Use of drone with digital photographic machine embedded for determination of leaf cover

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Abstract

The normalized difference vegetation index (NDVI) obtained via radiometer is important to determine the physiological state of plant, being a promising tool for decision making as to the best time for the application of agricultural pesticides, to analyze the threshold of economic damage. The use of drones with digital camera embedded in agriculture is in broad expansion. Through digital images analyzed in computer programs and correlated with NDVI it is possible to determine the leaf cover in plants. The aim of this study was to confirm the use of digital images at 30 m in height to determine the leaf cover, correlating them with NDVI values obtained on the ground. Therefore, 30 m height photos were taken with the help of a drone and three stages of maize development (N4, N8 and R1), which were considered as treatments; afterwards, the images were analyzed in software to survey the leaf cover. The NDVI data were obtained in the same areas at a height of 0.5 m from the crop canopy, and it were submitted to the Scott Knott Test at 5 % significance and Pearson correlation. There was no statistical difference between methods and the Pearson correlation coefficient value (0,952) confirms strong evidence for correlation between the two methods. Thus, it can be concluded that the use of drone with embedded digital camera has promising use for the determination of leaf cover in maize.

Keywords: Refletance. Digital image. Maize. NDVI.

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Introduction

Remote sensing is understood as an ensemble of techniques that captures spectral information of plants pigments, measuring culture reflectance without contact of measuring device or any kind of object (SILVA JÚNIOR et al., 2008). Thus, it is possible assess health and vigor of plants through data reading, being it a non-invasive technique that causes no damage (NILSSON, 1995).

By observing changes in the angle of leaves over time in a plant, it can be detected hydric stress; the color of leaves can inform limitations and nutritional imbalance, besides the possibility of identifying attack of pests and diseases (BARTON, 2012). According to Malenovský et al*.* (2009), the acquired data can be used to estimate, for example, chlorophyll content, water content or index of a leaf area.

Many multispectral sensors are capable of measuring electromagnetic radiation reflected or emitted by the vegetation (MALENOVSKÝ et al., 2009). The equipment used to obtain value of reflectance is the radiometer and its application on agriculture was only possible due to the development of proximal sensors, such as GreenSeeker®, N-Sensor and Crop Circle (BREDEMEIER et al., 2013).

The behavior of reflectance measures at different cultivation conditions are relevant information to be used on models to estimate damages (HIKISHIMA et al*.,* 2010), for productivity forecast (ALI et al., 2014; CAO et al., 2015), agriculture of precision, fertilizers application (CHANG et al., 2014) and premature detection of lesions caused by herbicides (YAO et al., 2012).

The GreenSeeker® is an instrument that provides normalized difference vegetation index (NDVI) via reflectance measures, the interpretation of the NDVI provides quick and direct information about nutritional conditions, physiological state, stress and potential crop yields (GROHS et al., 2009; GUTIÉRREZ-SOTO et al., 2011).

Nowadays, digital cameras are promising equipment to measure area leaf on field (ADAMI et al., 2008), since they are portable and acquire images with good resolution, in a quick and simple way (GODOY et al*.,* 2007). Zabot et al. (2008) state that the use of digital images is an easy tool to work with, being possible to collect many images in reduced time to process them with the support of specifics programs that read images. These specifics programs can detect, quantify and classify plant diseases from digital images at visible spectrum (BARBEDO, 2013). Another vantage is that analyses made with digital images have low costs, it can cost less than ten percent of the measurer leaf area equipment price (GONG et al., 2013).

Digital images manipulation through image editor software provide indexes which express the plant's green color. The use of quick technics, as digital image analysis, that allows evaluation directly on field, can optimize decisions making on the application of pesticides (BACKES et al., 2010).

VANTs and Drones represent a large variety of acknowledged agricultural assignments (FREEMAN; FREELAND; 2014), highlighting monitoring of natural resources, environment, atmosphere, hyperspectral imaging, lakes and river observation, such as agricultural practices imaging and soil use (JORGE et al., 2011).

The processing of digital images obtained through Drones and VANTs on softwares would dynamically evaluate larger areas of planting if compared to portable sensors, for example, GreenSeeker®.

Therefore, the objective of this work was to correlate digital images data obtained by Drone and processed on software with NDVI data collected on land with the purpose to determine leaf cover.

Material and methods

The experiment was conducted at Universidade Estadual de Londrina (UEL), located in Londrina city, Paraná, Brazil, 23°19’40,92” South latitude and 51°12’19,20” East longitude, 560 above sea leavel, in the 2013/14 harvest.

Digital images such as values of NDVI were obtained from three different phases of maize culture: V4, V8 and R1, which were used as treatments.

NDVI (Normalized Difference Vegetation Index) is the normalized vegetation index, defined as:

$$NDVI = \frac{NIR - RED}{NIR + RED}$$

\s

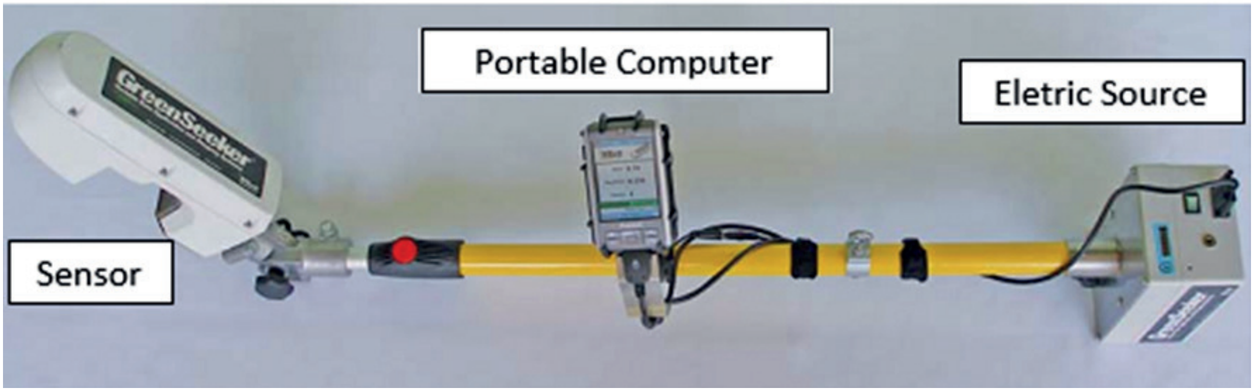
At which:

RED: radiation in the range of red (650 nm) incident on plant surface

NIR: near infrared (770 nm) reflected by it

Reflectance lectures (NDVI) were carried out 0,5 meters of distance from culture canopy, in central lines area, on gaps of 5 meters, totaling 14 lectures, with 3 repetitions each. The equipment used for reflectance measures was GreenSeeker®, model RT100, from NTech consisting of an adjustable sensor at increments of 15º, attached in an arm, also adjustable, that allows to keep it parallel to vegetation surface. The electric source is necessary to provide energy for optical sensor and the notebook. The notebook with programs is necessary for obtaining and storing data which are recorded on SD card (FIGURE1).

Figure 1. Components of GreenSeeker®, model RT100.



Source: adapted from GUTIÉRREZ-SOTO et al. (2011).

Digital photos were taken from a digital photographic machine: Go Pro of MP, attached to a drone Phanton 2Vision Quadcopter Digital (FIGURE 2) to 30 meters from height. The images were divided in 14 parts with the same dimensions of reflectance measures, the central parts were used to reduce fisheye effect of the camera after being processed on Life Cycle Assessment Software (LCAS), a software that analyzes leaf cover.

Figure 2. Drone Phantom 2 Vision Quadcopter with the camera Go Pro®.

Source: PHANTOM 2 (2015).

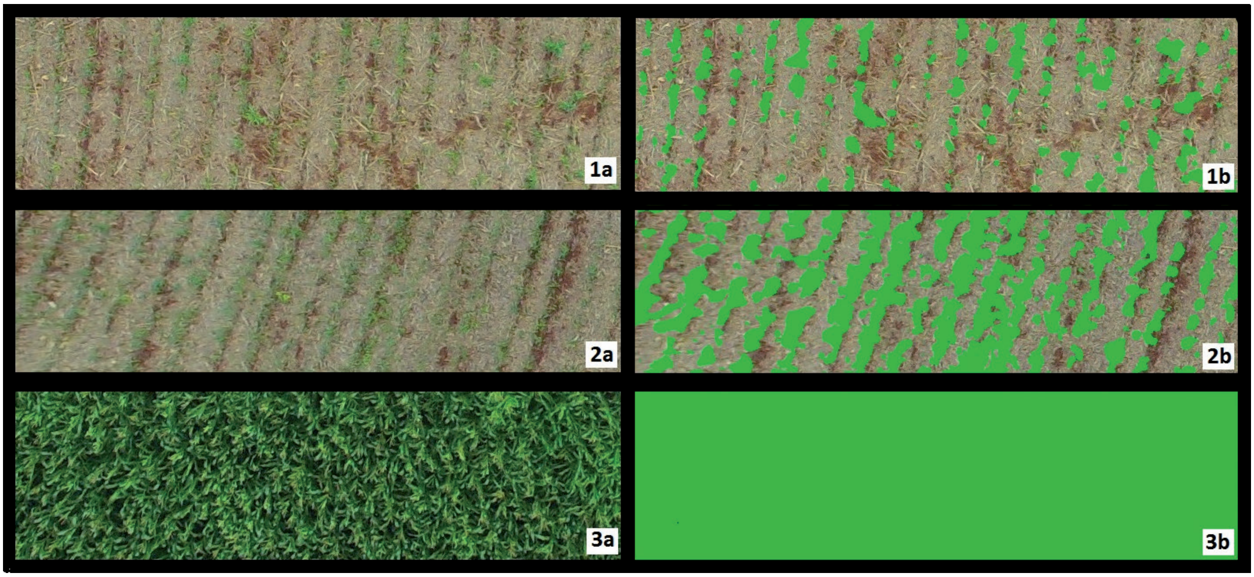
The LCAS was used to qualify leaf cover by counting green pixels on digital photos. LCAS, responsible for determination of coverage degree through RGB components analysis of digital images, was developed in the programming language Borland C++ Builder 6.0, compatible with Windows 32 bits system.

The statistic software used to compare means by Scott Knott's test was SASM-Agri (CANTERI et al., 2001).

Results and discussions

Digital images captured at 30 meters height were processed by LCAS, Figure 3 exemplifies leaf cover determination (%) in each one of the treatments through the software.

Figure 3. Sample of digital images taken at 30 meters height (1a, 2a and 3a), analyzed by the LCAS software to get maize leaf cover (%) (1b, 2b and 3b).



Source: Elaborated by the authors (2019).

Means were compared by Scott-Knott's Test, at 5 % of significance, at NDVI data from three stages of maize studied; it was observed statistical difference for the three treatments: N4, N8 and R1 (TABLE 1). The same was verified for leaf cover data obtained from digital images taken by a Drone, at 30 meters height from the ground, and processed by the LCAS (TABLE 1).

Table 1. Comparison means, 5 % significance, for the N4, N8 and R1 treatments for NDVI and leaf cover obtained through embedded digital camera linked to a drone and processed by image analysis software.

Treatment	NDVI	Leaf cover (%)
N4	340,57 a	15,53 a
N8	413,44 b	17,86 b
R1	665,19 c	99,44 c

* Means followed by different letters differ by the Scott-Knott´s Test ($P \leq 0.05$).
Source: Elaborated by the authors (2019).

By performing Pearson correlation between leaf cover and NDVI data, it was obtained the value of 95,5 %. Michels (2014) found 96,1 % of correlation between NDVI and leaf cover through digital images analysis of soy taken at 2 meters height, a similar value to the ones found in this work. These results show that even with a significant raise of distances in the images collection, with consequent increase in the evaluated area and studying cultures with distinct architectures, the capacity of verifying leaf cover differences was not affected. Since the results corroborate the values obtained by Michels (2014), it could ascertain a transportability of leaf cover analyzed by LCAS to differentiated structure cultures, as the case of soy and maize.

Conclusion

The leaf cover values in different situations on fields evaluated through processed digital images taken at 30 meters height and analyzed by LCAS demonstrated strong correlation with the values obtained from NDVI data. Therefore, it can be concluded the use of Drone is promising for leaf cover analysis.

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Utilização de drone com máquina fotográfica digital embarcada para a determinação de cobertura foliar

Resumo

O índice de vegetação por diferença normalizada (NDVI) obtido via radiômetro apresenta importância para determinar o estado fisiológico de planta, sendo uma ferramenta promissora para a tomada de decisão quanto ao melhor momento para aplicação de defensivos agrícolas, e analisar o limiar de dano econômico. A utilização de drones com máquina fotográfica digital embarcada na agricultura está em ampla expansão. Por meio das imagens digitais analisadas em programas computacionais e correlacionadas com o NDVI é possível determinar a cobertura foliar em plantas. O objetivo deste trabalho foi confirmar a utilização de imagens digitais a 30 m de altura para determinação da cobertura foliar correlacionando-as com os valores de NDVI obtidos em terra. Para isso, foram retiradas fotos digitais a 30 m de altura, com o auxílio de drone, em três estádios de desenvolvimento do milho (N4, N8 e R1), os quais foram considerados tratamentos; posteriormente, as imagens foram analisados em software para levantamento da cobertura foliar. Os dados de NDVI foram obtidos nas mesmas áreas a uma altura de 0,5 m do dossel da cultura e submetidos ao teste de comparação de médias Scott Knott a 5 % de significância e de correlação de Pearson. Não houve diferença estatística entre os métodos, o valor de correlação de Pearson apresentou coeficiente de 0,952, o que confirma uma forte evidência à correlação entre os dois métodos. Assim, pode-se concluir que o uso de drones com câmera digital incorporado tem uso promissor para a determinação da cobertura foliar em milho.

Palavras-chave: Refletância. Imagem digital. Milho. NDVI.

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