Detection of soybean varieties through remote sensor non-image hyperspectral

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Abstract. The main objective that guides this research is the characterization of the spectral behavior of each soybean variety at laboratory level (spectroradiometer in the range 350-2500 nm). The study area is located in the municipality of Deodápolis, state of Mato Grosso do Sul. Spectral readings for each swatch soybean were made in model spectroradiometer FieldSpec 3 JR, which performs measurements in the spectral range of 350 nm to 2500 nm. Spectral reading of each sheet was used the equipment ASD Plant Probe. Spectral readings were repeated 3 times in the same plant varieties for BMX Potência (I), NA5909 (II) FT Campo Mourão (III) and Don Mario (IV). The drop in reflectance is associated with absorption by leaf pigments, mainly by chlorophyll. In the blue spectral region, the absorption occurs near the wavelength of 445 nm and is linked to the presence of xanthophyll pigments, carotenes, chlorophylls α and β; in the red region only chlorophyll acts by absorbing energy around 645 nm. In the near infrared range (NIR) of 700 to 1300 nm, an increase in reflectance values close to 50% due to the internal structure of the sheet (size and shape of the cells and the amount of intercellular spaces). From this point on, up to 2500 nm (infrared medium - IVM), there is a gradual decrease in reflectance showing some features of absorption by the liquid water content. The analysis of the spectral curves of soybean varieties allowed the characterization as the basis of several key points reflectance.

Palavras-chave: cultura agrícola, curvas espectrais, espectrorradiometria, crop, spectral curves, spectroradiometry.

1. Introduction

In Brazil, agricultural crop forecasts are made through subjective data collected in municipalities, such as opinions of technicians and development agents, such as financing agencies, selling inputs and seeds, and information from the farmers themselves (IBGE, 2002). Thus, these estimates can´t be evaluated in terms of precision because there is no error associated with them. When it comes to soybean varieties, this verification is still practically verified only locally and its evaluation by sensed techniques is still scarce.

The importance of remote sensing is evident in this area, since timely information on the extent, phenological conditions, knowledge of varieties and the potential of crop production can establish strategies of action for marketing, regulation of strategic inventories and royalties, which makes it of great economic importance for a country (Chen, 1990). Since the cost of traditional field measurement techniques is expensive because it requires a lot of time and specialized manpower for large areas, the use of remote sensors becomes an alternative (Thenkabail et al., 1994).

In Brazil, the monitoring of the agricultural areas by means of orbital images is of great utility (Silva Junior et al., 2016), considering its territorial extension and enormous diversity of cultures, as well as the occurrence of regions of constant development. Studies on soybean cultivation can be confirmed around the world, addressing issues such as discrimination and quantification of areas (Silva Junior et al., 2014), identification of phenological stage (Sakamoto et al., 2010), productivity Chlorophyll (Peng and Gitelson, 2012), among others.

Thus, the main objective of this study is to characterize the spectral behavior of each soybean variety at the laboratory level (spectroradiometer in the spectral range from 350 to 2500 nm).

2. Material and Methods

The study area is located in the municipality of Deodápolis, southern region of the state of Mato Grosso do Sul, based on the geographic coordinates 21°00' to 24°00' latitude south and 52°00' to 55°'00 longitude west, Being composed of four areas with different soybean varieties implanted (Figure 1). Its average altitude is of 418 meters having as reference the mimeograph of Imbituba.

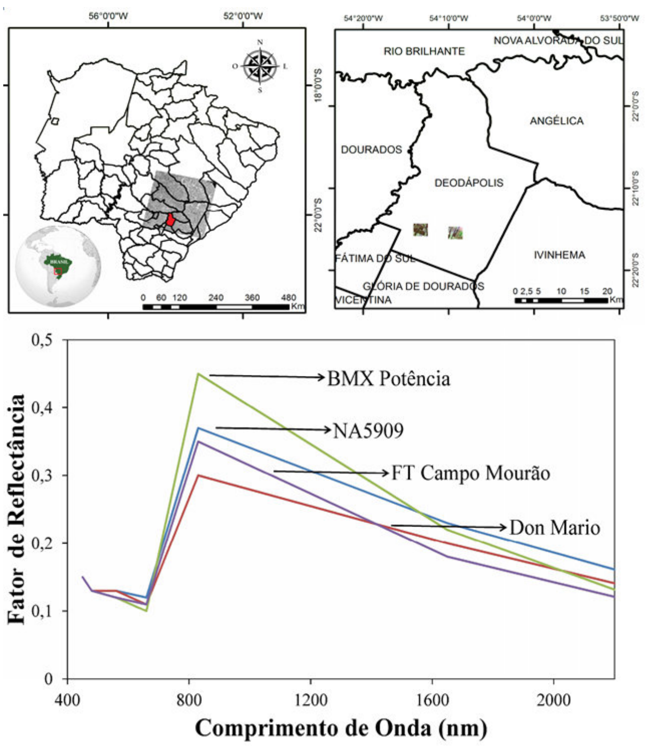

Figure 1. Study area concentrated in the four soybean plantations with different varieties, arranged by the OLI/Landsat-8 sensor spectral curve.

The spectral readings of each soybean leaf sample were made on the FieldSpec 3 JR spectroradiometer ASD, which performs spectral measurements in the range of 350 nm to 2500 nm (Figure 2a). The reading range is 1.4 nm in the range of 350 nm to 1050 nm and 2 nm in the range of 1000 nm to 2500 nm. Its spectral resolution is 3 nm in the spectral range from 350 nm to 700 nm and 30 nm in the range of 1400 nm to 2100 nm. In the spectral reading of each leaf, the ASD Plant Probe was used (Figure 2b), used for purposes of sheet measurements, its main characteristic being the non-destructive method and without interference of the reading room luminosity, it has a length of 25.4 cm, weight 0.7 kg and lamp 6.5 W. The ASD Plant Probe is designed for spectral contact measurements of solid raw materials. By means of this accessory, it is possible to minimize errors associated with diffuse light allowing also the analysis of samples through transparent plastic bags.

ISBN: 978-85-17-00088-1

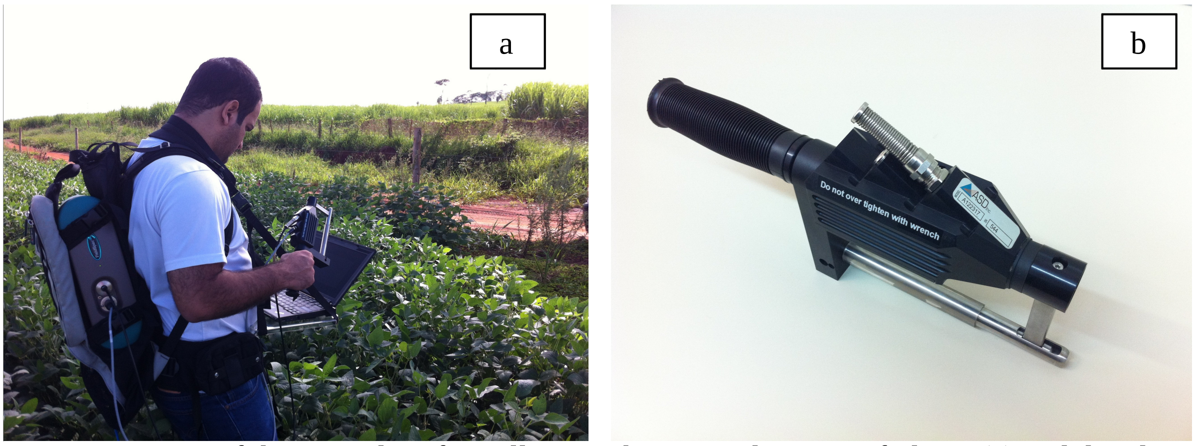

Figure 2. Overview of the procedure for collecting the spectral curves of plants (a) and detail of the ASD Plant Probe (b).

The spectral readings were repeated 3 times in the same plant for the BMX Potência (I), NA5909 (II), FT Campo Mourão (III) and Don Mario (IV) varieties on 30 and 31/01/2014. The data used in the work discussions were based on the average of the 3 readings for each sample.

The phenological stage of soybean cultivation of the four varieties was found in reproductive 5 (R5) with 80 days after germination, that is, in full physiological development with beginning of seed filling.

A white plate of the apparatus itself which reflects 100% of the light beam was used as the reference standard. The spectral data of this plate were stored by the system for further determination of the reflectance factor of the samples, which was multiplied by the readings obtained from each of them. In total 2,400 spectral readings of the vegetation were obtained. With this factor, graphical representations were produced, that is, spectral reflectance curves.

The intervals between inflections, curved and concave portions present in the mean curves of all soybean varieties studied were separated. In addition to the average range, the wavelength characterized by a strong inflection was also used (Figure 3).

The bands described in Figure 3 show the means of representative wavelength intervals and sharp inflection points which are representative of elements known as phototropism, a and b carotene and water, for example.

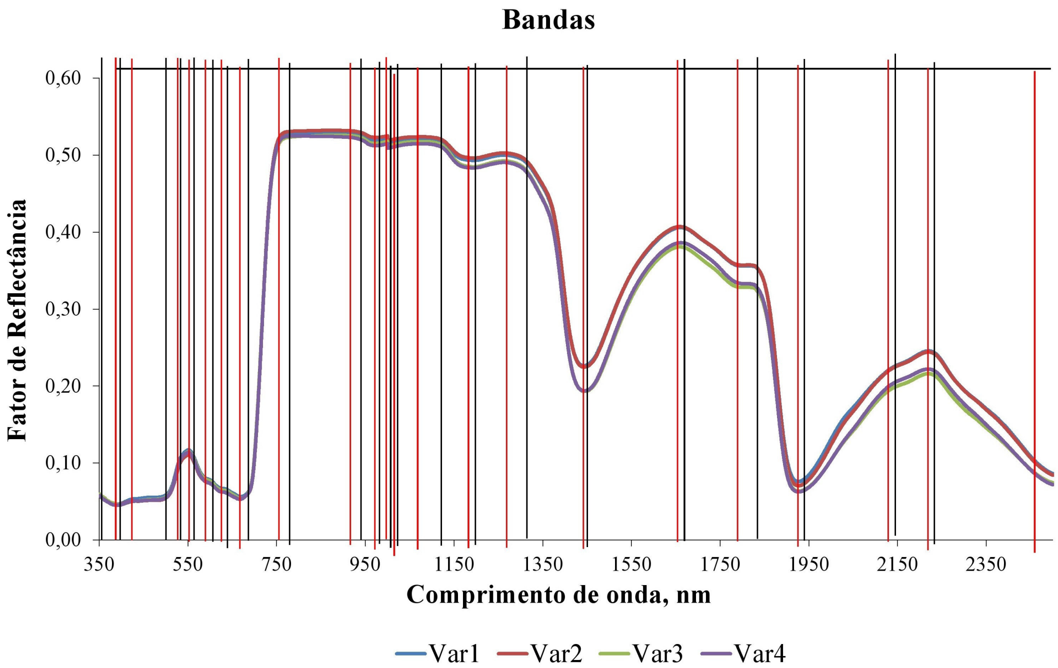

Figure 3. Bands with higher spectral representativity defined for the analyzes of the soybean varieties, in which: BMX Potência (Var1), NA5909 (Var2), FT Campo Mourão (Var3) and Don Mario (Var4).

After selecting the bands, the Statistical Analysis System (SAS, 2001) was used. The data matrix used in the statistical analysis was formed by 2150 wavelengths (350-2500 nm) of the reflectance factor, for the four soybean varieties. In order to establish the predictor variables that would best separate the varieties, the STEPDISC (SAS) procedure was initially used at the 5% probability level to select among the 2150 wavelengths, the ones that were most significant for generating the mathematical model. After this procedure, with the wavelengths selected, the following step was carried out for differentiation and characterization of the varieties studied. In this step, the discriminant analysis was carried out, with the objective of developing and validating the method for determining the variety from its spectral data. In this procedure, the evaluated variety is a function of its spectral response, that is, of the selected bands.

The set of data selected were composed of different bands, obtained from the different wavelengths. Each set was submitted to principal component analysis (PC) to verify their ability to discriminate soybean varieties and the relationship of each variable in each set with the varieties.

The PC analysis is a multivariate method that consists in transforming a set of p original variables X1, X2, ..., Xp belonging to individuals or populations into a new set of variables, Y1, Y2, ..., Yp of dimension, called main components. Each PC is a linear combination of the original variables, constructed in such a way as to explain the maximum of the total variability of these original and uncorrelated variables.

3. Results and Discussion

Spectral curves obtained by in situ spectroradiometry showed specific absorption bands very similar to both soybean varieties and can be observed in Figure 4.

It is observed in Figure 4, the spectral behavior of the leaves referring to the studied varieties. Similar to the results obtained by Moreira (2011), in the study of green leaf spectral response, it was found that in the wavelength range of 400 to 700 nm (visible range - VIS #1) the reflectance is low, in order of 10%, with a gentle increase of the response in the region of green (550 nm).

ISBN: 978-85-17-00088-1

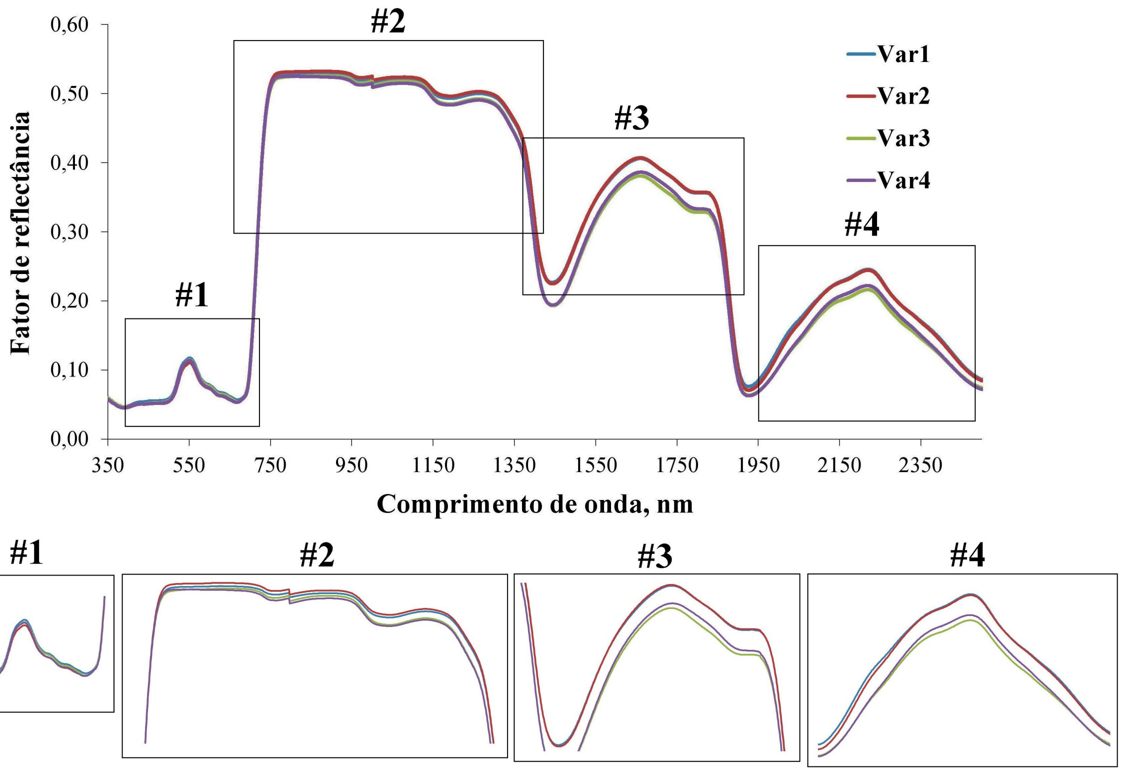

Figure 4. Spectral curves obtained in loco by means of a spectroradiometer of four soybean varieties in the municipality of Deodápolis (MS), where: BMX Potência (Var1), NA5909 (Var2), FT Campo Mourão (Var3) and Don Mario (Var4).

The decrease in reflectance is associated with absorption by foliar pigments, mainly by chlorophyll. In the spectral region of blue, absorption occurs in the vicinity of the wavelength of 445 nm and is associated with the presence of xanthophyll, carotene, chlorophyll *a* and *β* pigments; in the red region only chlorophyll acts, absorbing energy around 645 nm. In the near infrared range (IVP #2), from 700 to 1300 nm, reflectance increases to values close to 50% due to the internal structure of the leaf (cell size and shape and the amount of intercellular spaces). From this point on, up to 2,500 nm (mean infrared - IVM #3 - #4), there is gradual decrease in reflectance showing some absorption characteristics by the liquid water content.

In the first moment the model was tested in a way where all the individuals that served to generate this model were also used for the evaluation of the same. The data presented below, in Table 1, demonstrate the results obtained in this test after the fifty repetitions of the simulation. It was observed that the BMX Potência variety showed the highest percentage of accuracy reaching 25.24% for the observed values and 24.64% for the estimated values. However, all studied soybean varieties were adequately separated according to their spectral signatures, with values close to 25%, in which a total of 100% of the results represented each variety studied.

Table 1. Results obtained through simulated discriminant analysis with data used in the model (60%), using more populous classes.

Testing with Data Used in the Model					
Variety	**Var1**	**Var2**	**Var3**	**Var4**	**Total**[1]
BMX Potência (Var1)	6043[2]	0	0	0	604[3]
	25,24[3]	0,00	0,00	0,00	25,24[4]
	100,00[5]	0,00	0,00	0,00	
	99,90[6]	0,00	0,00	0,00	
NA5909 (Var2)	3	6033	0	0	6036
	0,01	25,20	0,00	0,00	25,21
	0,05	99,95	0,00	0,00	
	0,05	99,52	0,00	0,00	
FT Campo Mourão (Var3)	0	29	5815	85	5929
	0,00	0,12	24,29	0,36	24,76
	0,00	0,49	98,08	1,43	
	0,00	0,48	99,59	1,42	
Don Mario (Var4)	3	0	24	5908	5935
	0,01	0,00	0,10	24,68	24,79
	0,05	0,00	0,40	99,55	
	0,05	0,00	0,41	98,58	
Total[7]	6049	6062	5839	5993	23943[9]
	25,26[8]	25,32	24,39	25,03	100,00

[1]Full frequency in the line; [2] Frequency in relation to class; [3] % of the frequency in relation to the total; [4] % of the line frequency in relation to the total; [5] % frequency on the line; [6] % of frequency in the column; [7] Total frequency in the column; [8] % of the frequency in the column in relation to the total; [9] Total frequency for classes.

Regarding the main component, the accumulated variance in the first two components for the fifth set of data was 81.50% (Figure 5). From the PC analysis applied to the wavelength data it was possible to observe considerable distance between the varieties.

Based on Singh (1981) criteria, the bands between B1 and B23 did not contribute to the discrimination of soybean varieties. The bands B26 (55.41%) and B28 (35.14%) were the most important in the identification of the soybean genotypes evaluated.

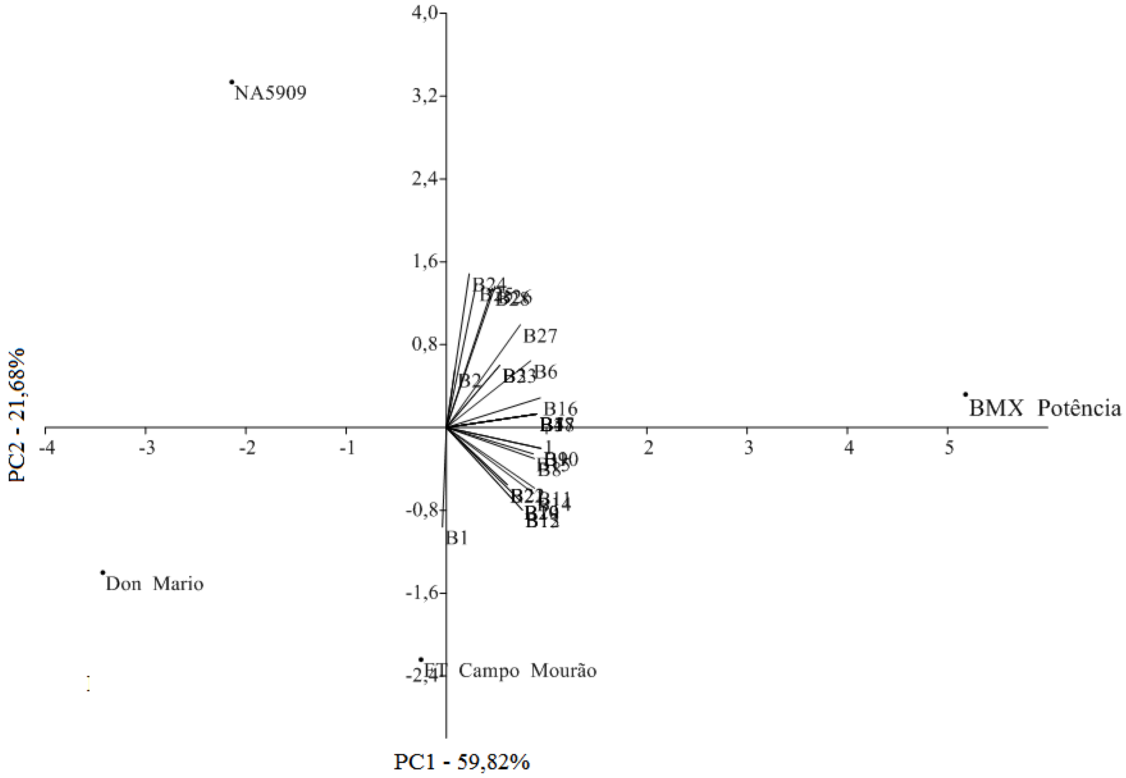

Figure 5. Analysis of major components between soybean varieties and the bands.

4. Conclusion

The analysis of the spectral curves of the soybean varieties allowed the characterization of the same ones based on several key points of reflectance;

The discrimination of soybean varieties was efficient and presented significant results when using the hyperspectral terrestrial sensor.

Acknowledgements

To the National Council for Scientific and Technological Development (CNPq) for the grant of the doctoral scholarship of the first author (140999/2014-0). To the Financier of Studies and Projects (FINEP) by the covenant of the spectroradiometer (01.09.1567.00).

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