek amonny s dolomitem – Ammonium Nitrate Magnesium); nutrients content - NO3 13.5 %, NH4 13.5 % and MgO4%. The field trial design was conducted in four replications, which gives the total number 108 parcels per experiment

The spectral measurements were taken in BBCH 27, 32, 39, 57 and 69 using ASD Fieldspec Handheld 2 passive spectroradiometer (see technical specification in Tab. 1) by walking through the experimental parcels. The average number of 98 reflectance spectral curves were obtained along the study area and processed by ASD Software RS3 (see description below). During the observation, a reference calibration of the instrument for current light condition was done using white Spectralon field calibration panel.

Fig. 1 ASD Hand Held 2 Portable Spectroradiometer

Simultaneously with spectroradiometric measurement more detailed survey of spectral properties of experimental variants was done by measuring the chlorophyll content in leaves (Yara Ntester), NDVI measurement of crop stand (Trimble GreenSeeker) and ground based imaging using DuncanTech MS3100 multispectral camera (see more information in Lukas et al., 2013). At each observation date, canopy structure parameters (number of plants, tillers and spikes, plant height, biomass) were measured and plant samples were taken for plant analysis. These results are not presented in this paper and their analysis and interpretation needs further research.

Tab. 1 ASD Handheld 2 Portable Spectroradiometer Specifications

Spectral Range (Wavelength Range)	325-1075 nm
Wavelength Accuracy	±1 nm
Spectral Resolution	<3.0 nm @ 700 nm
Integration Time	8.5 ms minimum (selectable)
Noise Equivalence Standard	5x10-9W/cm2/nm/sr @ 700 nm
Radiance (NEdL)	Pro: 5x10-10W/cm2/nm/sr @ 700 nm

Data processing and statistical analysis

The ASD Software RS3 Spectral Acquisition Software Version 6.0 was used to process and analyse recorded spectral curves. Standard statistical functions were applied to calculate mean, median and standard deviation to the selected files. Mean, Standard Deviation, and Median distinguishes the noise of each spectrometer. Spectral pattern of each measured sample was identified. The spectral characteristics of the device are shown in *Tab 1*. The protocol used for the collection of spectral data is based on measuring radiance from a Spectralon Reflectance Standards. The official website information can be found under the internet address: http://www.asdi.com/products/spectroscopy-software/rs3

RESULT AND DISCUSSION

The spectral curves of crop reflectance for the observed three levels of nitrogen fertilizing are presented in Fig 2. The results show that increase of nitrogen doses leaded to lower reflectance in the visible spectral range (400 – 700 nm), while in the near infrared spectral range (720 – 1000 nm) was the reflectance higher. This corresponds to the findings of Zhu et al. (2007) and thus provides a basis for the quantification of the nitrogen status of plants using their spectral parameters as shown for example by Li et al. (2013). The main factors responsible for the reflectance of vegetation are chlorophyll content (in the visible part of spectrum) and biomass (in near infrared region), both influenced by nitrogen fertilizing and crop management.

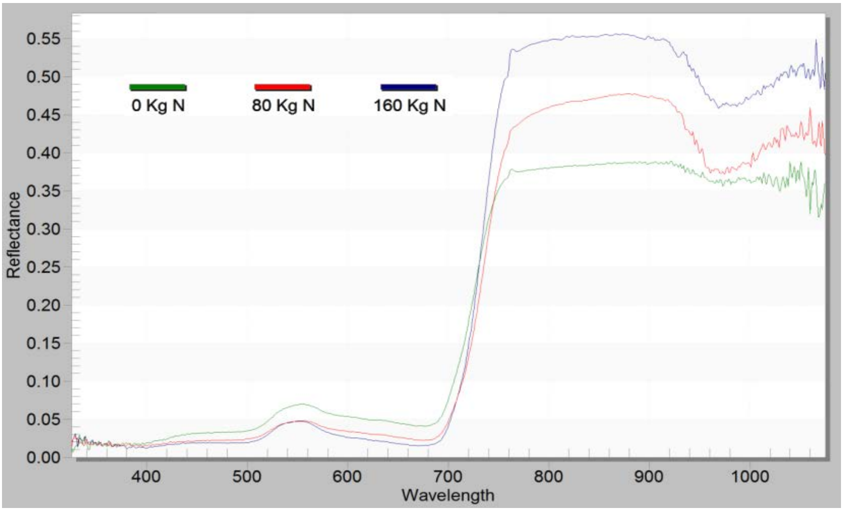

Fig. 2 The Spectral Reflectance Curves of three different nitrogen doses at BBCH39

The preliminary statistical analysis was done by the ASD Software RS3 in order to identify the spectral reflectance pattern of each nitrogen dose, the optimal reflectance to isolate each nitrogen dose and finally the specific wavelengths that could be used to isolate each nitrogen dose (see Tab. 2). As shown in Tab. 2 and Fig. 3, the optimal reflectance of 0 Kg N, 80 Kg N and 160 Kg N were respectively (0.4897-0.5973 , 0.5011-0.5733 and 0.5834-0.6761).

Tab. 2 The Optimal Reflectance to Differentiate between the three Nitrogen doses

Nitrogen doses	Optimal Reflectance Zones
0 Kg N	0.4897 – 0.5973
80 Kg N	0.5011 – 0.5733
160 Kg N	0.5834 – 0.6761

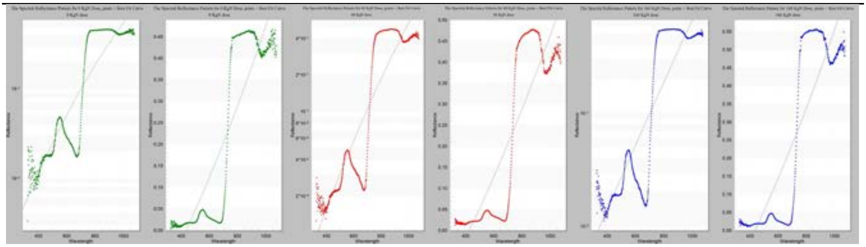

Fig. 3 The Spectral Reflectance Pattern for the Different Nitrogen Doses, points + Best Fit Curve

As the further research, the relationships between the spectral characteristics in form of vegetation indices and crop nutrition and structure parameters (see Material and Methods section) will be studied using traditional and multivariate statistical techniques. The experimental work is going to be continued during vegetation season in 2014 and extended to spring barley at the Agricultural Research Institute in Kroměříž. An influence of observed factors on the final yield will be examined and a recommendation for optimization of spectral measurement in precision agriculture will be proposed as the final outcome.

CONCLUSIONS

The preliminary analysis of the first year results from field experiment showed a sensitivity of spectral measurement to different levels of nitrogen application in winter wheat. Crop stand under good nutrition condition showed higher spectral reflectance in the visible region and lower in the near-infrared region in comparison to the control variants without N fertilizing. As the next step, more detailed statistical evaluation of spectral data will be done, including a comparison with the results of canopy structure and plant nutrition analysis to relate spectral vegetation indices with the agronomic important crop characteristics.

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