REVIEW

Multispectral Image Processing to Assess Sugarcane Nitrogen Needs

Procesamiento de imágenes multiespectrales para evaluar necesidades de Nitrógeno de caña de azúcar

https://cu-id.com/2177/v33n1e08

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ABSTRACT: Population growth has led to an exponential demand for agricultural products, to meet this demand it is necessary to improve management and achieve efficient use of resources without compromising the sustainability of ecosystems, particularly agricultural ones. One of the technologies that facilitate these tasks is precision agriculture (PA), which focuses on the optimization of resources and inputs based on the compilation of precise and timely geo-information of variables of agricultural interest with high spatio-temporal variability, obtained through remote sensors of three types: images captured by satellites or airplanes, images obtained from manned and unmanned aerial vehicles (UAVs) and specific information with sensors mounted on machinery or in the field. These limitations were overcome by using multispectral images, which has increased applications for agricultural purposes. Currently, multispectral images allow quantifying soil moisture, monitoring the presence of droughts and the degree of crop water stress, estimating the temporal and spatial variability of evapotranspiration, monitoring phenology, detecting nutritional deficiencies, estimating the degree of weed infestation. and insects, calculate organic carbon and soil salinity, and estimate yields and agricultural production. The use of geospatial technologies in the PA has changed the paradigm of agriculture and today constitutes a viable alternative to face the challenges that food production demands in a world with high climate variability.

Keywords: Agricultural Products, Demand, Variability, Spatiotemporal, Images, Multispectral.

RESUMEN: El crecimiento poblacional ha derivado en una demanda exponencial de productos agrícolas, para cubrir esta demanda se requiere mejorar la gestión y lograr un uso eficiente de recursos sin comprometer la sustentabilidad de los ecosistemas, en particular los agrícolas. Una de las tecnologías que facilitan estas tareas es la agricultura de precisión (AP), que se enfoca en la optimización de recursos e insumos basado en la compilación de geo información precisa y oportuna de variables de interés agrícola de alta variabilidad espacio-temporal, obtenida mediante sensores remotos de tres tipos: imágenes capturadas por satélites o aviones, imágenes obtenidas desde vehículos aéreos tripulados y no tripulados (VANT’s) e información puntual con sensores montados en maquinaria o en campo. Estas limitantes se superaron al usar imágenes multiespectrales, lo que ha incrementado las aplicaciones con fines agrícolas. Actualmente, las mágenes multiespectrales permiten cuantificar la humedad del suelo, monitorear la presencia de sequías y el grado de estrés hídrico de cultivos, estimar la variabilidad temporal y espacial de la evapotranspiración, dar seguimiento fenológico, detectar deficiencias nutricionales, estimar grado de infestación de malezas e insectos, calcular carbono orgánico y salinidad del suelo y estimar rendimientos y producción agrícola. El uso de tecnologías geoespaciales en la AP ha cambiado el paradigma de la agricultura y hoy en día constituye una alternativa viable para afrontar los retos que demanda la producción de alimentos en un mundo con alta variabilidad climática.

Palabras clave: productos agrícolas, demanda, variabilidad, espacio-temporal, imágenes, multiespectral.

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Received: 10/01/2023
Accepted: 09/12/2023

INTRODUCTION

Precision Agriculture (AP). Variability and efficiency

Agricultural producers need to efficiently exploit their plots with the aim of obtaining the highest possible profitability by optimizing inputs. Thanks to technological evolution, the agricultural sector can benefit from useful systems to apply on different farms, although innumerable techniques are still available. in development depending on the geographical area where the exploitation is located.

These techniques that help producers manage their farm must be adapted to the possibilities of each plot, according to the characteristics of the crop, the available land, and the costs that can be addressed. To implement these new technologies, a change of mentality on the part of the producer is necessary, since, in general, producers refuse to abandon the traditional techniques to which they are accustomed to adopt new, more modern techniques; However, this adoption would have to be justified by obtaining higher operating performance with lower costs in a very clear way (Cetin *et al.*, 2005).

The key factor why a different treatment from the traditional one is necessary lies in the existence of variability within the crop plot. Thanks to new technologies, it has been possible to verify through analysis (soil, plant, irrigation water...) that the plot is not uniform, it does not behave in the same way at all points of its extension and many have been the authors. that have tried to control this variability (Tardáguila *et al.*, 2008).

The treatment of this variability is what Precision Agriculture (PA) deals with, developed in the late 1980s in the United States, Australia and the United Kingdom due to the rise of global positioning systems (Hidalgo-Togores, 2006). In his doctoral thesis, Blackmore (2003) remembers the beginnings of PA as the effort to understand and manage the variability of fields.

The purpose of the PA focuses on better management of intraplate variability (variability within the same plot), since crop fields are not uniform in their characteristics (water availability, incident solar radiation, topography, slope...) nor in their needs, but there is variability, and therefore it is not efficient to treat the entire plot equally. According to the PA philosophy, measures must be taken to effectively treat each part of the land.

The key to PA is to apply what is necessary, where it is needed and at the right time, so that there is the greatest possible efficiency to avoid wasting resources. This efficiency is seen in the use of GPS antennas in AP systems, with which the points where work is being done are always located in space, in addition to involving the obtaining of data in real time, so the availability of information is greater.

Other purposes of this philosophy involve making the producer's task as easy as possible and helping him improve the management of the farm, making it more profitable. In short, the use of PA involves minimizing inputs, improving efficiency and creating more sustainable agriculture.

In general, the sensors used in AP can be grouped into three classes:

- control sensors,
- location sensors
- perception sensors

Artificial vision is a technique that, with the appearance of PA, has been incorporated into agriculture (Rees & Doyle, 2010). This incorporation represents great improvements, since these systems provide important information related to crops and their environment; Furthermore, they allow us to investigate regions of the electromagnetic spectrum where the human eye is not capable of operating. Some of the advantages of artificial vision in the agricultural field are:

- Reliability and objectivity, as the cameras are not affected by factors such as fatigue, acquired habits, etc., which do affect people and, therefore, human vision
- Increased productivity (profitability) and possibility of automating repetitive operations
- Elimination of invasive methods that destroy fruits and plants during their analysis
- Development of new sensors for visible spectrums that allow the detection of anomalies or lesions in fruits that are not visible to the human eye.

Precisely because it is a new application, it also presents some drawbacks that have not yet been resolved today that it has to deal with, since the crops are outdoors and, therefore, in changing lighting conditions due to the variation in position. of the Sun throughout the day (and year). In addition, there is great variability in the fruits, with differences between species, varieties and even at an individual level by size, shape or color; The fragility of the product can also be a drawback in post-harvest processes (Sáiz-Rubio & Rovira-Más, 2012).This article reviews one of the technologies that facilitate these tasks: precision agriculture (PA), which focuses on the optimization of resources and inputs based on the compilation of precise and timely geo-information on variables of agricultural interest. of high spatio-temporal variability, obtained through remote sensors of three types: images captured by satellites or airplanes, images obtained from manned and unmanned aerial vehicles and specific information with sensors mounted on machinery or in the field.

DEVELOPMENT OF THE TOPIC

Spectral composition

The various properties of the components of a scene are manifested through the spectral composition of the wavelengths that these components emit and are captured by special cameras. Some types of these cameras are the so-called hyperspectral, multispectral3 and spectrometers (Weekley, 2007).

In this way, various compounds in a scene can be characterized by what is called their spectral signature. Currently, characterizing scenes through their spectral signature has become a very useful alternative to identify the presence of objects that are difficult to identify using other traditional methods such as texture analysis, color segmentation, etc. An example of this is the identification of the presence of dangerous substances in an environment, the detection of pests in crops, among others.

Vegetation has a unique spectral signature that allows it to be easily distinguished from other land cover types in an optical/near-infrared image (Towers y von Martini, 2002). The spectral characteristics of vegetation vary with wavelength

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The plant pigment in the leaves, called chlorophyll, strongly absorbs radiation at red and blue wavelengths, but reflects the green wavelength (Towers & Von Martini, 2002). Beyond visible wavelengths, plant spectra show a strong increase in reflectance (Varvel *et al.*, 1997). The region of high plant reflectance at the near-infrared wavelength end is called the near-infrared plateau (Quebrajo-Moya *et al.*, 2016).

Professional software such as QGIS, Agisoft Photoscan and Pix4Dmapper Ag are used to process these multispectral images, the latter expressly dedicated to precision agriculture (Virlet, 2016).

Using these software, vegetation indices can be calculated, maps created and images georeferenced to be used later in the detection of diseases, the optimization of the application of fertilizers, water and/or chemicals to crops, as well as for the estimation of the crop growth.

The objective of the multispectral image processing system is to evaluate Nitrogen needs in sugar cane plantations (Saccharum officinarum).

National Precision Agriculture Program (PNAgP) Cuba

On January 19, 2018, in the Annual Review of the Joint Meeting between the Biotechnology and Pharmaceutical Industries Group (BioCubaFarma) and the Ministry of Agriculture (Minag), the then First Vice President of the Councils of State and Ministers Miguel Díaz -Canel Bermúdez, tells the National Center for the Production of Laboratory Animals (CENPALAB), to “dust off” all the projects that were being carried out in Precision Agriculture (AP) in the country. (PNAgP)

On March 15 of this year, a new AP project, updated with the new IT and IT Technologies, is presented to the Multisector Board of the Fund for Science and Innovation (FONCI) of the Ministry of Science, Technology and Environment (CITMA). Communications (ICTs), taking protein plants as a model due to their novelty. For its part, the Grain Research Institute (IIGranos), together with the GEOCUBA Business Group, present another PA project in rice cultivation. Both projects were later approved on May 3.

On April 16, the general aspects of AP technology and its applications in Minag were presented to the Executive Committee of the Council of Ministers (CECM), taking as a sole agreement to update the National Precision Agriculture Program (PNAgP).) until 2025, establishing the priorities for its application, making the Ministry of Agriculture responsible for this.

On May 3, 2018, a Working Group is convened and a meeting is held at Minag, to update the PNAgP. The Agricultural Engineering Research Institute (IAgric) is designated as coordinator of the Working Group and it is indicated to prepare a document that collects the experiences, specific results, as well as the impacts of its application. Likewise, the conditions in the country, the existing opportunities, as well as the needs, priorities and necessary alliances must be assessed. Priority is given to working on sugarcane, rice, potatoes, fruit trees and protein plants. The same companies that previously participated in this program are taken as scenarios and the areas of the UEB of Protein Plants, in San Pedro, under the administration of CENPALAB, are now included.

Although in our country there are various methods for calculating variables of agricultural interest, such as plant volume, calculating the cultivated area and calculating vegetative indices, these are still not sufficient to analyze large areas of crops and become extremely expensive and inaccurate due to the number of personnel involved and the type of measurements used. That is why the study will be carried out and it is intended to optimize these methods using a spectral resolution satellite imaging system that generates the results with greater accuracy, such as Global Positioning Systems (GPS), plant-climate-soil sensors and multispectral images obtained from satellites, airplanes or UAVs (García y Herrera, 2015).

Precision agriculture bases its purpose on taking into account the spatial and temporal variability within the crop land to decide on the moment, location, the necessary quantity and the type of input that must be administered, minimizing costs, impact on the environment. and maximizing production. Through this practice, a solution is provided to certain problems that may affect the development of crops, such as efficient water management, localized treatment of herbicides and optimal use of fertilizers, plant counting, early detection of pests and diseases. in crops, among others (Bongiovanni *et al.*, 2006).

The countries of the USA, Canada and Australia are leading the way in the use of this technique. According to a survey conducted in the US in 2011, the adoption of satellite images and aerial photographs in the PA increased from 16.1% to 30.3% between 2008 and 2011. The increasing use of PA by producers in said country was reported in a survey carried out by the Center for Agrobusiness and Food in 2011

Farmers' knowledge of variation in their fields is also an important factor influencing both the perception and adoption of PA technologies. It was observed that those people who have more knowledge about the spatial variation in soil properties of leased lands were more likely to recognize and adopt PA technology (Basso, 2014). Precision agriculture is relatively new and developing technologies make it possible to reduce its errors and costs to achieve ecologically and economically sustainable agriculture.

Image processing and calculation of Vegetative Indices

The information provided by multispectral images on plants and soils allows several parameters related to precision agriculture to be satisfactorily obtained. Various authors present specific applications of multispectral image processing.

According to Gago *et al.* (2015), the water status of plants is detected using high spatial resolution thermal images obtained using a UAV. Water stress in crops causes the closure of the stomata, reducing transpiration and increasing the temperature of the leaves, which can be monitored using thermal sensors. The volume of information obtained allows for better use of water.

According to Candiago *et al.* (2015), the nitrogen concentration of the leaf is obtained from the determination of the chlorophyll content of the plants, since they are closely related. In this way, the nutritional stress in the crops is determined, in order to make optimal use of fertilizers, using them only in the areas where they are necessary.

According to Tian (2002), the stress in the vegetation, produced by the presence of pests and diseases, is determined, generating diverse maps that allow the detection of processes in the crops in a focused manner, as well as sizing the problem and evaluating it in a timely manner. This will increase the economic benefits of farmers and avoid the unnecessary application of phytosanitary compounds.

To a large extent these applications are derived from vegetative indices, which are nothing more than algebraic combinations of several spectral bands, designed to highlight the vigor and properties of vegetation such as biomass, absorbed radiation and chlorophyll content (Gutierrez-Rodriguez *et al.*, 2005).

Among all the IVs that exist, the most used and derivable from a tri-band multispectral sensor are: NDVI, GNDVI and SAVI (Candiago *et al.*, 2015). Other IVs are the CWSI and the PRInorm, used to measure drought stress in crops, a fundamental parameter in crops due to the cyclical droughts that have been occurring in recent years.

The best known and most used vegetation index is the Normalized Differential Vegetation Index (NDVI Normalized Difference Vegetation Index). This index is based on the peculiar radiometric behavior of the vegetation, related to the photosynthetic activity and leaf structure of the plants, allowing the vigor of the plant to be determined.

NDVI values are a function of the energy absorbed or reflected by plants in various parts of the electromagnetic spectrum. The spectral response of healthy vegetation shows a clear contrast between the visible spectrum, especially the red band, and the Near Infrared (NIR). While in the visible the leaf pigments absorb most of the energy they receive, in the NIR, the cell walls of the leaves, which are full of water, reflect the greatest amount of energy.

In contrast, when the vegetation suffers some type of stress, whether due to the presence of pests or drought, the amount of water decreases in the cell walls, so the reflectivity decreases in the NIR and increases in parallel in the red as it has less chlorophyll absorption. This difference in the spectral response allows healthy vegetation to be identified with relative ease.

The first results suggest that the sensor is capable of detecting variations in chlorophyll in the leaf or the state of Nitrogen induced by varying its application levels, since the variations in the sensor readings (GNDVI) were highly correlated with the Nitrogen treatments performed and soil chlorophyll meter readings for both hybrids.

For more than 30 years, evidence has been accumulating on the potential and usefulness of measuring crop temperature to monitor its water status. Therefore, the measurement of roof temperature has been proposed as an alternative to measuring water potential. When water stress is induced, the leaf stomata close, the transpiration rate is reduced and its cooling effect decreases, which causes the leaf temperature to rise. It has been shown that the detection of the temperature of a plant cover using sensors or infrared images can be applied to calculate CWSI and thus estimate the water status of the crop to establish an adequate irrigation schedule in a multitude of crops (Quebrajo-Moya *et al.*, 2016).

A procedure to estimate soil moisture depletion and root depletion fraction using remote sensing CWSI was implemented by the authors (Colaizzi *et al.*, 2003). The procedure was tested on cotton with low-frequency surface irrigation in Maricopa, Arizona, and worked reasonably well. The CWSI was also related to in situ measurements of soil moisture through the water stress coefficient Ks and the correlation between the CWSI and the soil moisture reading. The use of the CWSI, to estimate FDEP (soil moisture depletion), that is, the time to irrigate, and the DR (root moisture depletion), that is, the amount of water to be irrigated, greatly improved management. of irrigation and provided greater for more than 30 years, evidence has been accumulating on the potential and usefulness of measuring crop temperature to monitor its water status. Therefore, the measurement of roof temperature has been proposed as an alternative to measuring water potential.

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Remote sensing

The term remote sensing is a translation of the English remote sensing, and refers not only to the capture of data from the air or space, but also to its subsequent processing. If a more formal definition were made, remote sensing would be described as the technique that allows acquiring and studying data on the Earth's surface from sensors installed on space platforms, by virtue of the electromagnetic interaction between the Earth and the sensor, and coming from the radiation source either from the sun (passive remote sensing) or from the sensor itself (active remote sensing) (Chuvieco, 2007).

The senses only perceive an object when they manage to decipher the information that it sends them and when their own vision is, in itself, a remote sensing process, in which three main elements participate Chuvieco (2007).

1. Sensor: the eye.
2. Photographic film: the observed object
3. Energy flow, which allows the previous two to be put in relation.

This flow comes from the object either by reflection of sunlight (color of the objects), by its own emission or, also, it could be energy emitted by the sensor itself and reflected by the object, in which case, remote sensing receives the name of ACTIVE, as opposed to PASSIVE remote sensing, in which the energy source is the sun.

The possibility of acquiring information at a distance is based on the specificity of the interaction between electromagnetic radiation and matter, since all objects have their own spectral response, despite the fact that they present a spectral combination similar to that of other objects or surfaces that They have the same characteristics or homogeneity.

Remote sensing

A remote sensor is an instrument capable of detecting, characterizing and quantifying the energy coming from objects located at a distance, thereby obtaining relevant information on certain characteristics that said objects have. Remote sensing allows us to acquire information that is impossible to identify with the human eye, since it has photosensitive cells for the so-called visible spectrum, a small portion of the electromagnetic spectrum that ranges between 450 to 700 nanometers (nm), all other wavelengths are not can be perceived by the human eye. Given the above, remote sensors are designed to capture data that exceed the limits of the human eye both by default and excess. This allows information to be extracted from images that is impossible to appreciate in any other way, generating applications for many fields of research. The data captured by the remote sensing system is stored in matrices where each value in the matrix represents a small portion of the reflected energy. This data stored in the matrix is subsequently represented with a color scale that is assigned according to the value stored in the cell. Once a graphic representation is assigned to the matrix, an image is obtained that is composed of pixels (values of each cell), however the resolution of the image is considered according to its spatial resolution (number of pixels per image), resolution spectral (range of the electromagnetic spectrum that can be captured), radiometric resolution (all possible values that a cell can take) and temporal resolution (time interval in which the image can be taken again for the same area).

Corine land cover (CLC)

For the identification of land cover there are several classification systems, however, the one used in Colombia is the Corine Land Cover (CLC) classification system. This system comes from a program of homogenization of concepts for the identification of land cover of the European Environment Agency for a scale of 1:100,000. This classification had to be appropriate to the reality of the Colombian terrain, since it differs from European geography. As a result of this adjustment, IDEAM has a classification based on CLC for the Colombian territory divided into five chapters

1. Artificialized territories.
2. Agricultural territories.
3. Forests and semi-natural areas.
4. Wet areas.
5. Water surface.

Coverage predominantly composed of sugar cane crops (Saccharum officinarum L), a tropical grass plant of the Poaceae family from which sugar is extracted, shaped like a giant grass related to sorghum and corn. It is a predominantly industrial crop. It is cut every 12 months, and the plantation lasts approximately 5 years, it has a solid stem 2 to 5 meters high with 5 or 6 cm in diameter. It is generally grown on flat land and the optimal production area is between 800 and 1,200 meters above sea level.

Definition of GIS

There are many definitions of GIS (Geographic Information Systems) which is not simply a program. In general, GIS are systems that allow the use of geographic information (the data has spatial coordinates). In particular, GIS allows you to view, consult, calculate and perform spatial analysis of data, which are mainly Raster and Vector types. Vector data is made up of objects that can be points, lines and polygons; Each object can have one or more attributes with values. A raster is a grid (or image) in which each cell has an attribute with values (Fisher y Unwin, 2005). Many GIS applications use raster images that are obtained with remote sensors.

Supervised classification

A semi-automatic classification (also called a supervised classification) is an image processing technique that allows the identification of materials in an image from their spectral signatures. There are several types of classification algorithms, but the general purpose is to produce a thematic land cover map. Image processing and spatial analysis with GIS require specific software, such as the QGIS Semi-Automatic Classification Plugin.

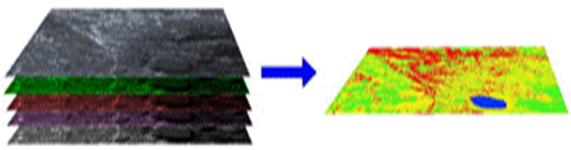

FIGURE 1. Multispectral image processed to produce a land cover classification (Landsat image provided by USGS)

Usually, supervised classification requires the user to select one or more Regions of Interest (rivers, or Training Areas) for each land cover class identified in the image. Rivers are polygons drawn over homogeneous areas of the image that overlap pixels belonging to the same land cover class.

Chlorophyll

Chlorophylls are a family of green pigments found in cyanobacteria and in all organisms that contain plastids in their cells, which includes plants and various groups of protists called algae. These molecules are responsible for capturing light energy in the first events of photosynthesis.

Nitrogen

Nitrogen is a chemical element, with atomic number 7, symbol N and which, under normal conditions, forms a diatomic gas (diatomic or molecular nitrogen) that constitutes 78% of atmospheric air. Sometimes called azoe - in ancient times, the symbol Az was used to represent nitrogen.

Floor

Soil is the unconsolidated part of the Earth's crust, biologically active, which tends to develop on the surface of rocks emerged under the influence of weather and living beings (weathering).

Soils are complex systems where a vast range of chemical, physical and biological processes occur, which are reflected in the variety of soils existing on Earth. Broadly speaking, it can be said that the components of soil are divided into solid, liquid and gaseous, and generally correspond to minerals and organic material such as water and air. More schematically, it is worth saying that the pedosphere, the set of all soils, encompasses parts of the lithosphere, the biosphere, the atmosphere and the hydrosphere.

Fertilizers

They are a type of chemical substance or mixture, natural or synthetic, used to enrich the soil and promote plant growth. Plants do not need complex compounds such as vitamins or amino acids, since they synthesize everything they need. However, they require a dozen chemical elements that must be presented in such a way that the plant can absorb them. Within this limitation, nitrogen, for example, can be administered with equal effectiveness in the form of urea, nitrate, ammonium compounds or pure ammonia.

Spectrometer

The spectrometer is a measuring instrument that analyzes the type of spectrum it emits.

a source or that is absorbed by a substance that is in the path of light produced by a source. These emission or absorption spectra are like a fingerprint of the substances that make up nature.

The operation of the spectrometer is based on the decomposition of light of the different wavelengths that compose it, based on the phenomena of refraction - which occurs in a prism - or diffraction - which occurs in a diffraction grating. This instrument measures the angles at which the maxima of the diffraction pattern occur. These angles are different and characterize the nature of the source that emits the light. The basic components of a spectrometer are a set of lenses, a collimator, a diffraction grating, and an eyepiece. Previously, detecting the spectrum was done with the naked eye, but today, it can be photographed and you can even use light sensors that mark the maximums and minimums.

Spectrophotometry

All substances can absorb radiant energy; Even glass that appears to be completely transparent absorbs radiation of wavelengths that do not belong to the visible spectrum. The absorption of ultraviolet, visible and infrared radiation depends, therefore, on the structure of the molecules and is characteristic of each chemical substance.

When light passes through a substance, some of the energy is absorbed (radiant energy cannot produce any effect without being absorbed). The color that the substances themselves acquire is due to the fact that they absorb certain wavelengths of the white light that falls on them and only allow those unabsorbed lengths to pass to our eyes.

Ultraviolet-visible spectrophotometry uses beams of radiation from the electromagnetic spectrum ranging from 80 to 400 nm in the UV range (mainly 200 to 400 nm, known as the near UV range) and from 400 to 800 nm in the of visible light, making it very useful for characterizing materials in the ultraviolet and visible regions of the spectrum. It is worth mentioning the fact that the absorption and transmittance of light depends on both the amount of concentration and the distance traveled.

Vegetation indices

The calculation of vegetation indices is a widely used technique within the field of remote sensing. Rahman (2004) mentions the improvement of discrimination between two covers that have very different refractive behavior in two or more bands, for example, in order to enhance soils and vegetation in the visible and near infrared, and to reduce the effect of relief (slope and orientation) on the spectral characterization of different roofs.

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Spectral indices

Vegetation indices (VI) combine spectral information contained in two or more bands, usually in the VIS and NIR, or both. These indices aim to extract optimal information about the investigated objects. In this regard, Rahman *et al.* (2004) y Lopes & Reynolds, 2012) state that some of these indices are very useful in measuring crop parameters such as leaf area, percentage of green biomass, productivity and photosynthetic activity. Within these indices, the NDVI (Normalized Difference Vegetation Index) stands out, which is associated with the variability of the chlorophyll of the leaves, their nitrogen content and sugarcane production.

To cite some examples, there is the green vegetation index (VI Green) derived from the spectral reflectance of the green and red bands, and used by Torres-Sánchez *et al.* (2013) both to determine the protein content in wheat leaves that are in the anthesis state and to predict the protein content at the time of harvest. Best *et al.* (2011), for their part, evaluated the vegetation indices NDVI and SAVI (Soil Adjusted Vegetation Index) obtained through remote sensing as estimators of the growth of cotton and sugar beet, being related to soil cover, biomass and leaf area index.

Finally, Best *et al.* (2011), found that by carrying out flights with a hyperspectral sensor and using the vegetation index PRI (Photo chemical Reflectance Index), diurnal changes could be detected in water stress indicators such as the difference between air temperature and canopy temperature, stomatal conductance and stem water potential.

Spectral indices for chlorophyll estimation

In the bibliographic review carried out, it was found that the spectrum of the plant presented a plateau between 750-800 nm, determined by the structure and composition of the leaf, and not by the chlorophyll content since the influence of this substance induced a minimum in the surroundings corresponding to 670 nm. According to the above, it can be said that the greater the presence of chlorophyll, the greater the depth of the spectrum with respect to the upper plateau.

Within a leaf, in addition to chlorophyll, there are pigments that have an important spectral absorption in the blue region, such as carotenoids. Therefore, the best interval to study chlorophyll through remote sensing techniques is between 600 and 700 nm Lopes & Reynolds (2012) .

According to Torres-Sánchez *et al.* (2013), the reflectance spectrum of adult and healthy plants is characterized by strong absorption (low reflectance) in the blue (400-500 nm), an increase in reflectance in the green (500-600 nm), a high absorption in the red (600-700 nm) and strong reflectance and transmittance in the infrared (NIR) (700 to 1500 nm). For its part, the reflectance response in the VIS region (400-700) is governed in plants by the effect and behavior of chlorophylls, carotenes and anthocyanins.

Normal reflectance is low in the region of 480 and 680 nm due to the absorption of chlorophyll and other pigments, and is high in the NIR due to the microcellular structure of the leaf and the canopy structure. Therefore, in this project, the use of vegetation indices that used the interval of the electromagnetic spectrum between 550 and 750 nm was implemented, since this range would be very useful for estimating chlorophyll (Table 1).

Interaction of radiation and the plant

Reflectance and transmission are defined as the rates of reflected or transmitted radiation from incident radiation. Incident radiation that is not reflected or transmitted by the leaf is absorbed. The interaction between solar radiation and plant molecules controls visible and infrared reflectance. Biochemical and structural components influence the tendency of plants to absorb, transmit and reflect different wavelengths of solar radiation between 300 and 3000 nm.

The absorption of shortwave radiation by plants is controlled by molecular interactions that occur within plant tissue, where electrons absorb incoming solar radiation at wavelengths controlled by chemical and structural bonds (Gates *et al.*, 1965). Therefore, changes in concentrations of adsorbent chemicals provide a basis for changes in plant absorption,

TABLE 1. Implemented spectral indices

INDICE	FORMULA
Modified Chlorophyll Absorption In Reflectance Index	MCARI= [(R700-R670)- 0,2(R700-R550)] (R700/R670)
Vogelman Indices	Vog1 = (R740)/(R720) Vog2 = (R734 - R747)/(R715 + R726) Vog3 = (R734 - R747)/(R715 + R720)
Gitelson & Merzlyak (1997)	GM1=R750/R550 GM2=R750/R700
Zarco-Tejada *et al.* (2001)	ZTM=(R750)/(R710)
Red - Edge Model (R-M)	R-M = R750/R720 - 1
Normalized Difference Vegetation Index	NDVI = (R800-R670) / (R800+R670)

transmission, and reflectance. The two visible and infrared absorption components that are mainly present in plant leaves are chlorophyll and water.

Chlorophyll absorption is affected by electron transitions between 430 and 460 nm, and 640 and 660 nm Basso (2014), while the absorption bands of water are around 970 nm, 1200 nm, 1450 nm, and 1780 No. Other biochemical absorbent compounds that are important are proteins, lipids, starch, cellulose, nitrogen and oils. However, it is worth noting that, through infrared reflectance, the estimation of the concentrations of these compounds is difficult to establish given the overlaps of the absorption bands of several biochemical components.

Now, based on the principle that "every object in nature has a unique distribution of electromagnetic radiation that can be reflected, transmitted or absorbed" García-Cervigón, (2015), the spectral signature curve is created, while each plant species It presents an exclusive reflectance influenced either by its morphological, physiological, nutritional characteristics or by the effect of a humidity deficit. In other words, the spectral signature is different depending on the wavelengths. By the way, Lopes y Reynolds, (2012)

They add that the signal received by the sensor corresponds to color, that is, the reflected electromagnetic energy.

The boom reached worldwide by multispectral image processing systems in precision agriculture has been evident. Demonstrating the importance of the use of spectral satellite images generated by these systems and their applications in sugarcane crops.

CONCLUSIONS

- The application of Precision Agriculture is the safest way to increase production, saving agricultural inputs and caring for the environment.
- The processing of multispectral resolution satellite images to evaluate Nitrogen needs in sugarcane plantations (Saccharum officinarum) should be the means to search for sugarcane yields.
- The research centers that exist in the country carry out different actions that respond to various programs and projects, but the response still does not solve the problems that arise in the productive sector based on its requirements

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Los autores de este trabajo declaran no tener conflicto de intereses.
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