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SPECTRAL REFLECTANCE OF RICE CANOPY AND RED EDGE POSITION (REP) AS INDICATOR OF HIGH-YIELDING VARIETY

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ABSTRACT:

Rice is the staple food in Iran. More than 80 percent of rice area is distributed in the two northern provinces of Mazandaran and Gilan, so that investment in increasing the quantity and quality can impact an effective role in economic independence and sustainable agriculture. Increased efficiency in rice production is possible through varietal technology, advances in yield enhancement, and the successful development of hybrid technology. Nondestructive methods such as study the spectral reflectance of rice fields is a reliable way in remote sensing study. In this study we tested the possibility to predict high-yielding rice varieties based on the spectral reflectance data in the red edge position (REP). Spectral reflectance of rice canopies from 350 to 2500 nm were acquired under clear sky in rice filed. The obtained results indicate that REP of Hybrid, Tarom, Neda and Khazar varieties are at longer wavelength, so they are predicted as more productive rice varieties.

1. INTRODUCTION

Remotely sensed data provide considerable potential for estimating agricultural area and yield forecasting at local, regional, and global scales (Kamthonkiat, et al., 2005; Xiao et al., 2006; Serra et al., 2007, Khajeddin & Pourmanafi, 2007; Ansari Amoli & Alimohmmadi, 2007). Estimation these information by remote sensing mainly depended on the spectral characteristics of field crops. Many studies using rice spectral reflectance data has been done to estimate its product and health condition at red edge region (Yang and Cheng, 2001; Xue, et al., 2004; Shen et al., 2007; Wang et al., 2008).

Some parameters such as chlorophyll content, nitrogen, LAI, biomass and relative water content were studied in the first derivative reflectance curve in the red edge region (Jago et al., 1999; Yoder and Pettigrew-Crosby, 1995; Skidmore and Mutanga 2007). This position is the point of maximum slope on the reflectance spectrum of vegetation between red and near-infrared wavelengths. Technically, the red edge is a spectral reflectance feature characterized by darkness in the red portion of the visible spectrum, due to absorption by chlorophyll, contrasting strongly with high reflectance in the NIR, due to light scattering from refraction along interfaces between leaf cells and air spaces inside the leaf (Bonham-Carter, 1988; Dawson and Curran, 1998, Tinetti et al., 2006). Field crop

reflectance actually was a kind of mixed reflectance, influenced not only by rice canopy but also by soil. Extraction REP which is based on derivative analysis minimizes interpolation errors and soil background effects and computationally, it is one of the simpler curve fitting techniques (Shafri et al., 2006).

Hybrid varieties have the potential to raise the yield of rice and thus overall rice productivity and profitability in the north of Iran. So this has led the public and private sectors to develop the use of hybrid rice technology in recent years. Successful deployment of using hybrid rice in sustainable management, however, requires information about the area and productivity of different rice cultivars. Spectral field reflectance could use in remote sensing data for accessing this information. The increase reflectance in the near infrared range and caused a shift in the position of the red edge toward longer wavelengths depend upon the productivity element in vegetation; have shown the most productivity of some cultivar rather than the other ones. The objectives of this study were to prepare the spectral fingerprint of most important rice cultivars of northern of Iran and study the red edge position related to high-yielding of different rice varieties.

2. MATERIAL AND METHODS

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This research was conducted in the rice research institute in Amol in the north of Iran. Spectral field measurements of seven different cultivars were acquired on different plots (Figure 1). A total of 76 spectrums from rice cultivars named Hybrid, Tarom, Neda, Nemat, Shiroudi, Khazar and Fajr (10–12 sample for each cultivars was measured) were analyzed. Figure 2 shows the crown canopy of each cultivar to be measured. A full range (350-2500 nm) portable spectroradiometer (ASD FieldSpec Pro FR) was used for spectral measurements. The field of view of optical sensor was 25 which positioned 30-40cm above the samples at nadir position. The measurements were conducted under clear sky between 10:00 and 14:00 local time in 27 August 2007. The noise spectra in water

absorption feature wavelength was removed based on standard deviation calculated of all reflectance values in each wavelength. The first derivative spectral curves calculated in Matlab software and the red edge position in this spectral range extracted based on the specified maximum slope.

$$FSD_\lambda = \frac{R_{\lambda+1} - R_\lambda}{\Delta\lambda}$$

FSD: First Derivative at λ wavelength

R: Reflectance

Figure 1: Spectral filed measurements of rice varieties

Khazar   Hybrid   Fajr

Shiroudi   Nemat   Neda

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Tarom

Figure 2: The canopy of seven rice variety to be measured

3. RESULT AND DISCUSSION

After spectral measurements, the result of performed processes on data was spectral curves at 2500-350 nm wavelengths. All the curves were quality reviewed and the noise spectra in water absorption feature were removed based on the standard deviation of all reflectance values in each wavelength. Figure 3 shows spectral characteristics of studied rice cultivars after necessary prepossessing. The first derivative Curve in the range of red edge wavelengths calculated (Figure 4) and the highest value obtained in this range as the maximum possible slope is determined as the red edge position for each of the seven cultivars (Fig. 6). Based on these results, the red edge position of the hybrid cultivar was the highest wavelength (724 nm) than the rest of rice cultivars. REP of Tarom, Khazar, Neda was at 716 nm while for Nemat, Shiroudi and Fajr were determined at 700, 694 and 694 nm, respectively (Figure 5). The results showed that Hybrid variety was the most likely variety than the others and has the highest chlorophyll and nitrogen concentrations inverse Shiroudi and Fajr variety based on spectral characteristics.
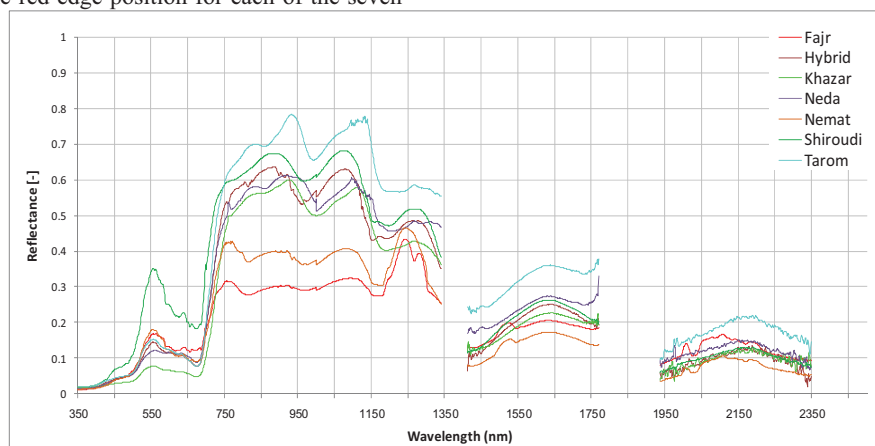

Figure 3: Spectral reflectance curves of seven rice variety of north of Iran

Red edge region are relatively insensitive to changes of biophysical factors such as soil cover percentage, optical properties, canopy structure, atmospheric effects, irradiance and solar zenith angle (Shafri et al., 2006; Clevers, 1999 and 2000), therefore this region is a reliable range to investigate the biochemical variables form canopy reflectance. The obtained Results from literatures proved the Relationship between chlorophyll and red edge position so that with increasing chlorophyll and nitrogen concentration the REP moves towards the longer wavelengths (Boochs et al, 1990 ،Curran et al., 1990 ؛ Fillella and Penuelas 1994; Shafri et al., 2006). The obtained results by Nemat Zade and Sattari (2003) also Allah Gholipour (2007) show that Hybrid variety is a high-yielding variety equal to 25-20% times than the other variety in this study. REP of Hybrid rice that positioned at longer wavelength could indicate more chlorophyll/nitrogen concentration and leaf area index, rather than the other varieties. Mutanga and Skidmore (2007) studied the relationship between REP and nitrogen content of grass vegetation. They indicated that nitrogen content correlated well with wavelength at 713nm and 725 nm as determined REP.

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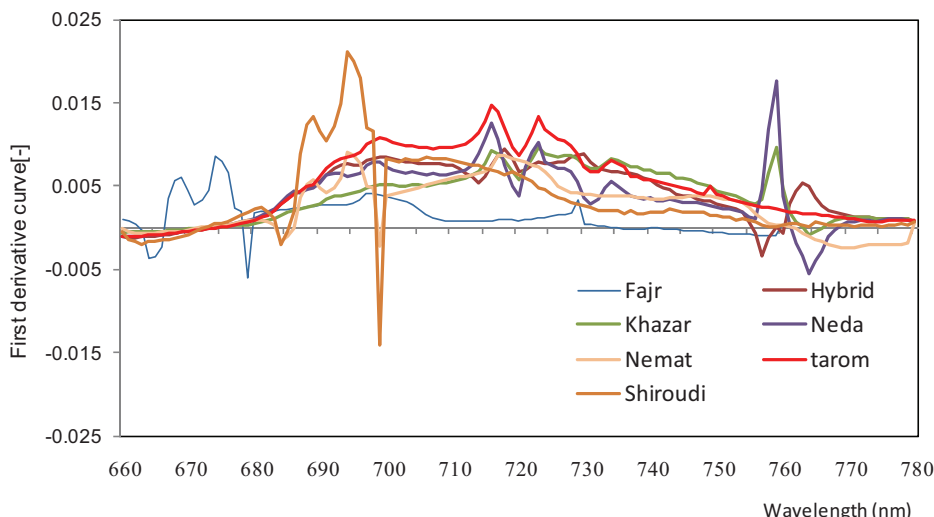Contents   Author Index   Keyword Index

Figure 4: The first derivative spectral reflectance curves of seven rice varieties at red edge region (660-780 nm)
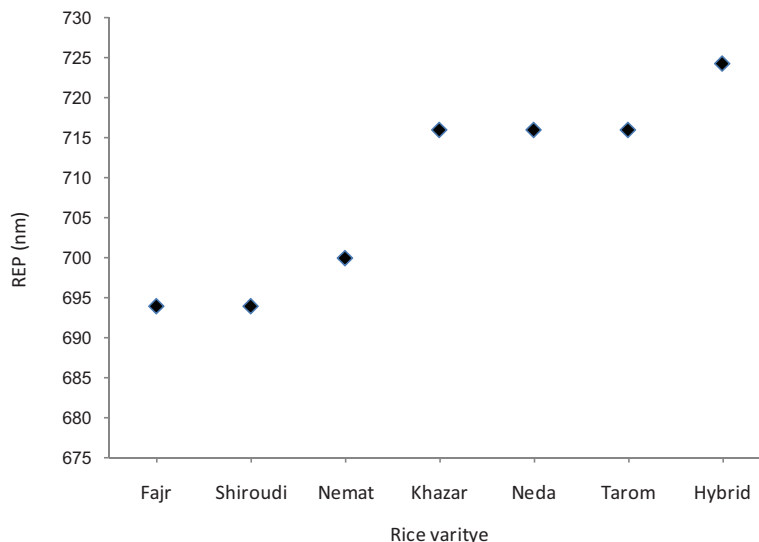
Figure 5: Red edge position (REP) obtained for each rice variety

4. CONCLUTIONS

Compared to traditional methods for indicating high-yielding rice variety and monitoring their filed area using remote sensing is quicker, exact, and more comfortable, especially on a large scale. Field spectroscopy can provide reliable information for applications of airborne or spaceborne remote sensing with data support and pertinent correction reference on the basis of spectral analysis, shifting distance of red edge position.

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