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# SPECTROSCOPIC APPROACH OF WINTER WHEAT (*Triticum aestivum L.*) NUTRITION AND PEST CONTROL

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***Abstract:*** Laboratory reflectance spectroscopy is a routine evaluation technique in many scientific areas. The objective is to present the capabilities of a portable spectro-radiometer which can be used both for field and laboratory examinations. In this study an ASD FieldSpec 3 Max spectro-radiometer was used in two different application forms to analyze the reflected electromagnetic radiation in the wavelength range of 350 to 2500 nm. The study introduces some preliminary results of nutrient sensitive changes in winter wheat spectra and brings on the necessity of high resolution spectral testing of insect luring, repelling illuminants.

***Key words***: *spectroscopy, winter wheat, pest control*

## INTRODUCTION

Spectroscopy studies the interaction between electromagnetic radiation and matter. The method of evaluating the spectral characteristics of different biotic or abiotic materials and surfaces originates in the laboratory spectroscopy, where it is generally used in physical and analytical chemistry hence atoms and molecules have unique spectra. Today the technological development has made possible to carry out high spectral resolution in-field analysis and airborne hyperspectral imaging and

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created new perspective for information management in site specific agricultural production [1, 2, 3].

In 2010 our Institute purchased an ASD FieldSpec 3 Max portable spectro-radiometer. The equipment can be widely used both in field and under laboratory circumstances. It is adequate to carry out independent, fast and precise evaluations in an economic way but also used to correct and validate simultaneous or near simultaneous airborne remote sensing data. This spectral sampling method results in the mean reflectance spectrum of the instantaneously scanned surface [4].

The device extends the range of the detectable visible light [5, 6, 7, 8] to NIR (near infrared) and the SWIR (shortwave infrared) region and covers the range of 350 to 2500 nm. Characteristic near infrared wavelengths can indicate changes in moisture content of vegetables [9]. Beyond the moisture content other relevant parameters can modify spectral characteristics [10], thus such wide spectral range can also increase the efficiency of computer vision based automatic fruit or crop inspection [11]. Though, the processing of these images is a very complex procedure [12]. In case the coordinates of in-field measurements are recorded the surficial spectrum can be fitted to the adequate pixel of a hyperspectral airborne image that is an important element of the subsequent evaluation processes. The number and the quality of in-field measurements determine the final accuracy of the airborne images.

The technology provides opportunity to obtain quantitative relationships between the environmental and physiological parameters of the vegetation [13, 14, 15, 16, 17], soil quality parameters [18, 19, 20] and the features of reflectance spectra (Fig. 1).

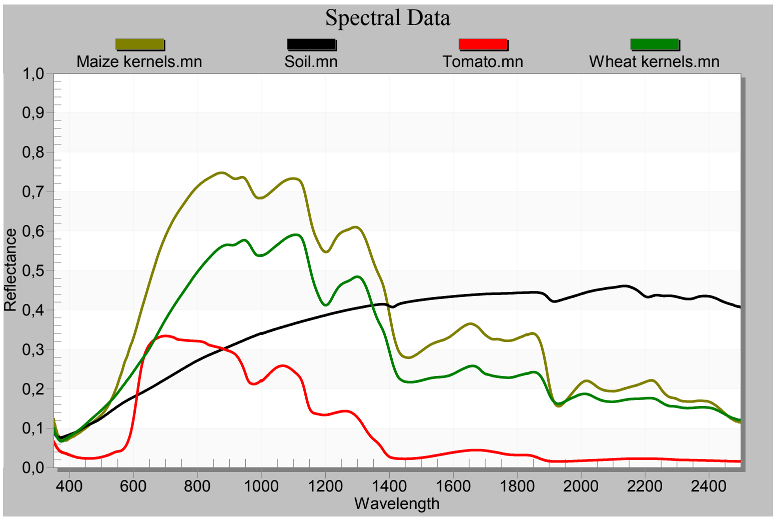



*Figure 1. Distinctive spectral features of different samples*

In this study we are introducing the technological basis of reflectance spectroscopy with preliminary results of segregating various nutrition levels in winter wheat production and a possible way to further increase the efficiency and/or selectivity of a new generation pest control system.

## MATERIAL AND METHODS

For laboratory tests we constructed a light-isolated cabinet where disturbing environmental light is shielded. The ASD Field Spec®3 MAX portable spectro-radiometer (Fig. 2) and the laboratory cabinet are presented in Figure 14. Two methods of data acquisition are possible according to the size and physical parameters of the object to be tested. ProLamp (Fig. 3) is used to illuminate the object from a distance of 30-70 cm. Measurements of small object areas can be carried out with PlantProbe sensor-head (Fig. 4) which has internal light source. Technical parameters of the spectro-radiometer are summarized in Table 1.

*Figure 2. ASD Field Spec®3 MAX*

*Figure 3. Laboratory cabinet*

*Figure 4. ProLamp light source*

*Figure 5. PlanProbe sensor-head*

*Table 1. Technical parameters of ASD Field Spec®3 MAX*

| | *ASD Field Spec®3 MAX* |
|---|---|
| *Spectral range [nm]* | *350 – 2500* |
| *Spectral sampling band [nm]* | *1.4 – 2* |
| *Spectral bands* | *2150* |
| *Spatial pixels* | *1* |
| *Spectral depth [bit]* | *16* |
| *Image rate [image]* | *Up to 100 ms* |
| *FOV [degree]* | *1, 8, 25* |
| *Detectors* | *Si and two InGaAs* |

## RESULTS AND DISCUSSION

### Identifying different nutrition levels of winter wheat

Experiments were carried out to identify spectral differences of winter wheat treated with various nutrient dozes. 'Alföld 90' winter wheat variety was tested on agronomic replicated blocks (Fig. 6 and Fig. 7).

*Figure 6. 'Alföld 90' winter wheat*

*Figure 7. Agronomic replicated blocks*

Each replication had two variants: fertilized and unfertilized. Fertilized variants received 80 kg ha-1 nitrogen fertilizer. Samples were collected and analyzed in laboratory. The analysis of the protein (Fig 8) and the wet gluten content (Fig 9) approved the correlation with the amount of ammonium-nitrate fertilizer. As a result of the treatment all values decreased significantly. Protein content with nitrogen fertilizer (80 kg) and without (0 kg)

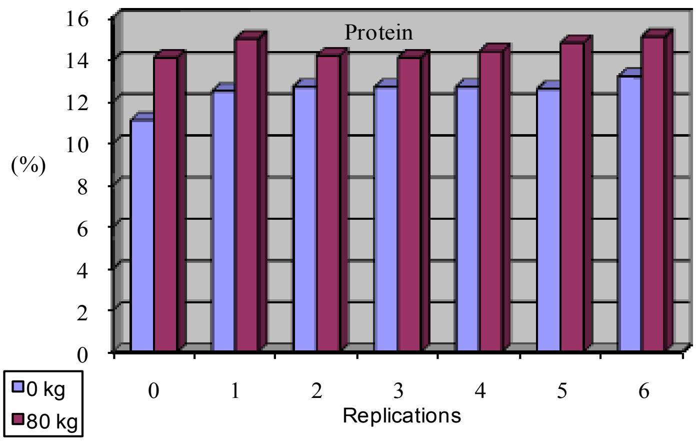



*Figure 8: Yield with nitrogen fertilizer (80 kg) and without (0 kg)*

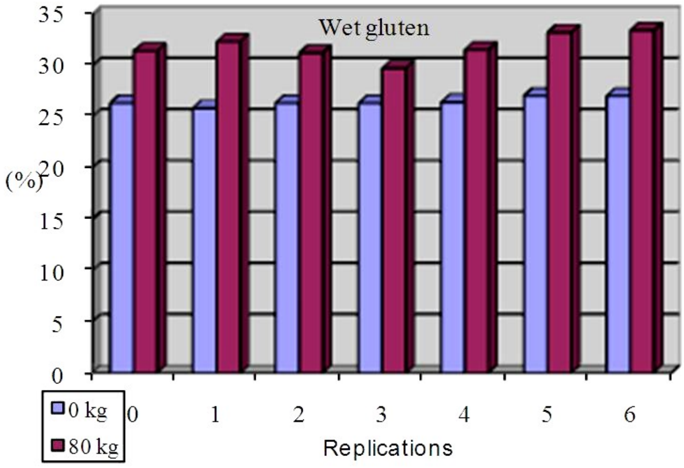
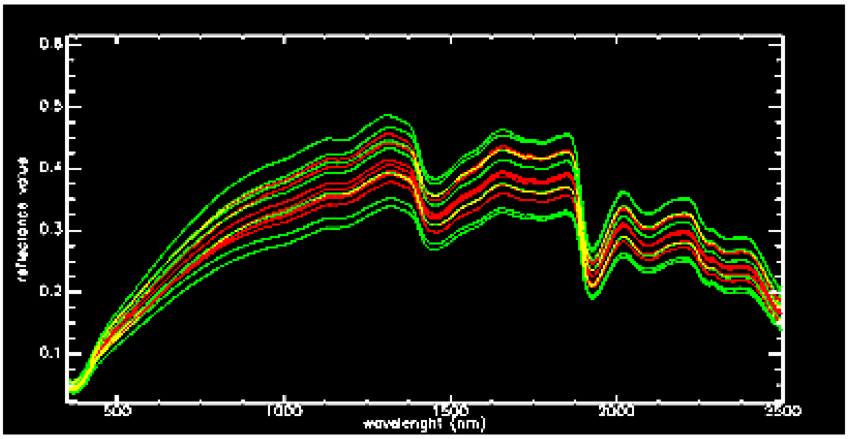



*Figure 9: Wet gluten content with nitrogen fertilizer (80 kg) and without (0 kg)*

Wheat ears were illuminated with ProLamp, kernel were tested with PlantProbe. Processing steps were carried out with ENVI software. We used continuum removal to normalize spectra. This made possible to compare the absorption features according to the common baseline (ITTVIS ENVI).

The mean reflectance spectra of the treatments were computed when evaluating the wheat ears and kernels by spectro-radiometry. Dashed line represents the nitrogen fertilized, while solid the not fertilized crops. Mean reflectance spectra of treatments are presented by Figure 10.

Normalized reflectance spectra with characteristic interval between 1700 nm and 1800 nm wavelength values were found in case of wheat ears and 500 to 800 nm at kernels (Fig 11).



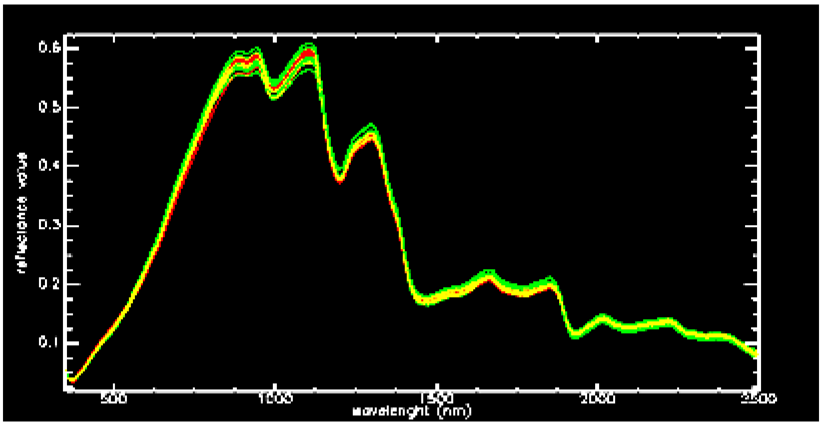



*Figure 10. Normal reflectance curves of wheat ears (up) and kernels (down) with (80 kg - red) and without fertilizer (0 kg – green lines)*

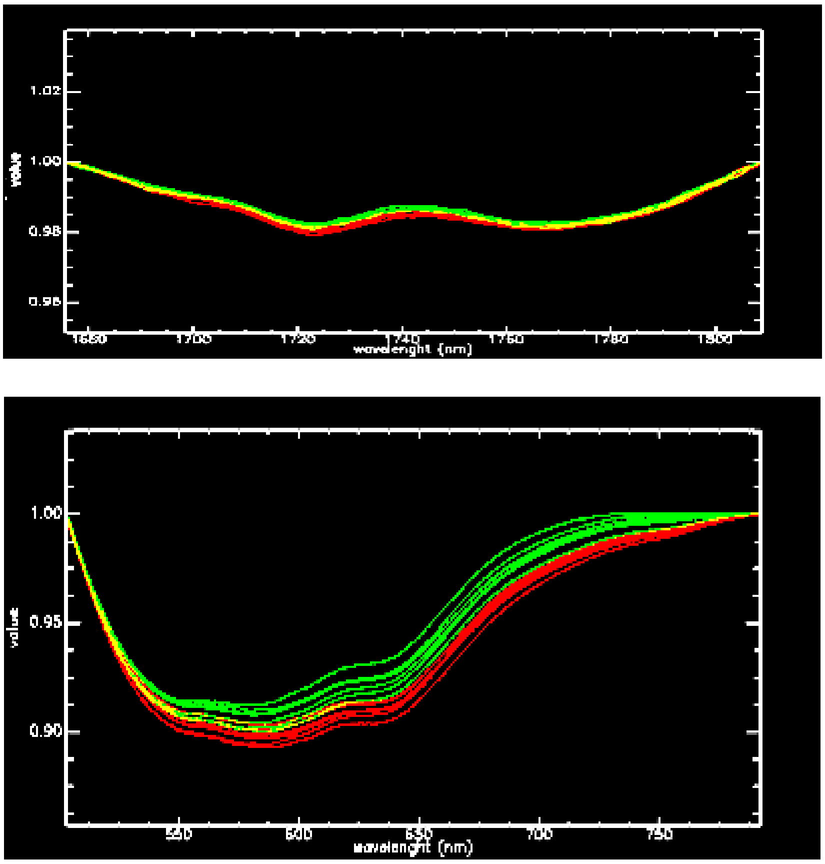



*Figure 11. A decreasing trend is indicated in the spectra of nitrogen treated (80 kg - red) wheat ears (up) and kernels (down) compared to untreated ones (0 kg – green lines)*

Differences in nitrogen treatment generated changes in spectral features of wheat ears and kernels. After normalizing the spectra we found two characteristic intervals in the wavelength range of 500 to 800 nm for wheat kernel and 1650 nm to 1800 nm for wheat ear samples. Both treatments show the same trend. After evaluating the most important parameters of the winter wheat (yield, protein, wet gluten content) with conventional laboratory technology the interrelation between spectra and nutrition application rate can be determined. Through calibration and validation process spectral instruments can contribute to better description and traction of nutrient supply and plant up-take.

**Spectral evaluation of artificial illuminants**

By the principle of pest's phototaxis and nocturnal habits the Shenzhen Fuwaysun Technology Co., Ltd. has developed a Solar Insect Killer (Fig. 12) - 1. solar cell, 2. power device with battery, 3. light bulb, 4. insect trap.


*Figure 12. (FWS-SP05-12/2 type Solar Insect Killer at the MACFRUT 2011. exhibition)*

Various illuminants are used to lure different insects into the trap which are very important elements of the system. There are two types, bulbs with wide and with narrow spectral characteristic. Nineteen narrow band illuminants are provided by the manufacturer (310 nm, 320 nm, 340 nm, 351 nm, 360 nm, 365 nm, 368 nm, 380 nm, 385 nm, 400 nm, 420 nm, 445 nm, 460 nm, 480 nm, 520 nm, 525 nm, 545 nm, 560 nm, 575 nm). The aim of our project was to evaluate the spectral distribution of each bulb in the wavelength range of 350-2500 nm.

In situ (Fig. 13) and ex situ measurements were made under laboratory circumstances (Fig. 14) - 1. Light bulb, 2. reference panel, 3. optical cable with 8° optic, 4. ASD FieldSpec 3 max - to determine the spectral feature of each illuminant.

The results showed that even the narrow band illuminants have several spectral peaks in the visible region and some bulbs have peaks in NIR range as well (Fig. 15 and 16).

Figure 13. In situ measuring method

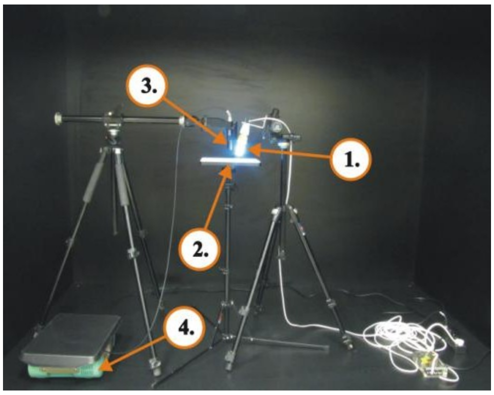



Figure 14. Measurement in laboratory cabinet

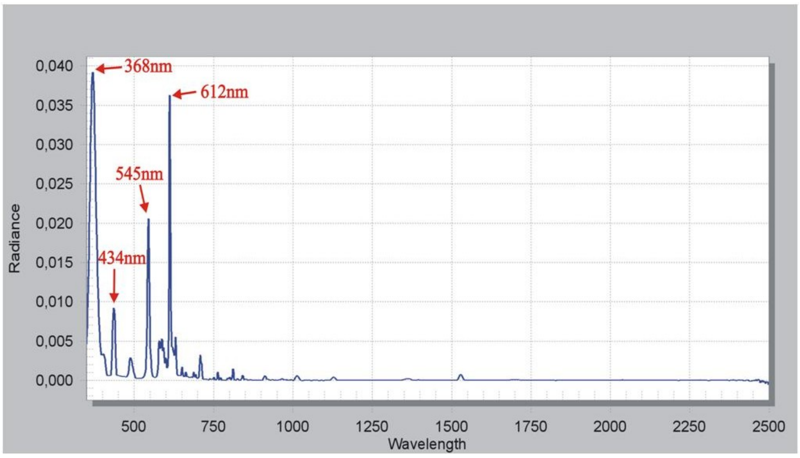



Figure 15. Narrow band illuminant 368 nm

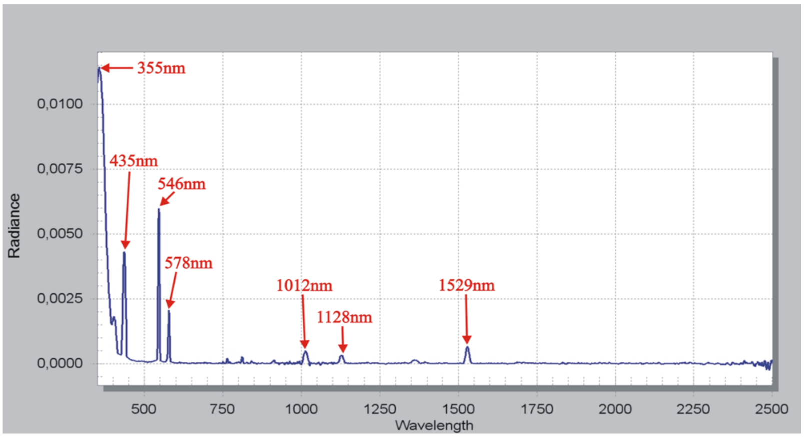



Figure 16. Narrow band illuminant 351 nm

The high resolution spectro-radiometer can enhance the specification of light sources. As insects have very fine and special sensitivity to EM radiation so a more precise selection (ex- or inclusion) of relevant spectral peaks can help even a species specific luring or repelling effect.

## CONCLUSIONS

The application of the high resolution spectro-radiometer has been proved useful in two absolutely different application areas. We found two characteristic intervals in the wavelength range of 500 to 800 nm for wheat kernel samples and 1650 nm to 1800 nm for wheat ear samples where both treatments show the same trend. Different nitrogen fertilizer doses resulted in different quantity and quality parameters of the tested wheat variety. Differences also generated changes in spectral features of ears and kernels. Our measurements showed that even the narrow band illuminants have several spectral peaks. With the presented evaluation method the classification of illuminants can be facilitated and refined. A more precise selection of relevant spectral characteristic can further increase the luring or repelling effect of illuminants.

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## SPEKTROSKOPSKI PRISTUP ISHRANI I ZAŠTITI OZIME PŠENICE (*Triticum aestivum L.*)

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***Sažetak:*** Laboratorijska refleksna spektroskopija je uobičajena tehnika evaluacije u mnogim naučnim oblastima. Cilj je da se predstave mogućnosti portabl spektroradiometra koji može da se koristi kako za poljska, tako i za laboratorijska ispitivanja. U ovom istraživanju upotrebljen je spektro-radiometar ASD FieldSpec 3 Max u dve različite aplikacione forme za analizu reflektovanog elektromagnetnog zračenja u opsegu talasnih dužina od 350 do 2500 nm. U radu su predstavljeni neki preliminarni rezultati osetljivih promena nutrijenata u spektru ozime pšenice i doprinos neophodnosti visoke rezolucije spektralnog testiranja svetlećih tela za privlačenje i odbijanje insekata.

***Ključne reči***: *spectroscopy, winter wheat, pest control*

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