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DIGITALIZATION OF AGRICULTURE IN NORTHERN BARAGAN, BY USING DRONES, FOR THE PURPOSE OF MONITORING CROPS, TO INCREASES THE EFFICIENCY OF AGRICULTURAL TECHNOLOGIES

[1]Adrian LEOPA, [2]Daniela TRIFAN, [1]Valentin BARDAHAN, [1]Niculai HAUK
[1]“Dunarea de Jos” University of Galati, Romania
[2]SCDA Braila Romania
e-mail: adrian.leopa@ugal.ro

ABSTRACT

With the increase of the population appeared the need to increase the agricultural production. However, this desideratum comes with a series of requirements that are somewhat contradictory:

- reducing the use of pesticides;
- reducing the quantities of agricultural fertilizers by optimizing their use;
- the use of more environmentally friendly technologies;
- cost reduction.

Thus appeared the concept of "precision agriculture" that meets the requirements listed. This concept involves processing a large volume of digitized data. The data must be purchased with appropriate means, processed with specialized software and interpreted by qualified specialists.

The software also generates the data necessary for the practical application, on farms, of the measures necessary to achieve a precision agriculture.

KEYWORDS: drones, precision agriculture, digitalization

1. Introduction

In order to obtain data regarding the state of the crops at a given moment, photographs of the area of interest are taken. The photos are taken in digital format. The height from which the photos are taken considers:

- the cameras resolution;
- the minimum resolution necessary to highlight significant details;
- the type of culture analysed;
- expected economic efficiency.

There are the following data acquisition options:

- Acquisition of data using specialized satellites. It depends on the moment of the satellite passing over the observed area, on the level of cloudiness at the time of taking the photos and on the resolution of the cameras used. Given the high height from which the shooting is taken, large areas with a low resolution are framed;
- Data acquisition using specially equipped aircraft, ensures good resolutions but requires large areas, specially arranged, from where the aircraft can make take-offs and landings;
- Acquisition of data using drones. It is expanding, especially in the case of medium and small surfaces analysed. It can be achieved when the atmospheric conditions are acceptable, from a relatively low altitude. The resolutions obtained allow the highlighting of significant details. The increase of the storage and data processing capacities, together with the improvement of the software, allowed the imposition of this solution, especially in small and medium farms. Another advantage comes from the existence of a significant number of companies specialized in making specialized equipment and software.

This paper analyses some aspects related to the use of drones in precision agriculture.

Both flying wing drones and multicopter drones are used. The former is used for medium to large areas and the multicopter are used for small and medium areas.

Multispectral cameras are used for data acquisition. Practically, several images in different spectra are made from the same point. Based on previous research, certain relationships have been established, at the level of a combination of pixels from different spectra, which allow:

- establishing the health level of the culture at a given time;
- soil moisture level;
- the level of useful substances in the soil;
- the presence of weeds in different areas;
- a possible attack of some pests;
- the existence of natural or artificial obstacles that can affect the work of agricultural equipment;
- vegetation level at the time of data acquisition.

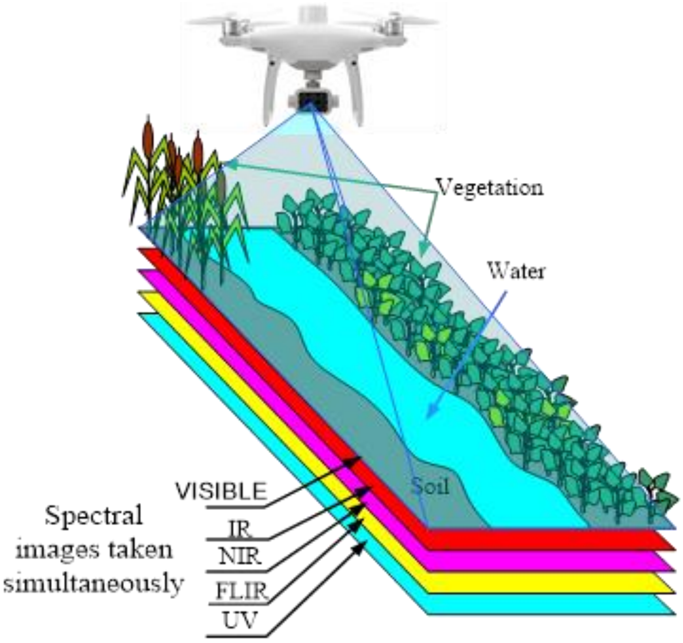

Fig. 1. *The multispectral data acquisition*

In Fig. 1 presents the principle according to which multispectral analysis works. The camera takes several images, from the same place, on a single surface. Each image is made in a different spectrum. The spectral components are emitted depending on the condition of the plants and the soil.

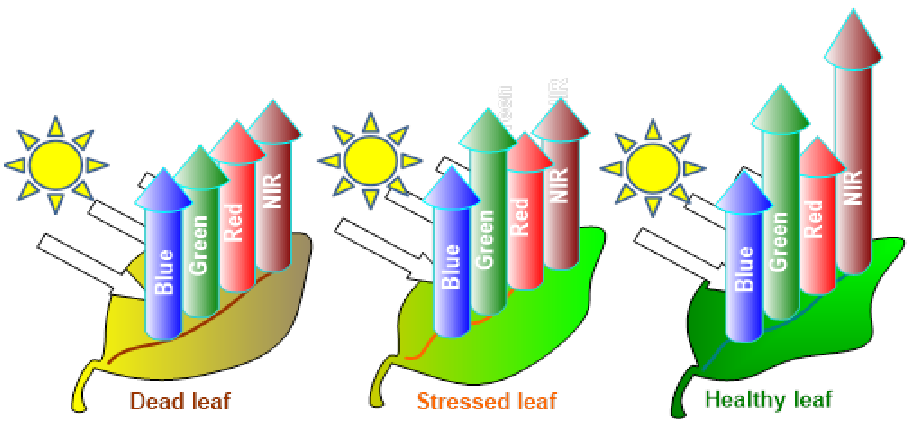

Fig. 2. *The way the light is reflected by the vegetation in different biological stages*

Figure 2 highlights aspects of how light is reflected by the leaves of plants in different vegetation situations. This different way of reflection is the basis of the analyses that are made starting from the multispectral images.

The images thus made are processed with specialized software, obtaining useful information about the respective agricultural crop.

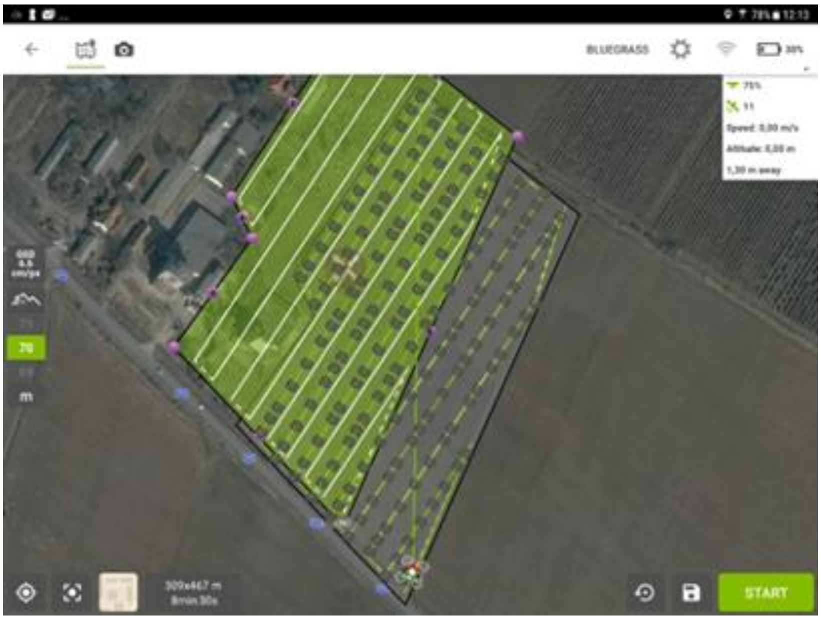

***Fig. 3.** Image capture with flight plane and multispectral shooting*

Because the drones fly at low altitudes (maximum 120 m, according to aviation regulations), the overall picture is obtained from several photos of the area. These are done with a precise planning of the flight route, so that there are sufficient side overlays of the images for assembling the images with specialized software. Figure 3 shows a screenshot that shows the flight plan of a drone over an area of SCDA Braila. The points where the multispectral photos will be taken are highlighted.

2. Data processing

The realization of multispectral images consists in the simultaneous performance, from the same point of the drone's trajectory, of several images in different spectra. The images are digital and have entered, among other data, the GPS coordinates of the point from which they were taken.

After downloading the information, they are processed with specialized software.

The first stage consists in obtaining the overall image of the analysed area, on each spectrum (orthophotoplans). These are 3D images.

Based on these images, is calculated, at the pixel level, and are represented in the form of maps, the so-called vegetation indices.

The vegetation index is an indicator that is calculated as a result of operations with different spectral ranges of remote sensing data and is related to vegetation parameters. The calculation of most vegetation indices is based on two sections, the most stable, of the spectral reflectance of plants.

The most widely used vegetation index is the NDVI, Normalized Difference Vegetation Index. It characterizes the health of vegetation and allows farmers to assess germination, growth, the presence of weeds or diseases, and to predict field productivity. The values of the indices are generated starting from the green mass, which absorbs the electromagnetic waves in the visible red range and reflects them in the near infrared range. The red region of the spectrum (0.62-0.75 μm) represents the maximum absorption of solar radiation by chlorophyll, and the near infrared area (0.75-1.3 μm) and has the maximum energy reflection by the leaf cell structure. Thus, high photosynthetic activity leads to lower values of reflection coefficients in the red region of the spectrum and high values in the near infrared region of the spectrum.

The NVDI index is calculated with relation 1.

$$NVDI = \frac{NIR - Red}{NIR + Red} \quad (1)$$

There are other vegetation indices, each with applicability for various requirements, each with specific calculation relationships.

Figure 4 shows an example of spectral analysis, with the generation of a zoned map, starting from the spectral images of the analysed area. It is observed that the NDVI analysis highlighted areas with different characteristics, impossible to see in the visible spectrum.

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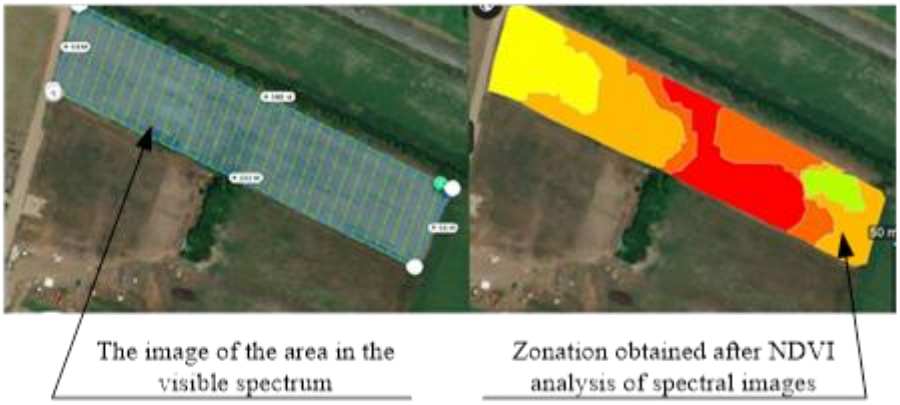

Fig. 4. *Comparison between the image obtained in the visible spectrum and the zoning obtained from the NDVI analysis*

3. Use of results

3.1. Using the MyJohnDeere platform for variable rate applications

John Deere machines benefit from the possibility of using the computer platform dedicated to them, which allows continuous communication between the machine working in the field and the agronomist. Through the MyJohnDeere platform, agronomic decisions can be easily transmitted to the machine and operator, and the execution of the work is reported in real time. The Operations Center application can be used for the remote transmission, to the machines equipped with intelligent John Deere displays and the JDLink system, of the maps for the application of dispersions with variable rate, these being able to be used in few moments from the transmission. Figure 5 shows a screenshot of the application during the file transfer.

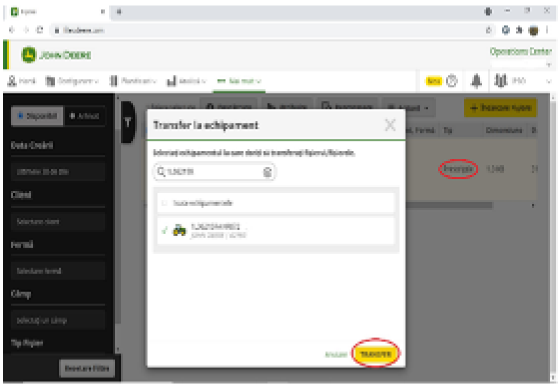

Fig. 5. *Transfer of the prescription file, from the Operations Centre application, to the variable rate spreading machine*

The application commands are sent to the implementation system through the ISOBUS system, which connects the machine and the implementation. After starting the machine-implementation system and starting the application, the implementation in the plot of the proposed rate can be watched in real time on the display.

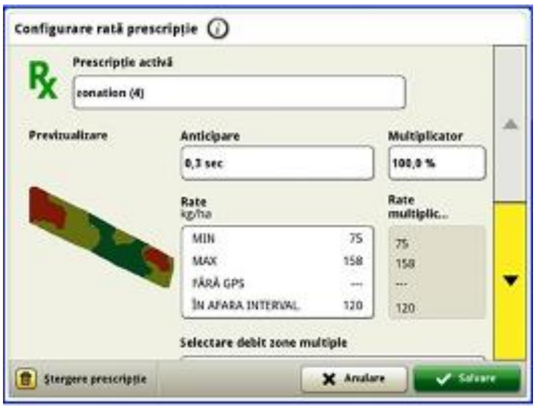

Fig. 6. *View of information received on the John Deere smart display*

Fig. 7. *Automatic transfer of the application command to the implementation system*

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Fig. 8. *Visualization of the application of dispersions, on the machine display, in real time*

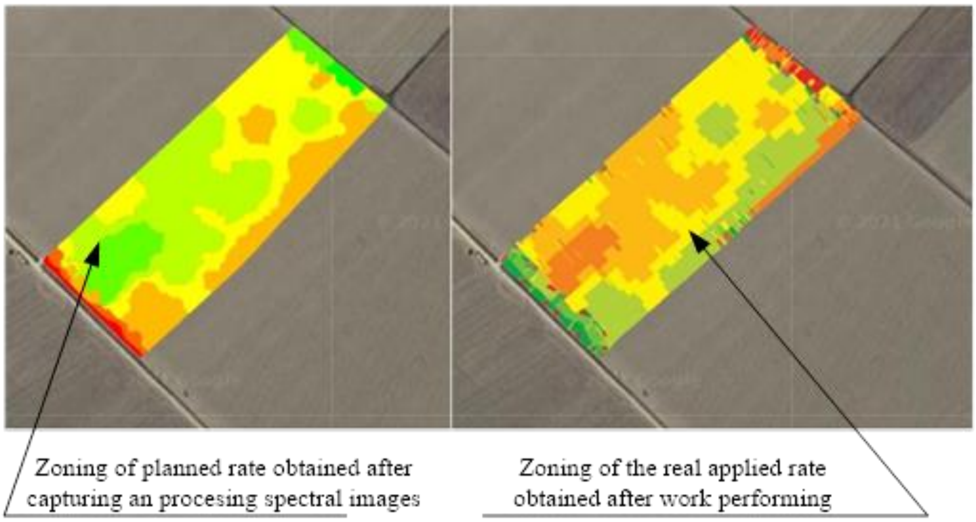

Fig. 9. *Comparative analysis, taken from the Operations Centre, between the planned rate and the applied rate*

At the same time, the data of the performed work are transmitted through the JDLink system to the Operations Centre application, where they can be compared: Planned Rate vs. Applied Rate

3.2. The need for agrochemical study

Precision agriculture is based on the extensive use of flight systems, which can provide essential data on crops, but for a limited time. Flying over agricultural crops with flight systems, equipped with different sensors, is an essential component on which precision agriculture is based. In this way, certain deficiencies can be detected in real time and can be corrected to avoid a possible decrease in the expected harvest.

For the efficient application of precision agriculture, it is necessary to know in advance the physico-chemical parameters of the soil in order to establish the fertilization plan for the cultivated areas, according to the scheduled crop and the expected harvests.

Therefore, in the current context, the realization of a precise agrochemical study can no longer be optional, it becomes mandatory in order to obtain an expected harvest by the farmer.

In order to carry out an agrochemical study, the well-known steps must be completed, namely:

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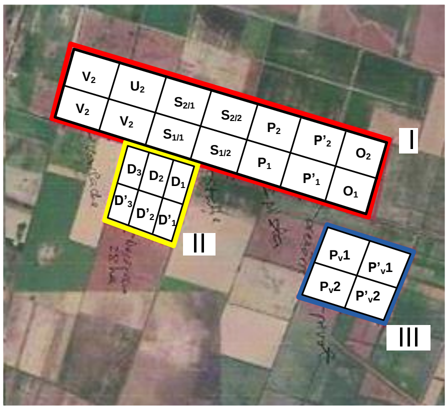
- the field phase, consists in taking soil samples based on a previously established model;
- the laboratory phase, consists in the analysis of the soil samples taken previously to know the physico-chemical properties;
- the office phase, consists of the analysis of the limiting factors of the agricultural production, the realization of the cartographic materials, of the interpretative tables and of the fertilization plans, depending on the crop structure desired by the beneficiary and the expected productions.

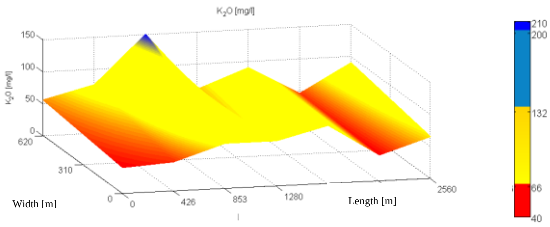
In order to prepare cartographic materials, a mathematical apparatus integrated in a software can be used. Therefore, using the calculation technique, cartograms with chemical fertility indices can be obtained, their degree of fidelity being in close correlation with the location of the points from which the soil samples are collected. Obtaining maps as accurate as possible requires taking soil samples from points at equidistant distances from each other. In other words, the refinement of the cartograms is possible by approximating the agricultural area with a matrix, and the soil samples are taken from points corresponding to its elements.

For example, the following is a mapping carried out in the research project, PN-III-P2-2.1-PTE-2019-0085, in which a series of maps with chemical fertility indices for different agricultural areas were made.

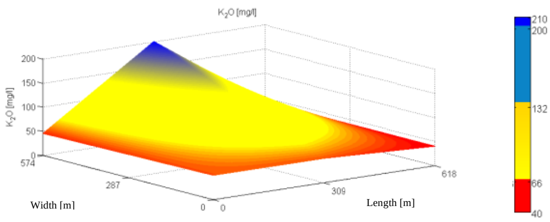
The presented mapping had as objective the determination of the supply state with mobile potassium, its novelty degree consisting in the fact that for its elaboration the MATLAB program was used, Fig. 10 [1-3].



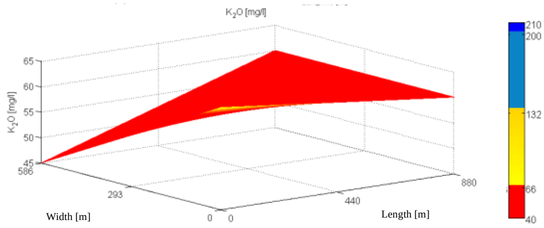
a. Map of the areas for which the state of supply of mobile potassium was represented



b. 3D map for experimentally determined CTSS values, field I



c. 3D map for experimentally determined CTSS values, field II



d. 3D map for experimentally determined CTSS values, field III

Fig. 10. *3D maps for the state of supply of mobile potassium*

4. Conclusion

The trend of population growth on a global level and implicitly of the need for food, forces current generations to identify viable solutions to increase agricultural production, but in full agreement with the commitments arising from Romania's adoption of the principle of sustainable development.

Therefore, agriculture has an obligation to ensure a growing production, but without affecting the chances of future generations to meet their own needs. As presented in this paper, one of the possibilities for achieving this goal is precision agriculture. Compared to classical agriculture, precision agriculture, as the name suggests, uses modern means that allow real-time monitoring of crops, which allows a reduced reaction time. A suitable reaction time does nothing but stagnate the decrease in production in some cases, and in others lead to an increase in it. The use of the calculation technique in the agrochemical study represents a substantial advantage in the accurate evaluation of soil nutrients. The correlation of the maps thus obtained over several years, represents a modern method by which it can appreciate the tendency of qualitative parameters of the analysed soil.

Also, flying over crops with the help of aerial drones at certain intervals, provides in addition to an effective reaction time in certain situations, but helps to accurately dose fertilizers.

Proper dosing of these chemicals significantly and long-term reduces soil pollution.

Even if the adoption of precision agriculture by farmers generates additional costs, it is estimated that these costs will be amortized by the crop increase obtained in these conditions.

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References

[1]. ***, *Raport tehnic, etapa I*, proiectul PN-III-P2-2.1-PTE-2019-0085.

[2]. Marin Ghinea, Virgiliu Fireteanu, *Matlab - Calcul numeric, grafică, aplicații*, Ed. Teora.

[3]. Leopa A., Trifan D., *Quantification of Atmospheric Pollution by Qualitative Analysis of Precipitation as Snow*, The Annals of „Dunărea de Jos” University of Galați, Fascicle IX Metallurgy and Materials Science, Galati University Press, special issue - 2013, p. 197-203, ISSN 1453-083X, 2013.