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RESEARCH INTO THE POTENTIAL OF UTILIZING IMAGE PROCESSING FOR THE EVALUATION OF MAIZE CULTURE

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Abstract

The monitoring of soil nitrogen supply using drone provided images and image processing. Thus, we intend to facilitate the decision farmers make when they come to the question: "How much nitrogen should be applied to a maize crop that will result in the best output?". In this article we develop this theme, that of finding out the levels of nitrogen using drone supplied images, without the need for a person to physically go inside the crop and make the determination. There will be three zones that will receive different amounts of nitrogen, namely: N0, N100, N150. Then, the processing and analyzing of the results will use latest technologies available: GIS tools, Python scripting, pixel classification, GPS measurements and a professional drone.

***Key words**: affected area, drone, GIS instruments, GPS measuring, pixel classification*

INTRODUCTION

Nitrogen fertilization is an indispensable component in maize cultures. The most common dilemma is related to fertilization, as well as what is the optimal amount to help develop and produce the desired plant. We try to find a solution to those kind of problems with the help of modern determination and observation systems.

MATERIALS AND METHODS

Determining the nitrogen supply and chlorophyll

Determinations to assess the supply of plants with nitrogen were done using the N Tester when the maize plants were at BBCH 60 (Karthika P et al., 2014), and the intensity of the chlorophyll using SPAD-502 Chlorophyll Meter (Abdelhamid, M., et al., 2003). Also, the deviate standards DS were calculated using Duncan TEST.

Figure 1 shows the method used to determine a leafs nitrogen levels.

For each experimental parcel, 6 repetitions were performed, each with 30 measurements. (Suhartono, 2016).

Figure 1. N Tester measurement procedure

Determining coordinates of landmarks

Locating the determination points was done using Trimble R4 GPS L1 + L2 technology.

For image georeferencing, three landmarks were fixed to the ground and had their coordinates measured.

Image acquisition

The images were taken with the use of the camera from the Phantom 3 Professional Drone. The sensor on the camera is a 1/2.3"CMOS, with 20mm lens and f/2.8 focus. The ISO range is 100-1600.

The drone flew in a fixed circuit, at different altitudes, between 50 and 250 meters (Córcoles, J et al., 2013) (Figure 2).

Figure 2. Phantom 3 Professional Drone filming and taking pictures

Image processing

To process the images we used LeoWorks 4.0, also Python scripts to group pixels into color classes.

For the case at hand, LeoWorks represents a visual analysis tool that is available to any photo interpreter.

The NDVI index is usually defined by the following formula:

$$\mathrm{NDVI} = \frac{(\mathrm{NIR} - \mathrm{VIS})}{(\mathrm{NIR} + \mathrm{VIS})}$$

where VIS and NIR stand for the spectral reflectance measurements acquired in the visible (red) and near-infrared regions (Mahdi M. Ali et al., 2012). In this case, we used the following adapted formula:

$$\mathrm{NVDI} = (G-B)/(G+B)$$

where G is the green band of the images and represents to the spectral reflectance measurements in the near-infrared regions (NIR), and B is the blue band in the images and represents the spectral reflectance measurements in the visible regions (VIS).

For a detailed analysis the image was classified in grayscale (Figure 6).

The gray hues have ranges between 0 and 255. The ones in the image have been grouped in 4 classes. For each class the percentage is calculated, then the weighted average, according to the formula:

$$\overline{X} = \frac{\sum_{i=1}^{n} x_i p_i}{\sum_{i=1}^{n} p_i} = \frac{x_1p_1 + x_2p_2 + \ldots + x_np_n}{p_1+p_2+ \ldots +p_n}$$

where x represents the gray hue and p it's weight. The sum of the weights is always 100.

Subsequently, we evaluated the correlations between the level of fertilization, the nitrogen content of the leaves, the degree of supply on the chlorophyll and classes of gray obtained using XLSTAT that runs under Microsoft Excel.

RESULTS AND DISCUSSIONS

After taking the group images it can be observed in the following figure the image that contains the 3 study zones and the 3 landmarks used for georeferencing.

We can see the 3 zones with different intensities of green even before processing the image, which leads to a better results (Figure 3).

Figure 3. Orthophoto from the drone

During the first phase we determine the NDVI vegetation index and we can observe that Zone 1 is the most affected followed by Zone 3 where the level of chlorophyll is much higher (Figure 4).

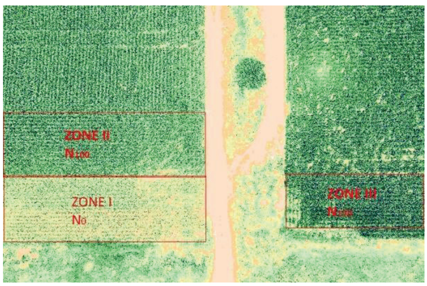

Figure 4. NDVI index applied for the 3 zones

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The results determined for the concentration of nitrogen and the chlorophyll in the leaves at BBCH 60 are tabulated in Table 1.

Table 1. Monitoring the levels of nitrogen supply and the concentration of chlorophyll BBCH60.

Nitrogen	Nitrogen	Chlorophyll
N0	720.25	29.2
N100	738_a	34.2_b
N150	780.75_a	36.4_a
DS	31.22	1.46

Analyzing the data presented in the table below we find that the increase in the nitrogen administered from 0 to 150 corresponds with an increase in the levels of nitrogen in the leaves.
After increasing the dose of nitrogen we find an increase in leaf chlorophyll from 29.2 unfertilized to 33.2 fertilized with 100 nitrogen kg/ha, and to 36.4 with 150 kg/ha, respectively.
Figure 5 shows the centralized results of the determinations, regarding the gray hues obtained from processing the images.

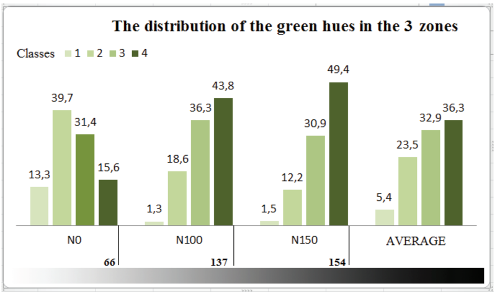

Figure 5. The distribution of the green shades in the 3 zones

By analyzing the data we find that by increasing the amount of nitrogen administered, the distribution in the 4 classes converges in the class with the highest intensity.
From the point of view of the average concentration of gray the values vary between 65.07 and 153.64.
The increase in the the amount of nitrogen administered resulted in all cases in an significant increase in the shades of gray (Figure 6).
Further, linear correlations were drawn between shades of gray obtained and the levels of chlorophyll a nitrogen.

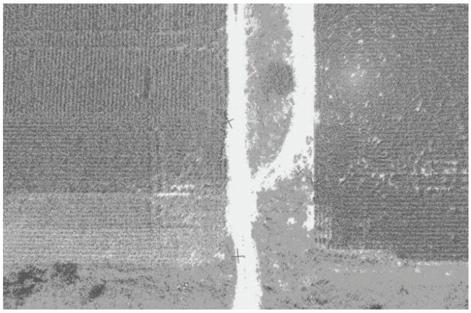

Figure 6. Classifications using shades of gray

The chart in Figure 7 shows that between there exists a correlation between the nitrogen levels and shades of gray, with a coefficient of 0.839.

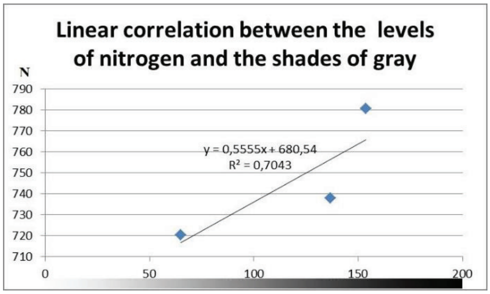

Figure 7. Linear correlation between the levels of nitrogen and the shades of gray

The chart in Figure 8 shows that between there exists a correlation between chlorophyll levels and shades of gray, with a coefficient of 0.961.

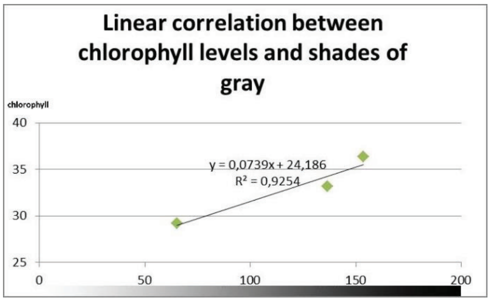

Figure 8. Linear correlation between chlorophyll levels and shades of gray

Each shade of gray corresponds to a quantity of nitrogen and to a chlorophyll level. Because of this, a classification by shade of green was made to better visualize the data.

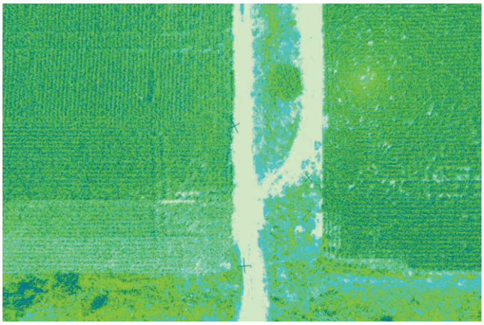

Figure 9. Image classification with Python scripts

The 4 shades of green can be observed below, as well as the respective percentage from the image.
The first two shades are predominant in the first zone where the nitrogen levels are lower, representing 53% of the image. The second zone shows a larger percentage of better shades, of 80.1%, and the third zone the better shades form a 80.3% percentage.

Zone 1
13.3% 39.7% 31.4% 15.6%
Zone 2
1.3% 18.6% 36.3% 43.8%
Zone 3
1.5% 12.2% 30.9% 49.4%

CONCLUSIONS

We can conclude that there exists a correlation between the levels of nitrogen administered and the percentage of gray.
There is also a linear correlation between the levels of nitrogen administered and the chlorophyll.
Thus, by demonstrating that there is correlation between the two methods, the classic and modern, this method can be taken into account for future studies regarding drone acquired images to determine the level of nitrogen and chlorophyll. This method requires less time spent being stationary in the field, compared to the classical method in which the land is surveyed by foot and multiple datasets are collected.
Using this method that we presented, we can appreciate the health of the culture and the degree of administration with nitrogen using gray hues.
Also, we can observe that this monitoring method is efficient and precise, compared to other processing methods, such as measuring the affected areas using GPS equipment, the "stop and go" method or digitizing vertex by vertex, which is more error prone because the ability of the human eye to distinguish is not as good as a computer (Trif A. et al., 2016).
We recommend this kind of modern methods to determine similar objectives in the future.

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