MULTISPECTRAL MONITORING TRIAL DESTINED TO QUANTIFY THE NITROGEN NUTRITIONAL STATUS OF BARLEY CROP

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Abstract. *The mechatronic systems are implemented in precision agriculture being often used for monitoring the sub-processes involved in a complex agricultural system, while to each sub-process, corresponds a sub-system. The involved sub-systems are often interconnected by IoT (Internet of Things). aims a series of elements, which are the components of a network of sensors, elements, etc. In order to Our research was developed in the year 2018, on West Plain, Benecu de Jos, Timiş County, and aimed to multispectral monitoring of the vegetation indices of a barley culture, using "Dorne Technology". The collected indices were georeferenced, and based on input data best fertilization solutions were formulated. Our study implemented using NDVI drone technology, associated with captures from Google satelite allows the accurate quantification of barley dry matter conten, and nitrogen absorbtion from soil by the barley culture. Our findings show differences in both, dry matter content of the plants, and also differences in nitrogen absorbtion ratio, based on maps delivered by the drone software. These results allow us to determine the exact amount of nitrogen that plants need in order to provide maximum production at lower costs and high quality. The concept of Internet of Things aims a series of elements, which are the components of a network of sensors, elements, etc. In order to manage these networks, which are usually made up of huge amounts of data, special approaches are needed, involving complex computing tools (e.g. Big data, Cloud Computing, etc.). An advantage of including these tools is that human factor is not needed in computational stage, the existence of a compatible devices network being enough. Our study implemented using NDVI drone technology, associated with captures from Google satelite allows the accurate quantification of barley dry matter conten, and nitrogen absorbtion from soil by the barley culture. Our findings show differences in both, dry matter content of the plants, and also differences in nitrogen absorbtion ratio, based on maps delivered by the drone software. These results allow us to determine the exact amount of nitrogen that plants need in order to provide maximum production at lower costs and high quality.*

Keywords: precision agriculture, high quality, NDVI, Big data, Cloud Computing

INTRODUCTION

Presently, a large variety of mechatronic systems are implemented in precision agriculture. The mechatronic systems are also often used for monitoring the sub-processes involved in a complex agricultural system, while to each sub-process, corresponds a sub-system. The involved sub-systems are often interconnected by IoT (Internet of Things). The concept of Internet of Things aims a series of elements, which are the components of a network of sensors, elements, etc (Ahlmeyer and Chircu, 2016; Singh et al., 2017). In order to manage these networks, which are usually made up of huge amounts of data, special approaches are needed, involving complex computing tools (e.g. Big data, Cloud Computing, etc.). An advantage of including these tools is that human factor is not needed in computational stage, the existence of a compatible devices network being enough.

Examples of using Internet of Things (IoT) in agriculture are: the networks of measuring climatic factors stations (including weather forecasting systems), placed in different points of an agricultural field, orchard, etc.; wireless sensors destined to perform real time measurements of soil pH, moisture, etc., located in different points of an agricultural field, and examples may continue (Baker et al., 2010; Rad et al., 2015; Sarode et al., 2018). These considerations show the importance of wireless systems and solutions for implementation of mechatronics in agriculture.

These systems include besides applications as GPS (Global Positioning System), RS (Remote Sensing), or GIS (Geographic Information System), a large variety of technologies, as: IrDA (Infrared data Association), WPAN (Wireless Personal area Network), multi-hop WLAN (Multi-hop Wireless Local Area Network), Bluetooth, etc. (Eitel et al., 2014; Souza, et al., 2017; Practicing precision agriculture involves the use of agricultural equipment that performs fully automated or even autonomous works, from the land preparation sowing, and treatment phase, to harvesting, using satellite navigation systems and correlating the geographical position with the type of decision to be taken (localized fertilizers for example), weighing in real time the harvested products, or drawing up land productivity maps (Salma et al., 2019).

According to the using destination, different technologies may be practiced, namely: NDVI, NDRE, and GNDVI (Huang et al, 2019). Usually, they are used for monitoring the following vegetation indices, whatever the crop:

- the ground vegetation - NDVI (normalized difference vegetation index),
- the chlorophyll content in plants, which gave valuable information about plant status - NDRE (normalized difference red edge), which also helps to the assessment of the NDVI indicator, especially when high chlorophyll levels are synthetized
- the photosynthetic activity, which is correlated with water needs - GNDVI (Green Normalized Difference Vegetation Index).

The output of the abount mentioned three technologies consists in field data specific maps, which allow the user the posssibility of their comparation (Erdle et al., 2011; Gianluca et al., 2018; Wang et al., 2014; Zhao et al., 2004).

The aim of this research is to emphasize the efficacy of drones in assessing the fertilization needs of a barly culture, using NDVI ”drone technology”.

MATERIAL AND METHODS

Our research was developed in the year 2018, on West Plain, Benecu de Jos, Timiș County. An experimental plot, in size of 5.40 ha, was organized. In order to obtain detailed recommendations concerning the nitrogen fertilization, the plot was divided in five sub-plots.

The barley culture was maintained using the conventional technology. The barley crop was maintained on a clay soil. In order to perform a work drone flight, the user must introduce in the drone software parameters that decribe the size of the experimental plot and the geographical coordinates of the plot. With these parameters introduced in its software, the drone is able to identify the experimental plot in the field.

The accumulators’ capacity supplies 45 minutes of independence for the drone's flight. This time of 45 minutes allows drone a capacity to fly over an area up to 45 ha, at 250 - 300 m height. The height may vary depending on the environmental conditions.

During the time of the flight drone can take up to 75 - 80 pictures per ha and it has a superposition of 75% for each picture taken.

The NDVI drone technology was used in this experiment, associated with captures from Google satelite for obtaining accurate data concerning dry matter content of barley, and nitrogent absorbtion from soil by the barley culture. The recommendations based on the drone flight output, fertilization dosis maps delivered by the drone software, respectively are much or less detailed, function of sub-plots taken into consideration, and data introduced in drone software, before the flight.

RESULTS AND DISCUSSIONS

In order to deliver recommendations concerning the nitrogen fertilization of the barley culture located in the experimental field, preliminary research is needed. It aims dry matter content in barley, and also nitrogen absorbtion from the field. Thus, using the drone technology, we identified two solutions, for supplying accurate results concerning the dry matter content of the barley culture. One of them consists in data obtained from drone flight, emphasized by a specific map (Fig. 1), while the other one consists in adjusting dry matter content in experimental barley crop, by overlapping the images captured by the drone with the images made by a Google satellite (Fig. 2).

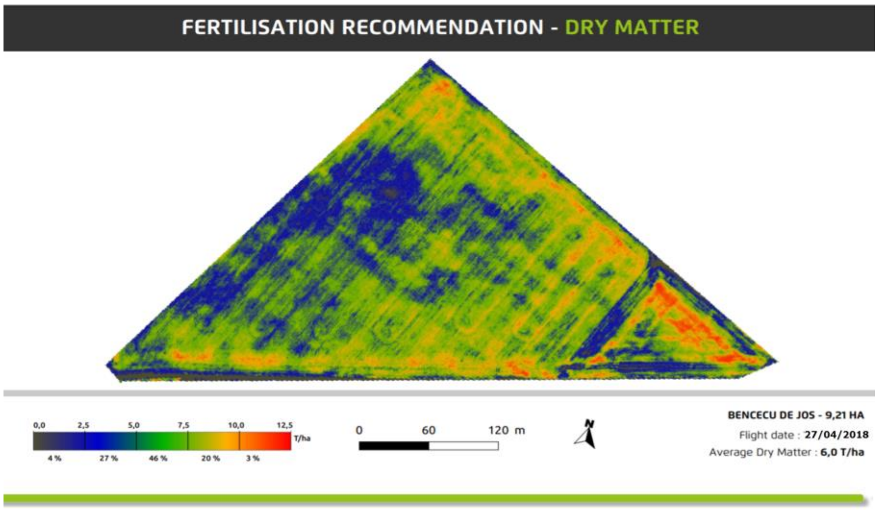

Figure 1. The dry matter content in barley crop

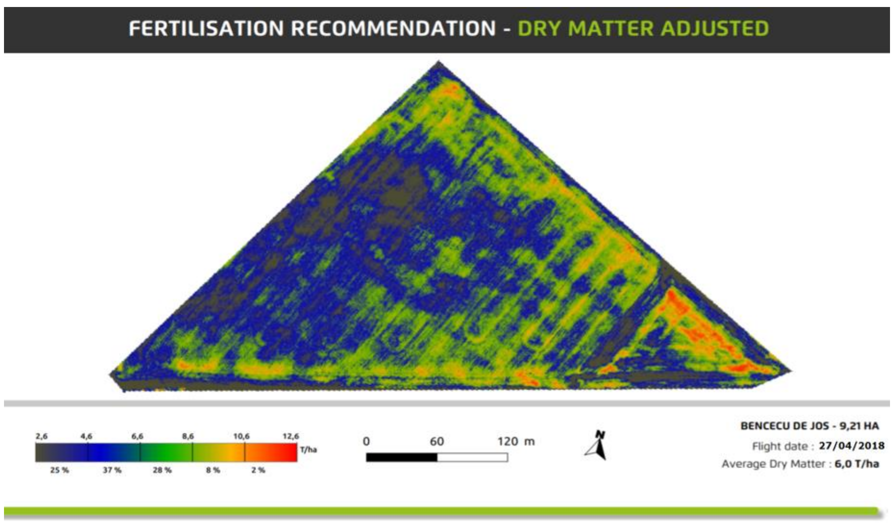

Figure 2. The dry matter content in the crop – dry matter adjusted

The drone software allows the separation of the immages in two separate ones, where there are represented the amounts of dry matter on the plot. Because, in this way there are available two sources for making the maps, data resulted from drone flight and satellite, respectively, we obtain results of higher quality and accuracy. Both diagrams emphasize that the amount of dry matter distributed on the total plot area ranges from a minimum of 2.6 t/ha up to a maximum of 12.6 t/ha resulting in an average of 6 t dry matter/ha (Fig 1, and Fig. 2).

Concerning the study of the amount of absorbed nitrogen, we also adopted the methodology of using both, data obtained from drone flight, delivered as nitrogen absorbed map (Fig. 3), and data resulted from adjusting nitrogen absorbtion in experimental barley crop, by overlapping the images captured by the drone with the images made by a Google satellite, delivered as nitrogen absorbed map (Fig. 4).

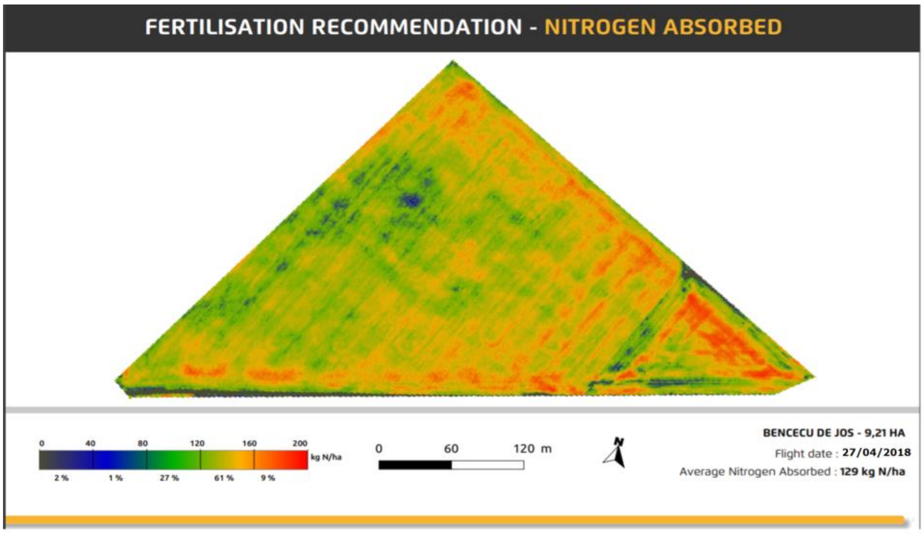

Figure 3. The recommended nitrogen fertilization level by the drone – nitrogen absorbed

The amount of nitrogen absorbed emphasized by the maps delivered, ranges from a minimum of 91 kg/ha nitrogen up to a maximum amount of 199 kg/ha nitrogen, with a mean of 129 kg/ha absorbed nitrogen. Both maps emphasize the mean amount of nitrogen absorbed by the plants and the distribution of nitrogen absorption on the plot surface.

According to data collected from the field using NDVI drone technology, the nitrogen fertilization amount is recommended, also based on drone software output, and delivered mapsmof barley dry matter and amount of nitroigen absorbed, respectively. The drone technology alows two types of recommendations, simple, and detailed, respectively. Thus, according to the simple recommendation (Fig. 5), a mean amount of 30 kg/ha active substance nitrogen may be administered. But according to specific particularities of the area cultivated with barley, meaning different soil fertility, on 41% of the experimental area of 9.21 ha, corresponding to 3.80 ha, according to the simple fertilization map (blue colour), the ammount of fertilization dose is 24 kg/ha nitrogen active substance (Fig. 5).

Thus, on the rest of the experimental area, meaning 59% of the entire plot, corresponding to 5.41 ha, according to the simple fertilization map (red colour), the ammount of fertilization dose is 33 kg/ha nitrogen active substance (Fig. 5).

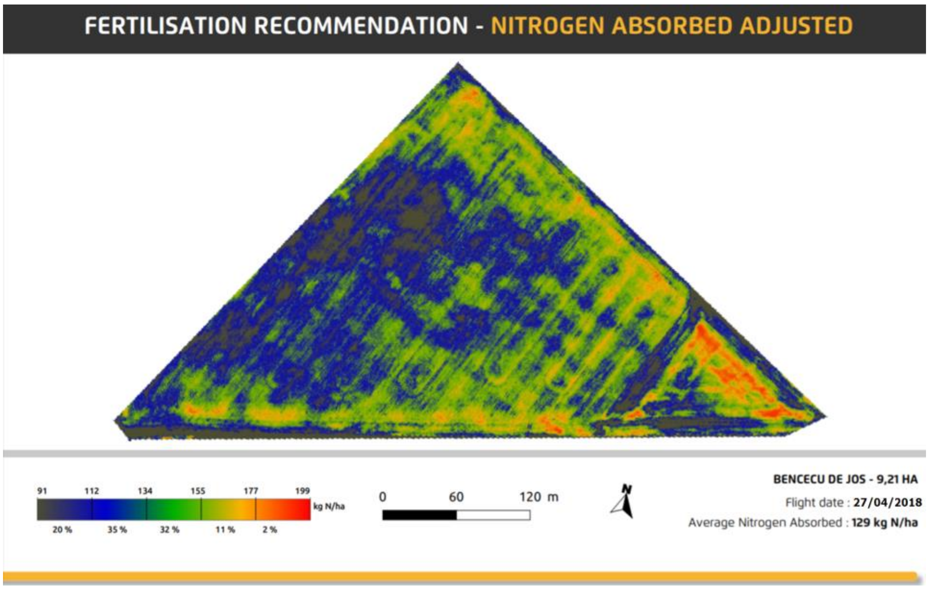

Figure 4. The recommended nitrogen fertilization level by the drone – nitrogen adjusted

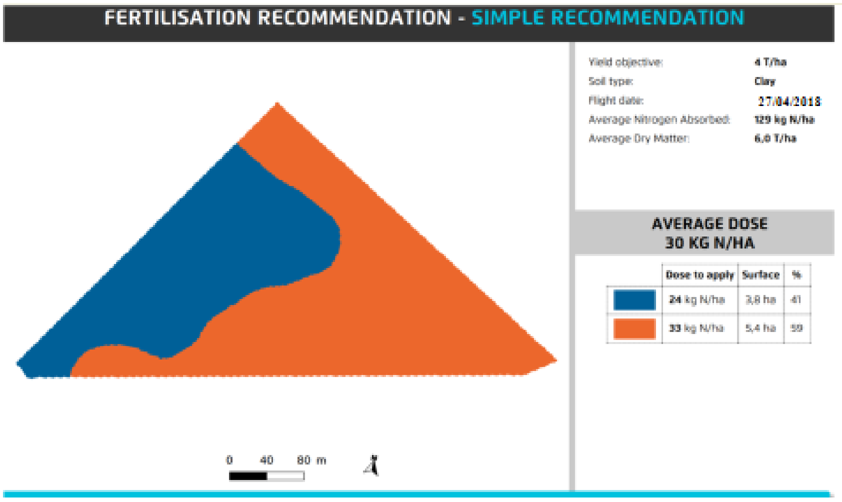

Figure 5. The mean amount of nitrogen recommended by the drone – simple recommendation

When detailed recommendations concerning the nitrogen fertilization are aimed, we used the data obtained from the subdivision in five sub-plots (Fig. 6), as follows:

- ➢ on 5% of the experimental area, corresponding to 0.40 ha, according to the detailed fertilization map (dark blue colour), the ammount of fertilization dose is 14 kg/ha nitrogen active substance;
- ➢ on 15% of the experimental area, corresponding to 1.40 ha, according to the detailed fertilization map (light blue colour), the ammount of fertilization dose is 19 kg/ha nitrogen active substance;

- on 30% of the experimental area, corresponding to 2.80 ha, according to the detailed fertilization map (green colour), the ammount of fertilization dose is 26 kg/ha nitrogen active substance.

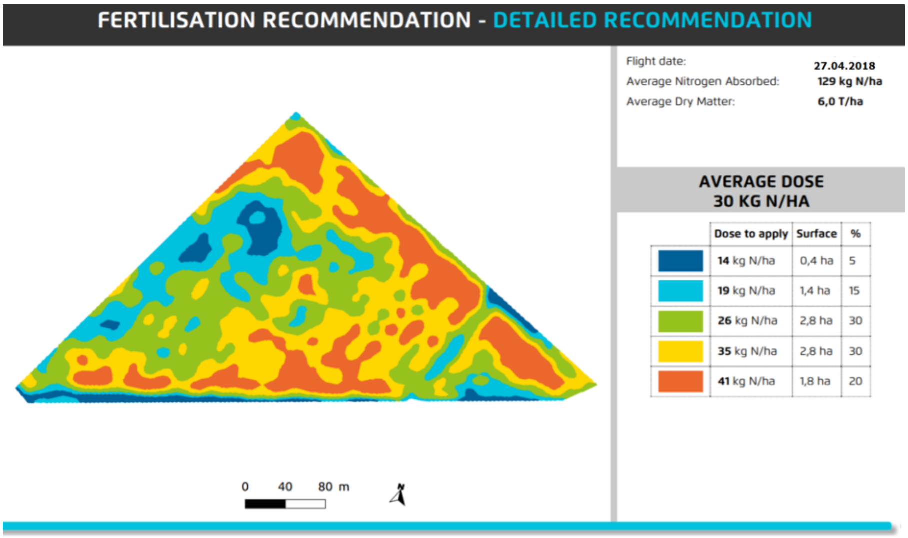

Figure 6. The mean amount of nitrogen recommended by the drone – detailed recommendation

- on 30% of the experimental area, corresponding to 2.80 ha, according to the detailed fertilization map (yellow colour), the ammount of fertilization dose is 35 kg/ha nitrogen active substance;
- on 20% of the experimental area, corresponding to 1.80 ha, according to the detailed fertilization map (red colour), the ammount of fertilization dose is 41 kg/ha nitrogen active substance.

CONCLUSIONS

Our study implemented using NDVI drone technology, associated with captures from Google satelite allows the accurate quantification of barley dry matter conten, and nitrogen absorbtion from soil by the barley culture. Our findings show differences in both, dry matter content of the plants, and also differences in nitrogen absorbtion ratio, based on maps delivered by the drone software. These results allow us to determine the exact amount of nitrogen that plants need in order to provide maximum production at lower costs and high quality.

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