USE OF REMOTE SENSING IMAGES IN CROP MONITORING CASE STUDY: SOYBEAN CROP

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Abstract*. The study used remote sensing images in order to analyze and describe the monitoring process for soybean crop. Soybean, which has been the subject of this study, is a culture of particular economic importance due to its many uses. It is used in human nutrition, in the production of animal feed, but also as a raw material for some industries Worldwide in the production of soybean vegetable oil is the second largest after the palm. The satellite images were achieved by the PlanetScope satellite system, images in 4 spectral bands: RED, GREEN, BLUE and NIR, with a 3 m spatial resolution, that show the dynamics of this crop over the period analyzed. The study was carried out over a total time interval (T) of 121 days, from 27.03.2020 to 24.07.2020. The parcel analyzed in this research is part of Experimental Didactic Station of BUASVM Timisoara and it is located in Timis County and it has approx. 55 hectares. Eight satellite scenes were taken over and processed for the 2 combination of spectral bands: Red Green Blue and Near Infrared Red Green and for the calculation and interpretation of 2 useful vegetation indices in such monitoring, namely, the Normalized Difference Vegetation Index (NDVI) and The modified soil-adjusted vegetation index (MSAVI2). Processing of the acquired images was performed with specialized software: ERDAS Image 2014 and ArcGIS v. 10.3, and mathematical processing was done with the Past software. The variation of NDVI index in relation to time, over the study period, a 3rd degree polynomial equation, under statistical safety, R^2=0.966, p=0.00208. The NDVI index variation in relation with MSAVI2 has been described by a 2nd degree polynomial equation under statistical security conditions, R^2=0.999, p<0.001. Cluster analysis led to grouping of variants according to time of remote sensing (D) acquisition based on affinity under high statistical accuracy (Coph.corr. = 0,955).*

Keywords: *agricultural crops, vegetation indices, monitoring, remote sensing*

INTRODUCTION

Remote sensing images are increasingly used for crop assessment (LATTE and LEJEUNE, 2020; GOVEDARICA and JAKOVLJEVIĆ, 2019; JOVANOVIĆ ET al., 2016; HERBEI et al., 2015a, b), forest area monitoring (GOVEDARICA et al., 2015), protected areas or real-time risk tracking. In addition to remote-sensing images, large-scale use is also made of precision farming with UAV (CALINA et al., 2020; CALINA et al., 2018) equipped with a multi-spectral camera to monitor agricultural crops and detect real-time problems that may occur in certain conditions in agricultural crops

The spectral bands of remote sensing images contain specific information and the combination of these results in a series of new information (HERBEI et al., 2016), which is complex and highly safe for the characterization of the vegetation covering (JAKUBAUSKAS et al., 2002) and, in particular, of agricultural crops (BOLTON and FRIEDL, 2013).

Combination of remote sensing sciences and GIS (BEGOV UNGUR ET AL., 2016; FILIP ET AL., 2016), is used to analyse various issues such as crop area assessment, land cover and land use, mapping crop season and crop phenology, crop growth dynamics aspects, determination of vegetation indices, current agricultural monitoring (YOU et al., 2003; HERBEI and SALA, 2014).

Various studies have been carried out to analyse the development of the vegetation covering (SALA et al., 2015)in areas affected by natural factors or man-made activities (BERTICI et al., 2012; TARAU et al., 2013; BERTICI et al., 2013), or to study the possibility of identifying crops and separating different species of agricultural crops using multispectral data. The dynamics of the soybean crop, which is analysed in this research, are based on remote sensing images and mathematical models for the evolution of this type of crop based on spectral information obtained from satellite images. Similar studies have been carried out at sunflower (HERBEI and SALA, 2015), and mathematical models have been used to optimize different agricultural crops (SALA and BOLDEA, 2011).

Soybean, which has been the subject of this study, is a culture of particular economic importance due to its many uses. It is used in human nutrition, in the production of animal feed, but also as a raw material for some industries.

In the diet, both seeds and young seedpods and plants are used. Soybean makes a wide range of products - vegetable milk, vegetable cheese, coffee surrogate, chocolate, soy flour can be made from bakery products, and soybean oil is used for cooking and salads, but also for margarine production. Protein fibres from soybean are used to produce "vegetable meat" with which a multitude of other products are prepared - pâtés, meats, etc. The plant is very valuable in animal feed and soybean oil is also used in the production of soaps, paints and plastics. Worldwide in the production of soybean vegetable oil is the second largest after the palm (www.agro.basf.eo)

MATERIAL AND METHOD

The study area analysed in this paper is part of the Experimental Didactic Station of BUASVM Timisoara, in Timis County. In this study, an attempt was made to monitor a plot grown with soya of approx. 55ha, the approximate geographical coordinates being 45°47’28’’N and 21°09’13’’E.

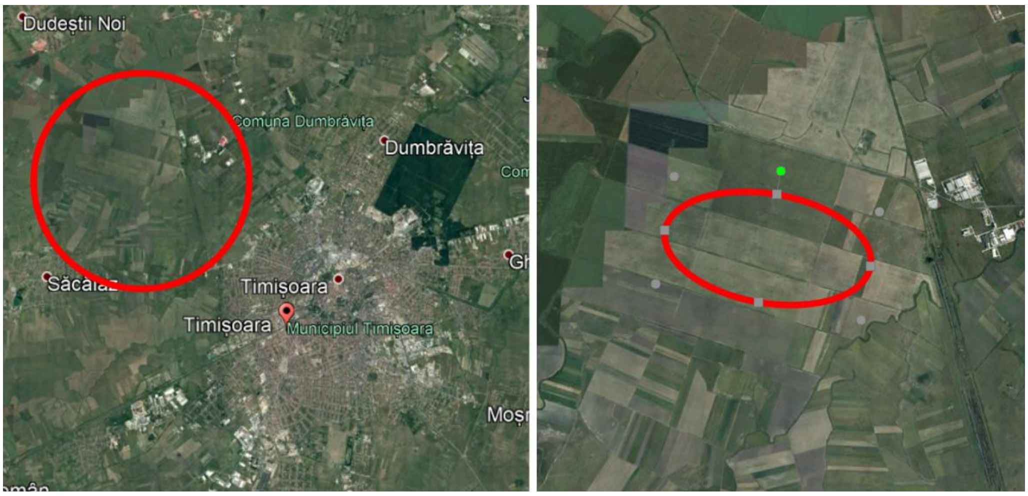

Figure 1. Location of the Study Area

In this study, in order to monitor soybean cultivation, satellite images were acquired from the PlanetScope remote sensing system between 27.03.2020 and 24.07.2020, downloaded on the Planet Labs portal (PLANET TEAM)

Thus, 8 satellite scenes were taken over and processed for the calculation and interpretation of 2 useful vegetation indices in such monitoring, namely, the Normalized Difference Vegetation Index (NDVI) and The modified soil-adjusted vegetation index

(MSAVI2) (Rouse et al., 1973; Gitelson, 2004; Qi et al., 1994).

Processing of the acquired images was performed with specialized software: ERDAS Image 2014 and ArcGIS v. 10.3, and mathematical processing was done with the Past software (Hammer et al., 2001).

The PlanetScope remote sensing system offers free multi-spectral data in the form of calibrated images that have been processed to allow analysts to derive information products for data science and analysis. This product is designed for a wide variety of applications requiring images with accurate geolocation and cartographic projection in 4 spectral bands: Red, Green, Blue and near Infrared at a spatial resolution of 3m.

The NDVI is a measure of plant health and is based on how the plant reflects light at certain frequencies (somewhere absorbed and others are reflected). This index is very often used in agriculture because it provides high precision for fertilizer application and irrigation, among other agro-land treatment activities, at specific growth stages.

$$NDVI = (NIR - R)/(NIR + R) \quad (1)$$

Where: NIR and R are the surface reflectance of the NIR band and red band.

Chlorophyll (a health indicator) strongly absorbs visible light and the cellular structure of the leaves strongly reflects near infrared light. When the plant becomes dehydrated, sick, disease-affected, etc., the foam layer deteriorates and the plant absorbs more of near infrared light rather than reflecting it. Thus, the observation of how the NIR changes compared to red light gives an accurate indication of the presence of chlorophyll, which correlates with plant health.

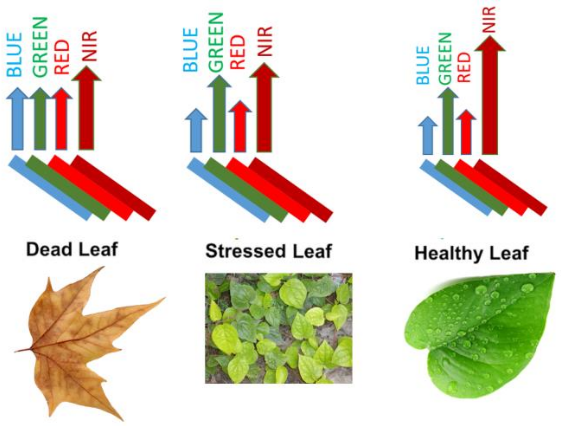

Figure 2. Mode of radiation reflection by leaves function state of health

The MSAVI index and its subsequent revision, MSAVI2, are ground-adjusted vegetation indices that aim to address some of the NDVI limitations when applied in areas with a high surface of exposed soil.

$$\mathrm{MSAVI} = \left(\frac{1}{2}\right) * \left(2 * (\mathrm{NIR} + 1) - \sqrt{\left((2 * \mathrm{NIR} + 1)^2 - 8 * (\mathrm{NIR} - \mathrm{Red})\right)}\right) \quad (2)$$

Where: NIR and R are the surface reflectance of the NIR band and red band.

RESULTS AND DISCUSSIONS

The images taken from the Planet Scope system on the www.planet.com portal have undergone pre-processing using special software (Erdas Image), and then on the basis of the spectral bands of this system, 2 combinations of spectral bands were made, useful in monitoring soybean cultivation, namely, The combination of RGB, respective the combination of NIR RED GREEN

NATURAL COLOURS

RED – GREEN – BLUE (BAND 3 – BAND 2 – BAND 1)

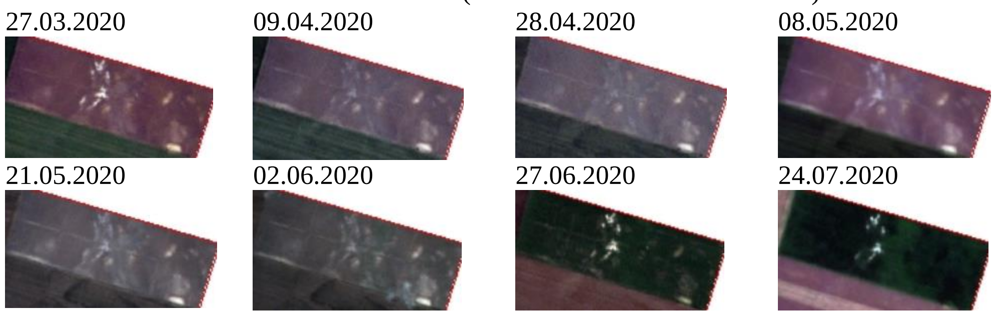

Figure 3. RED GREEN BLUE Maps

INFRARED - COLOURS

NIR – RED – GREEN (BAND 4 – BAND 3 – BAND 2)

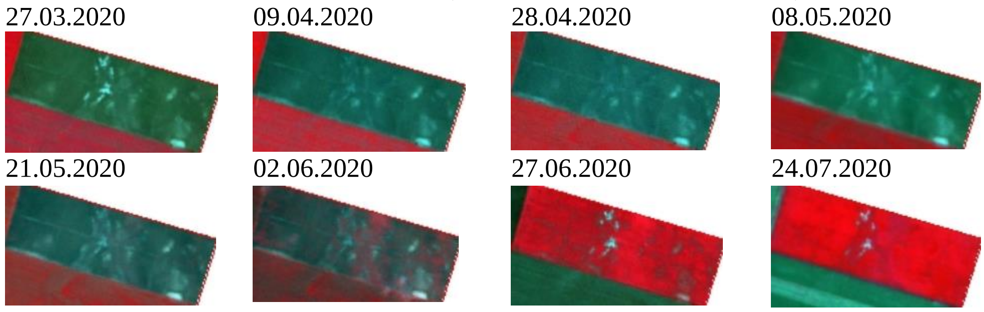

Figure 4. NIR – RED - GREEN Maps

NDVI INDEX

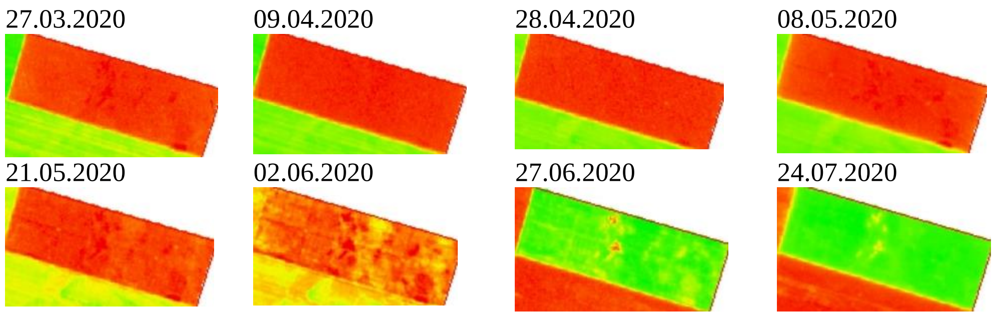

Figure 5. Maps of NDVI

MSAVI2 INDEX

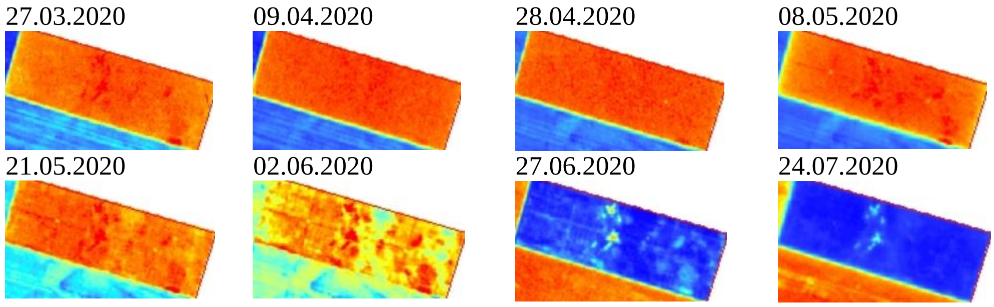

Figure 6. Maps of MSAVI2

Figures 3 and 4 show the development of the soybean crop from the parcel studied in the period 27.03.2020 – 24.07.2020, based on 8 images taken from the remote sensing system used in this study. Based on the spectral bands of the Planet Scope remote sensing system, for monitoring soybean cultivation, 2 vegetation indices were calculated, namely, the NDVI and MSAVI2 index, as shown in figures 5 and 6.

The evolution of the NDVI and MSAVI indices over the period 27.03.2020-24.07.2020 is outlined in Table 1.

Table 1

The values of the MSAVI and NDVI indices for soybean cultivation

	T	MSAVI	NDVI
D1 27.03	0	0.141133	0.079338
D2 9.04	14	-0.0632	-0.02589
D3 28.04	33	0.027648	0.01781
D4 8.05	44	0.134101	0.078556
D5 21.05	57	0.10198	0.056823
D6 2.06	69	0.214767	0.123082
D7 27.06	94	0.667391	0.508017
D7 24.07	121	0.82435	0.704807

Based on the numerical values of the calculated indices, an ANOVA test single factor analysis has been performed, as outlined in the table below.

Table 2

ANOVA test, single factor

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	15423.02	2	7711.509	14.22889	0.000124	9.772326
Within Groups	11381.19	21	541.9614			
Total	26804.21	23				

Alpha=0.001

The variation of NDVI index in relation to time, over the study period, a 3rd degree polynomial equation, relationship (3), was described under statistical safety, R^2=0.966, p=0.00208.

$$NDVI = -6.274E-07T^3 + 0.0001889T^2 - 0.008359T + 0.07869 \quad (3)$$

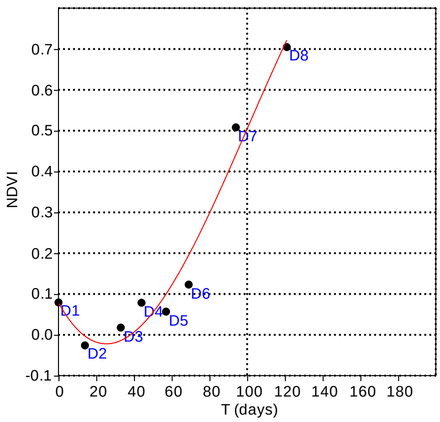

Figure 7 Graphical distribution of the NDVI index values in relation to time

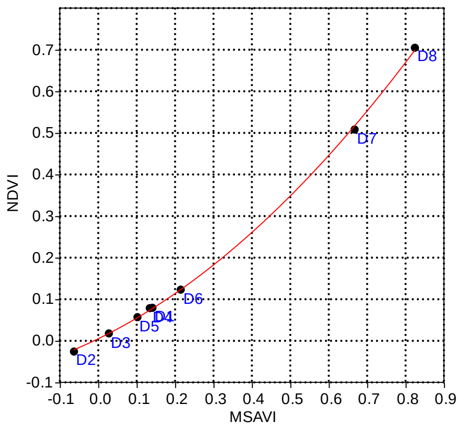

Figure 8 NDVI variation by MSAV2, soybean crop

The NDVI index variation in relation with MSAVI2 has been described by a 2nd degree polynomial equation, the relationship (4) under statistical security conditions, R^2=0.999, p<0.001.

$$NDVI = 0.478MSAVI^2 + 0.448MSAVI + 0.004966 \tag{4}$$

Cluster analysis led to grouping of variants according to time of remote sensing (D) acquisition based on affinity and resulted in the diagram in Figure 10 under high statistical accuracy (Coph.corr. = 0,955). Two distinct clusters with several sub-clusters each result. The high affinity was found in variants 7 with 8 and 2 with 3, Table 3.

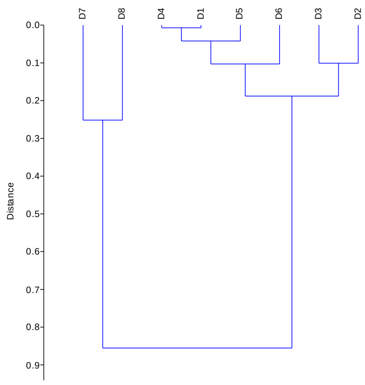

Figure 9. Cluster analysis

Table 3

The values of the similarity coefficient

	D1	D2	D3	D4	D5	D6	D7	D8
D1		0.22984	0.12909	0.007075	0.045165	0.085648	0.67876	0.92628
D2	0.22984		0.10081	0.22324	0.18473	0.31537	0.90488	1.1496
D3	0.12909	0.10081		0.12257	0.083947	0.2147	0.80596	1.052
D4	0.007075	0.22324	0.12257		0.038783	0.092139	0.68471	0.93201
D5	0.045165	0.18473	0.083947	0.038783		0.13081	0.72337	0.97041
D6	0.085648	0.31537	0.2147	0.092139	0.13081		0.59417	0.84261
D7	0.67876	0.90488	0.80596	0.68471	0.72337	0.59417		0.25172
D8	0.92628	1.1496	1.052	0.93201	0.97041	0.84261	0.25172	

CONCLUSIONS

From the remote sensing images of the PlanetScope system, a monitoring was carried out based on 8 satellite scenes from March to July 2020 on a soya cultivated plot. From remote sensing images, 8 RGB combinations and 8 NIR-Red-Green combinations were made that show the dynamics of this crop over the period analysed. Graphs were also developed and the variation functions of the NDVI index in relation with time and MSAVI2 index were determined. Based on the calculated index values, cluster grouping was possible depending on the time of acquisition of remote sensing images under statistical security given by the Cophenetic coefficient.

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