Characterization of *Diatraea saccharalis* in Sugarcane (*Saccharum officinarum*) with Field Spectroradiometry

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Abstract— *Applications of remote sensing in agriculture have increased in recent years, especially for the development of sensors with better spatial and spectral resolutions. The objective of this study was to assess and evaluate the spatial and spectral variability of infection Diatraea saccharalis of sugarcane (Saccharum officinarum) through optical sensors in the Huasteca, Mexico. The methodology consisted in to make in situ measurements with a hyperspectral spectroradiometer in areas with and without apparent damage by the plague. For spatial and scaling representation Landsat 8 images were used. The data obtained in the field showed the spectral behavior of the plague; and the space-spectral reflectance variation was made by visibles and infrared bands for the vegetation. This process is an important approach to take a look from the geographical point of view to the problems related to the risk assessment of plague and diseases, their incidence, spread and severity, as well as support for sampling and monitoring activities. The used of these technologies provides advantages in research and in the implementation of precision farming techniques.*

Keywords— Remote sensing, Spectroradiometry, Diatraea saccharalis, Saccharum officinarum, NDVI

I. INTRODUCTION

The incorporation of Remote Sensing (RS) in agronomy studies has increased over the last 10 years due to the development of sensors with better spectral and spatial resolutions, using the spectral information to describe the variation in space of vegetation or landscape [1], [2]. The use of RS is effective, fast, non-destructive, and accessible in operational and accurately; provides information of large areas during a growing season on numerous occasions to detect changes in physiological and biochemical processes of plants, even with water, nutritional or derived from pests, weeds and disease stress. Also identify species, determine the state of health and plant vigor, crop inventorying, analyzing the structure of the canopy, all in a wide range of scales. That is, the use of RS to optimize agricultural practices as a function of the spatial and temporal variability within fields, through methods capable of recovering with biophysical variables level accuracy canopy registered by the reflectance [3], [4].

The use of RS in agriculture has also specialized particularly hyperspectral, since the length of electromagnetic wave detail in terms of the specific position of the absorption bands, spectral form, spectral variability and similarity or differentiation is seen other vegetation [5]. These sensors, known as spectroradiometers field, are used to obtain spectral signatures *in situ*, that strengthen the quality of the spatial and temporal analysis; in these optoelectronic systems, the radiance received by the optical components is decomposed into a continuous band of hundreds, which offers a potential improvement in crop assessment [6]. The importance of these portable field sensors lies in the pure obtaining the spectral signature of the measured object, which can be correlated with data from satellite sensors, and if they are equal and simultaneous, you can generate a spectral labeling within the image systematization help automatic pixels from training to differentiate characteristics in crops of the same area [7]. The organization and integration of these firms may be based on the construction of spectral libraries that can account for the variability between plant species, and discrimination between healthy (or no apparent damage) and nutritional deficiencies vegetation. In this regard, [5] reported that there are few relevant studies on the development of spectral libraries for the differentiation of crops and their possible deficiencies and diseases.

The use of RS in studies of sugarcane cultivation has been implemented in numerous ways, mainly because of the economic importance of culture and its spatial distribution is generally symmetrical and uniform. Some of the applications are classification and mapping of sugarcane, identification of phenological stages and growing degree days, discrimination of varieties, monitoring of irrigation and nutritional stress, detection of damage by insects and diseases, predicting yields and management of crop residues. In all cases, applications that have been implemented are aimed at increasing productivity (yields and crop quality) with reduced production costs for increasingly competitive markets [8], [9].

According to [10] there are three types of limiting factors on productivity of sugarcane: physiological (phenology, canopy, cell characteristics), environmental (water CO2, radiance, climate, soil fertility.) and agronomic (weeds, pests, diseases, toxicity). Of these, the constraints that most affect productivity are those relating to edafoecological characteristics (32.2%) and management in the management of pests and diseases (20.3%) [11]. The latter process has affected crop cane sugar level vegetative stress, where the spectral response is caused by biochemical cellular level and sheet changes, which in turn have an influence on the pigment systems and content humidity. On the other hand, stress can cause changes in the structure of the coverage, the leaf area index (LAI) and biomass [12].

Detection of health of vegetation depends on the relationship between changes of intense red and infrared reflectance and absorption of photosynthetically active radiation (APAR) of the surface of the vegetation [13]. Damage caused by diseases and pests can be measured by changes in chlorophyll content of plants, which can be analyzed for changes in patterns of spectral images taken by satellites. These techniques using multispectral images to identify areas under stress. [14] and [15] they showed that the normalized difference vegetation index (NDVI) was the parameter that showed better correlation in evaluating the health status of crops.

It is known that many diseases and pests cause changes in leaf pigments in the biochemical components and generate metabolic alterations in infected leaves [16]. These pathological conditions of the plant may influence their spectral characteristics of the leaf tissue and can be detected in the visible and / or near infrared (NIR) of the spectrum. In fact, the visible and infrared regions are known to provide the maximum of information on the level of physiological stress in plants [17]. Therefore, the difference in spectral reflectance between healthy (or without apparent damage) culture and one affected by a disease or pest, used to diagnose the health of the plant [18].

The study on the space-time reflectance variation of solar radiation in the visible bands, infrared and vegetation index are important approaches to analyze geographically related problems risk assessment of pest and disease incidence, spread and severity, as well as to support the activities of sampling and monitoring are carried out to protect the cultivation of sugarcane. Therefore, the aim of this study was to characterize the damage caused by *Diatraea saccharalis* through the analysis of spectral signatures using spectroradiometry field and satellite imagery, as an input in the early detection of the problem plant sugarcane in the Huasteca region, Mexico. The hypothesis raised refers to the use of remote sensing, both satellite and field can be important tools for recognition and characterization of damage caused by pests and diseases in sugarcane, becoming a Space input to help generate regional action plans for environmentally sustainable and more economical management, and enhancing decision-making field technicians. The use of these technologies has advantages in both research and the implementation of precision farming techniques, and while your applications continue to be studied in more developed countries, Mexico has not been able to establish a synergy with conventional jobs country. There disinterest in modeling sugarcane using active optical sensors, and sugarcane area Huasteca, not available a tool to characterize the problems associated with the production of sugar cane and has not generated a methodology remote sensing in order to establish spatial and quantitative aspects relevant as the area occupied by sugarcane cultivation, the productivity level areas supply the mills and farms, the estimated yield of sugarcane and recognition of pest or diseases.

II. MATERIAL AND METHOD

The cultivation of sugarcane is of great economic importance in Mexico, both the area planted and the amount of monetary resources operated, and the economic benefit involved. The state of San Luis Potosi is third in acreage with 8.7% (71.725 ha) of the national total. The average yield of the harvest field in 2013-2014 was 69.5 Mg ha-1 with a production value of 150 million dollars equivalent to nearly 5 million tons harvested [19]. The sugarcane area of San Luis Potosi is located between the extreme coordinates 21º41' - 23º4'N and 97º59'- 99º29'W. One of the main problems is the entomological borer sugarcane *Diatraea saccharalis* and presence occurs almost all year, but the highest incidence is reported from November to May [20], [21]. The study period was between 2 and 28 February 2012 at two sites in Figure 1: Rancho Rioverdito in the Plan of San Luis sugarmill (A) and the common La Marina in Plan de Ayala sugarmill (B). Measurements were made in leaves with apparent damage *D. saccharalis*, who had a level of wilting and/or yellowing (dead heart) stem with evident presence of tunnels and galleries. Measurements in sugarcane leaf were also no apparent damage borer within the same plot. For validation, GPS control points were taken in the presence of the pest. He tried to avoid heterogeneity in sampling, so all readings were made on the variety of sugarcane RD 75-11 and edafoecological both sites had similar characteristics.

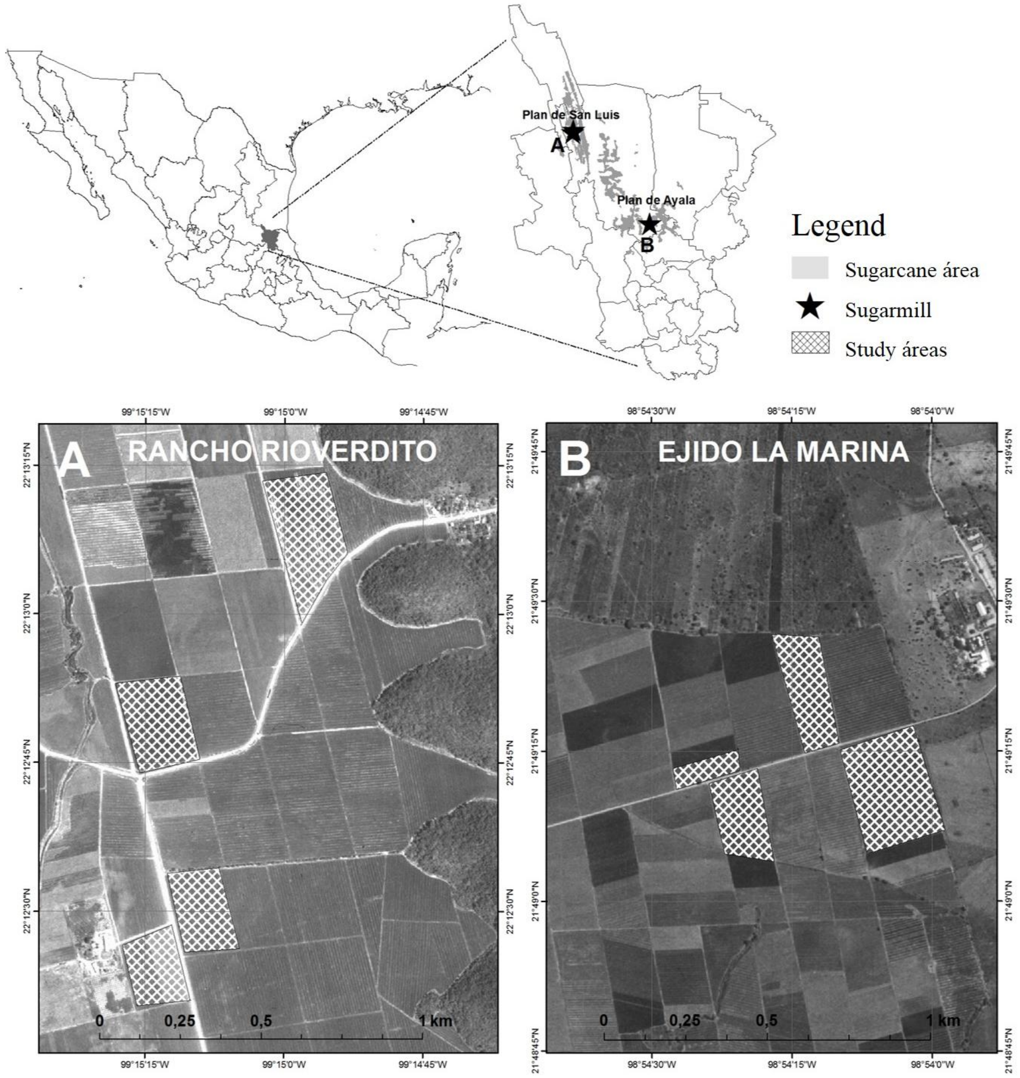

FIGURE 1: STUDY AREA

The *in-situ* measurements were made with a portable field Spectroradiometer GER-1500 (Spectral Vista Corporation) model that covers a spectral range of 350-1050 nm, (UV, visible and near infrared) to 512 separate bands, a spectral accuracy ± 2 nm. Five readings per sample point, where the spectroradiometer nadir moved into position at a distance of 0.3 m from the sheet, covering a field of view of 4 ° (0.02 m^2) were taken. The instrument was calibrated and optimized before each reading, using a portable panel with silicon diode array reference target whose spectral reflectance is characterized accurately [22]. Measurements were made on clear days (free of cloudiness) between 10:00 and 15:00, in order to minimize the effect of variation of solar radiation incident position. The data obtained are lowered and imported into a spreadsheet, were ordered by wavelength in ascending and calculation between reflectance data of the object (reed leaves) and laptop data panel was made in order to obtain the spectral coefficient.

To scale the information gathered in the field, the Normalized Difference Vegetation Index (NDVI), which detects the plant stress and changes during crop growth due to the effect of pests or diseases [23], [14]. This index, according [24] is designed to highlight the properties of vegetation through standardized near-infrared reflectance (730-805 nm) and red visible difference band (580-680 nm).

III. RESULTS AND DISCUSSION

An area of 37.6 ha were sampled (19.97 ha in Rancho Rioverdito and 17.63 ha in La Marina), where 800 measurements in situ, 400 records for both sites (200 on sugarcane affected by *Diatraea saccharalis* and 200 in cane without damage were obtained apparent). In Figure 2-A, Rancho Rioverdito, the spectral signature of damaged leaves *D. saccharalis* showed higher percent reflectance that leaves no apparent damage visible regions; in the red band (600 - 700 nm), almost no separation 15%, being affected by the *D. saccharalis* blade which has greater reflectance and the green band (500 - 600 nm) there is a separation of 12% reflectance, which shows the measures yellowing plants. Values in infrared (> 700 nm) spectral signature with the damage is below the signature without apparent damage. These data are consistent with those presented by [24 - 26] indicating that stressed vegetation has a lower percentage of reflectance in the Near Infrared (NIR) and superior in the visible, particularly in the red and green reflectance, which indicate that the energy absorbed by the plant not sufficient to properly complete the photosynthesis.

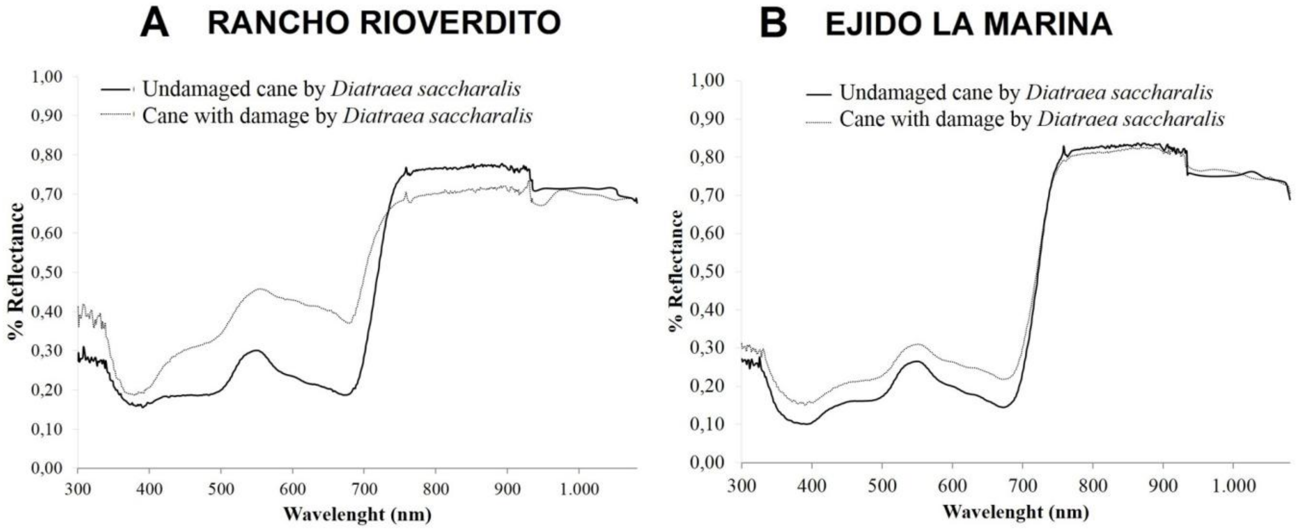

FIGURE 2: SPECTRAL SIGNATURES OF SUGARCANE DAMAGE IN RANCHO RIOVERDITO (A) AND COMMON LA MARINA (B)

In Figure 2-B, common La Marina, the spectral signature cane leaf without apparent damage it is similar to that reported by [27] visible under 10% reflectance, slightly higher in the green band, while near-infrared is greater than 80% reflectance region. Unlike plant affected by pest, which has a spectral behavior very similar to Rancho Rioverdito where the amount of reflected power is greater in the visible, but similar to the NIR regarding behavior leaves no apparent damage.

From the spectral signatures, the data used in the visible and NIR spectral classification for over a Landsat 8 OLI_TIRS image dated February 13, 2013 with a spatial resolution of 30 m. As indicated [27] scaling radiometric data through Landsat is no need for spatial resolution, but it is in terms of spectral resolution. In this sense, the use of NDVI was made from data calculated by the field measurements and scaling was based on these calculations. Figure 3 shows the results of that operation, where most widespread classifications were made in the Rancho Rioverdito as much cane borer, this due to the small difference between the spectral signatures (pest-plant). The area affected by borer calculated based on the classification was 68.5% of 19.97 hectares measured, being the two largest parcels which were almost entirely affected by the plague. In the common La Marina, the classification is more defined and boundaries between healthy cane and plants affected by the plague difference. In total 43.7% of the monitored area (17.63 ha.) Was rated borer damage. In both cases, there are plots of sugar cane that could be classified, this spectral difference given by the variety, age and crop management.

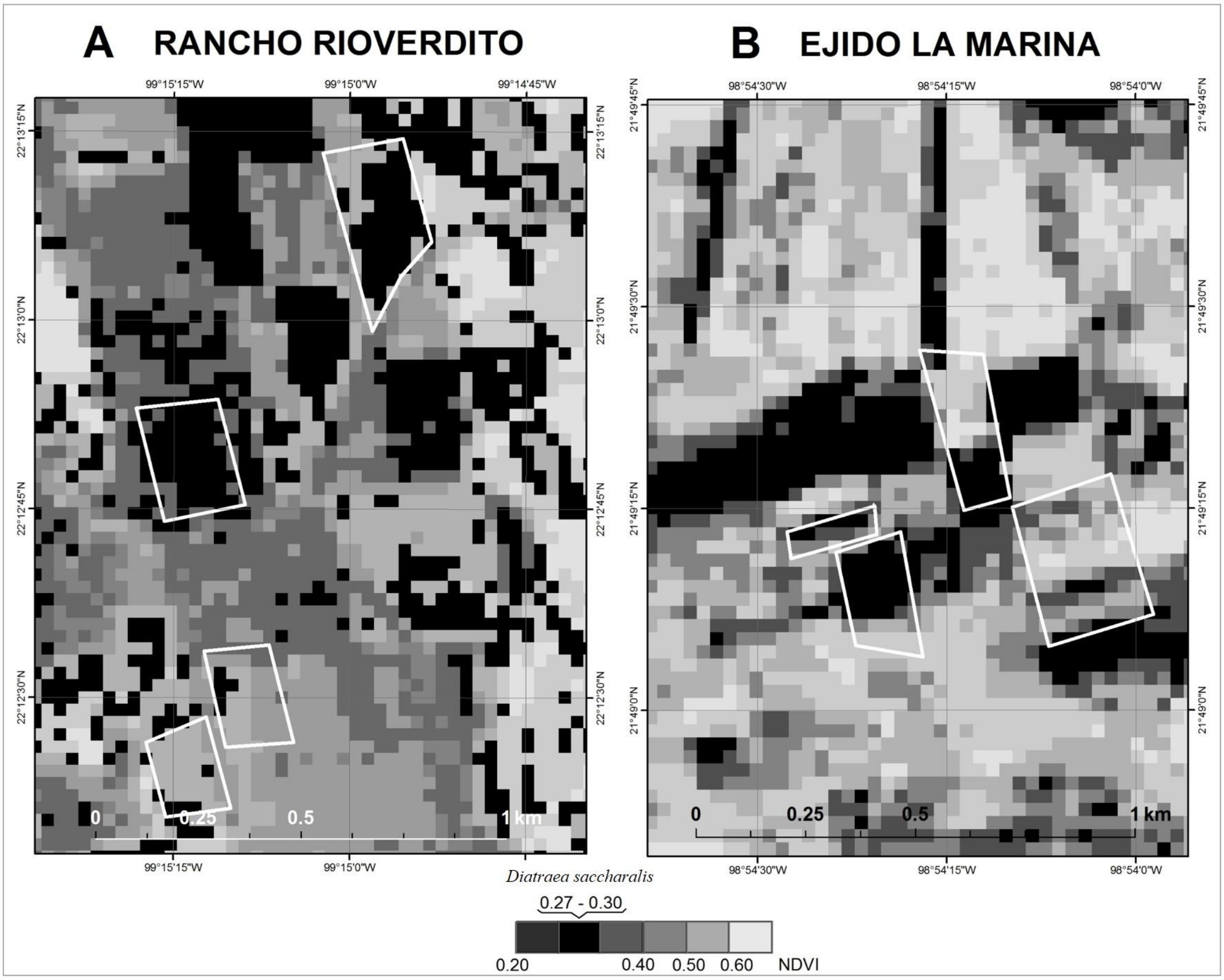

FIGURE 3: SATELLITE IMAGE CLASSIFICATION BASED ON SPECTRAL INDICES.

For the reliability of the classification made with the Landsat satellite images, a confusion matrix was performed, based on 40 points at random, near the monitored plots, where 13 of these points were areas without apparent damage by borer and 17 damage by the pest. Matrix shows that the methodology used to differentiate without apparent damage affected areas in an 82.5% effective. The total reliability is based on both sites, where an effectiveness of 79.8% was taken into the classification made at Rancho Rioverdito, while in the common La Marina was held effectiveness of 85.5% (Table 1).

TABLE 1: CONFUSION MATRIX FOR CLASSIFICATION OF SATELLITE IMAGES AND THE HYPERSPECTRAL DATA ACQUIRED IN FIELD

		FORETOLD	
		TRUE	FALSE
OBSERVED	TRUE	14	3
	FALSE	4	9

IV. CONCLUSION

The use of satellite images and field Spectroradiometer can help detect areas affected by pests, mainly to directly or indirectly damaging to the leaves of the plant sugar cane. In that sense, the spatial analysis the applicability of geotechnologies is supported in the agricultural sector and scope that can be performed in short periods of time covering a large area of cultivation is demonstrated. For diseases such as sugarcane borer, improved techniques spectroradiometry field and scaling to satellite images give rise to the starting point to convert the traditional plant model in a model of precision.

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