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ADAPTATION OF SPECTROSCOPIC ANALYSIS IN WINTER WHEAT (TRITICUM AESTIVUM L.) EXAMINATION AND PEST CONTROL

Annotation

Laboratory reflectance spectroscopy is a routine evaluation technique in many scientific areas. The objective is to present the capabilities of a portable spectroradiometer which can be used both for field and laboratory examinations. In this study an ASD FieldSpec 3 Max spectroradiometer 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.

Keywords: spectroscopy, winter wheat, pest control.

Ключевые слова: озимая пшеница, отражательная спектроскопия, портативный спектрорадиометр, электромагнитная радиация, светочувствительный питательный элемент.

Кілт сөздер: winter wheat, reflective spectroscopy, portable spektroradiometr, electromagnetic radiation, a photosensitive nutritious element.

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 created new perspective for information management in site specific agricultural production (Papp and Fenyvesi 2007, Fenyvesi 2008., Késmárki-Gally et al. 2008, Fenyvesi and Késmárki-Gally 2009) which can also enhance the optimization of effectiveness and efficiency of model assisted agricultural production systems (Késmárki-Gally and Fenyvesi 2004, Fenyvesi et al. 2007, Késmárki Gally 2009).

In 2010 our Institute purchased an ASD FieldSpec 3 Max portable spectroradiometer.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.

The device extends the range of the detectable visible light (Lágymányosi and Szabó 2010, 2011) 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 (Kaszab et al. 2008). Beyond the moisture content other relevant parameters can modify spectral characteristics (Erdeiné Késmárky-Gally 2009). Though, the processing of these images is a very complex procedure (Firtha et al. 2008). In case the coordinates of in-field measurements are recorded the surfacial 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 (Erdélyi 2006, 2009, Balla et al.

2011, Klupács et al. 2011), soil quality parameters (Tolner 2011, Máthé 2010) and the features of reflectance spectra (Fig. 1).

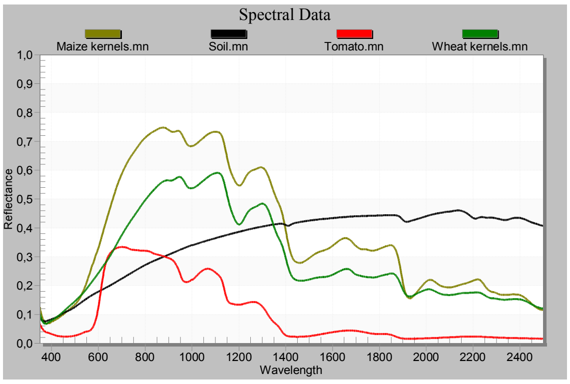


Figure 1 – Distinctive spectral features of different samples

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.

Materials and methods

For laboratory tests we constructed a light-isolated cabinet where disturbing environmental light is shielded. The ASD Field Spec®3 MAX portable spectroradiometer (Fig. 2) and the laboratory cabinet are presented in Figure 3. Two methods of data acquisition are possible according to the size and physical parameters of the object to be tested. ProLamp (Fig. 4) 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.5) which has internal light source. Technical parameters of the spectroradiometer 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

Research

Identifying different nutrition levels of winter wheat

Experiments were carried out to identify spectral differences of winter wheat treated with various nutrient dozes. ‘Alföld90’ 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. 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).

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. 8) - 1. solar cell, 2. power device with battery, 3. light bulb, 4. insect trap.

Figure 8 – (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 (310nm, 320nm, 340nm, 351nm, 360nm, 365nm, 368nm, 380nm, 385nm, 400nm, 420nm, 445nm, 460nm, 480nm, 520nm, 525nm, 545nm, 560nm, 575nm). 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. 9) and ex situ measurements were made under laboratory circumstances (Fig. 10) - 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.

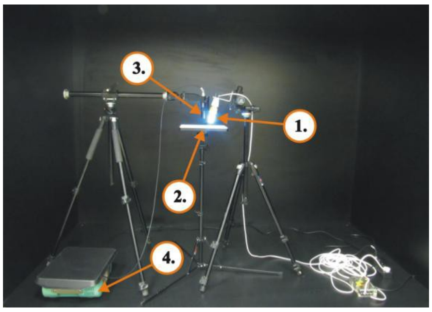


Figure 9 – In situ measuring method Figure 10 – Measurment in laboratory cabinet

Discussion of Results

Identifying different nutrition levels of wheat varieties

The mean reflectance spectra of the treatments were computed when evaluating the wheat ears and kernels by spectroradiometry. Dashed line represents the nitrogen fertilized, while solid the not fertilized crops.Mean reflectance spectra of treatments are presented by Figure 11.

Figure 11:

Normal reflectance curves of wheat ears (left) and kernels (right) with (80 kg - dashed) and without fertilizer (0 kg - solid lines)

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 12).

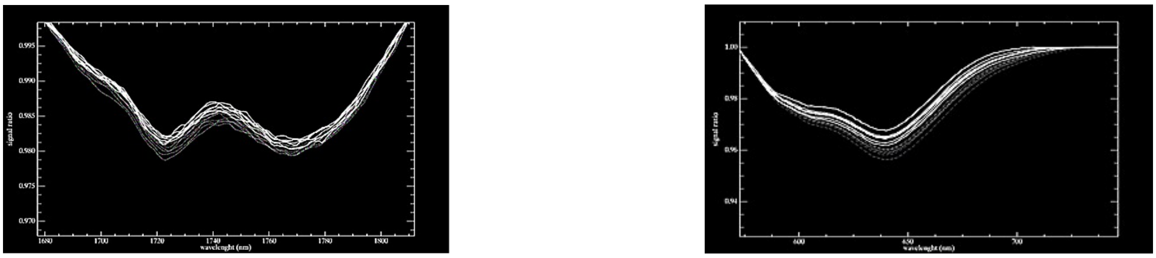


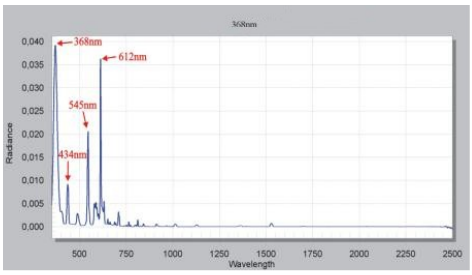
Figure 12:

A decreasing trend is indicated in the spectra of nitrogen treated (80 kg - dashed) wheat ears (left) and kernels (right) compared to untreated ones (0 kg – solid 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

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. 13 and 14).



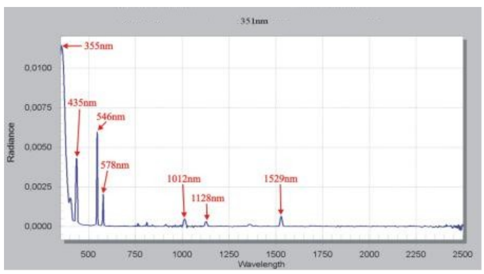


Figure 13 – Narrow band illuminant 368 nm Figure 14 – Narrow band illuminant 351 nm

The high resolution spectroradimeter 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 helpeven a species specific luring or repelling effect.

Conclusions

The application of the high resolution spectroradiometer 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 effectof illuminants.

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Резюме

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КҮЗДІК БИДАЙ (TRITICUM AESTIVUM L.) СҰРПЫН ЗЕРТТЕУ ҮШІН

СПЕКТРОСКОПИЯЛЫҚ ТАЛДАУДЫҢ БЕЙІМДЕЛУІ

ЖӘНЕ ЗИЯНКЕСТЕРМЕН КҮРЕС

Зертханалық шағылдырғыш спектроскопия – көптеген ғылым саласындағы қарапайым бағалау техникасы. Жұмыстың мақсаты – портативтік (ықшам) спектрорадиометрді егіс даласында, сондай-ақ зертханалық эксперименттер жүргізуде қолданылу қабылетімен таныстыру. Бұл зерттеуде ASD FieldSpec 3 Max спектрорадиометрі толқын ұзындығы 350-ден 2500 нм-ге дейінгі диапазондағы екі әртүрлі пішіндегі шағылдырғыш электромагниттік радиацияны талдауға қолданылды. Зерттеу күздік бидайдың жарыққа сезімтал қуат көзі элементтері спектрінің кейбір алдын-ала өзгеру нәтижелерін көрсетті және бұл жарық көзінің шағылдырғышына зиянкестерді алдап түсіруде жоғары рұхсат етілген қабылеті бар спектральдық тестілеудің қаеттілігіне назар аудартты.

Кілт сөздер: күздік бидай, шағылдырғыш спектроскопия, портативтік (ықшам) спектрорадиометр, электромагниттік радиация, жарыққа сезімтал көзі элементі.

Резюме

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АДАПТАЦИЯ СПЕКТРОСКОПИЧЕСКОГО АНАЛИЗА

ДЛЯ ИССЛЕДОВАНИЙ ОЗИМОГО СОРТА ПШЕНИЦЫ (TRITICUM AESTIVUM L.)

И БОРЬБЫ С ВРЕДИТЕЛЯМИ

Лабораторная отражательная спектроскопия – это обычная техника оценки во многих научных областях. Цель состоит в том, чтобы представить способности портативного спектрорадиометра, который может использоваться как для полевых, так и для лабораторных экспертиз. В этом исследовании спектрорадиометр ASD FieldSpec 3 Max использовался в двух различных формах, чтобы проанализировать отраженную электромагнитную радиацию в диапазоне длин волн от 350 до 2500 нм. Исследование представляет некоторые предварительные результаты изменений спектра светочувствительного питательного элемента озимой пшеницы и вызывает необходимость спектрального тестирования с высокой разрешающей способностью для заманивания насекомых при отражении источника света.

Ключевые слова: озимая пшеница, отражательная спектроскопия, портативный спектрорадиометр, электромагнитная радиация, светочувствительный питательный элемент.

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